Studies on Economic Growth and Inflation

Theory and Empirics

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Abstract

This thesis consists of four independent papers. Paper I examines the effect of environmental policy on economic growth in a small open economy in a neoclassical framework with pollution as an input. We show that the effect of environmental policy on growth is stronger in the open economy case relative to the closed economy model if the country has strong aversion to pollution and thus serves as a net exporter of capital in the international capital market. On the other hand, if the agents in the economy have low aversion to pollution and thus import capital, the effect of environmental care on growth is stronger in the closed economy relative to the open economy. Paper II analyses the effect of asymmetry in factor endowments between resource-rich and resource-poor countries on equilibrium bias of technology development and adoption possibilities. First, we show that the bias in equilibrium technology in the resource-poor North is determined by its relative abundance of human capital and physical capital. Secondly, we show that the equilibrium bias in technology in the resource abundant South is dependent positively (negatively) on the relative abundance (scarcity) of skilled (unskilled) labour and the relative abundance (scarcity) of physical (natural) capital in the North. This force is dampened by the relative scarcity of skilled labour and physical capital in the South. These forces drive wage inequality, high cost of capital and skill technology mismatch in the South, all of which are bad for growth. These effects cumulatively, explains part of the observed differences in growth performance between resource -rich and resource-poor countries. Paper III investigated the relationship between long run economic growth in Ghana and natural resource abundance using time series econometric techniques. Using a number of indicators that could proxy for resource abundance in eight alternative specifications, the results rejected the resource curse hypothesis. Paper IV provides an empirical analysis of the factors accounting for inflation dynamics in Ghana using the bounds test and other econometric approaches. We find that real output, nominal exchange rate, broad money supply, nominal interest rate and fiscal deficit play a dominant role in the inflationary process in Ghana.

Keywords: economic growth, environmental policy, directed technical change, Technology adoption, natural resource curse, fully-modified least squares estimator, Inflation, Ghana

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Dedication

To Ernestina and Janessa

List of Publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I   Adu, G. Effects on Growth of environmental policy in a small open economy (Submitted to the Journal of Environmental Economics and Policy Studies)

II   Adu, G. Directed technical change, technology adoption and the resource curse hypothesis (Submitted to the Journal of International Trade and Economic Development)

III   Adu, G. Natural resource abundance and economic growth: the case of Ghana (Submitted to the Journal of Resources Policy)

IV   Adu, G. and Marbuah, G. (2011). Determinants of inflation in Ghana: an empirical investigations. South African Journal of Economics, 79(3), 251-269

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6

1 Introduction

This thesis addresses four broad questions. What are the effects on growth of environmental policy in a small open economy? What are the sources of productivity differences between resource abundant countries and resource-poor economies? Can the post independence poor growth of the Ghanaian economy be attributed to her abundant natural resource endowments? What are the forces behind inflation dynamics in Ghana? Each question has been addressed in a full length paper. I have approached the first two questions theoretically. I tackled the third question empirically while the last question combines both theory and empirics.

This thesis is composed of four independent papers. Paper I analyzes the effects on growth of environmental policy in a small open economy in a one-sector aggregated neoclassical-type model in which pollution is an argument in both production and the utility function. Though there are many studies in this area, none of the previous studies makes an extension to allow for capital flows across national borders. Paper II applies the directed technical change framework of Acemoglu (1998, 2002) and follows Acemoglu and Zilibotti (2001) and Gancia and Zilibotti (2009) to investigate the role of skilled/capital biased technological change in the resource-poor North in explaining the natural resource curse for the resource-rich South. Paper III uses time series econometrics to seek evidence on the natural resource curse hypothesis on Ghana. Paper IV applies both theory and time series econometric methods to examine the forces behind inflation dynamics in Ghana.

The issues raised in this thesis deserve much attention. There is still much controversy over the possibility of continued growth without damaging effects on the environment. The pessimistic view is that of zero growth in the long run as the sure way of avoiding environmental catastrophe. This will then imply

that over time per capita consumption will decline monotonically, unless population growth is also pegged at zero. On the other hand, the optimistic school of thought is of the view that continued growth in the world with continued technological advancement need not be harmful to the environment. There is thus still much scope for investigation into the nexus between environmental protection and long run economic growth.

Trade openness and the flow of foreign direct investment are known to be among the factors that contribute to long-run economic growth, both theoretically and empirically. Economic growth, given the distribution of income, reduces poverty and population growth and thereby reduces the stress on natural resources and the environment. Population growth exacerbates poverty and increases the pressure on the environment. To the poor, environmental quality is a luxury that they cannot afford. However, concerns have also been raised about the fact that trade openness and the flow of foreign direct investment, especially in mining and forestry result in environmental degradation in the host country. Also, economic growth requires the direct use of the environment either as a source or a sink or both, either of which may result in environmental degradation.

Recent research on economic growth has developed methods that are suitable for analysis of the pair wise nexuses between economic growth and environment, trade and growth and that existing between trade and environment, respectively. In particular, there is an emerging literature on growth in open economies (see Ventura, 2005). However, this literature has not incorporated environmental issues (and the literature that studies the interrelationship between trade and environment does not consider growth; see Copeland and Taylor (2003)). It would be particularly interesting to analyze the consequences (in terms of differences between countries with respect to growth rates between countries, and thus the long-run world income distribution) of differences in environmental (and other) polices. Does a stricter environmental policy in one country lead to an outflow of capital and a lower growth rate? If positive health effects of clean environment are taken into account, the answer to the above question is far from obvious apriori. It is therefore important to probe further, theoretically, into what effect environmental policy has on growth in a small open economy.

Another contentious area of debate in the literature on growth and environment is the natural resource curse hypothesis. It seems to be an empirical regularity

that resource abundant countries have performed poorly in terms of long run economic growth when they are compared with their resource poor counterparts (see for instance Sachs and Warner, 1995, 2001; Gylfason and Zoega, 2002; Gylfason, 2001). However, it is hard to explain the resource curse phenomenon with sound economic theory. One property of the production function at the firm level is Monotonicity. If the aggregate production function inherits this property, then resource abundance should not lead to a poor growth performance. There is thus the need to do more theoretical investigations about the sources of productivity differences between resource rich countries and their resource poor counterparts. The second paper in this thesis therefore develops a theoretical model that complements the existing theories to explain the resource curse hypothesis using the directed technical change framework of Acemoglu (2002).

With regards to the resource curse hypothesis, Ghana appears to be an interesting case to study. The first reason is that it is on record that Ghana is one of the most naturally endowed countries in the world. Ghana is one of the world leaders in cocoa, timber and minerals exports. In spite of this, the country has remained poor with annual GDP growth averaging about 3% since independence in 1957. The question begging to be asked is whether the poor growth record of Ghana can be blamed on her natural resource wealth. There is tendency for one to conclude that Ghana suffers from the paradox of plenty phenomenon. The second reason is that Ghana has recently discovered crude oil in commercial quantities. This suggests that there is hope for Ghana becoming a commercial crude oil producer. The announcement of the discovery put smiles on the faces of many Ghanaians, at least for the reason that the discovery and extraction of the oil will accelerate the long awaited elevation of Ghana from low-income country to middle-income country status in the immediate run and possibly high income status in the long run. But this hope may be a mirage if the resource curse hypothesis has a support from the Ghanaian data. The third paper in this thesis therefore applied time series methods to seek evidence on the resource curse hypothesis in the Ghanaian data.

Inflation is widely regarded as one of the most important macroeconomic indicators and a major focus of economic policy, particularly, monetary policy. However, no single consensus theory of inflation has emerged. Moreover, evidence from inflation studies shows that the causes of inflation are many and varied. Furthermore, in most cases the forces that drive the inflation process

are country specific. The fourth paper therefore combines theory and time series econometrics to identify the key determinants of inflation in Ghana.

2 Summaries of the Appended Papers

In the previous section, the major questions dealt with in Papers I-IV were put into a broader perspective. In this section, Papers I-IV are summarised, in turn highlighting more on methodologies, key findings and contributions to the literature. Note that we only present brief summaries here and therefore the interested reader is encouraged to read the details from the appended papers.

2.1 Summary of Paper I

The pollution haven hypothesis (PHH) is one of the most contentious and hotly debated predictions in international environmental economics. The central prediction of the PHH is that liberalized trade in goods will lead to the relocation of pollution intensive production from high income and stringent environmental regulation countries to low income and lax environmental regulation countries.

This paper complements the existing theoretical literature on the PHH phenomenon, by introducing the time dimension. We thus extend the basic static multi-sector trade models in the previous literature (e.g. Copeland and Taylor 1994; 2003) into a dynamic model. To do this in a simplified framework, we use a one-sector aggregated growth model with pollution, similar to Brock (1977), which allows for international capital flows. Other related studies include Keeler, Spence and Zeckhauser, 1971; Forster, 1973; Gruver, 1976; Brock, 1977; Becker, 1982; Musu, 1989; Tahvonen and Kuuluvainen, 1993; van der Ploeg and Withagen, 1991; Selden and Song, 1995, for similar studies. However, none of these studies allows for international capital flows. In the previous literature, a higher demand for environmental quality forces (some of) the dirty production sector abroad. In this paper, a high demand for environmental quality directs savings away from polluting domestic production investments to investments on the "clean" (from

the small country's perspective) international capital markets. The model contains only one physical kind of good, but foreigners can buy domestic output and domestic residents can buy foreign output. The function of international (and inter-temporal) trade in our model is to allow domestic production to diverge from domestic expenditure on consumption and investment. Thus we consider the intertemporal aspects of international trade but neglect the implications for patterns of inter-sectoral specialization and comparative advantage in production. The latter case is well addressed in the previous literature (see for instance Copeland and Taylor, 2003; Levinson and Taylor, 2008). We solve a social planner's problem for both the open and closed economy cases in the main text and relegated the decentralized equilibrium analysis for the closed economy case to the appendix.

The following emerged as the key findings of the paper. First, we found that the growth rate of consumption is constant in all periods due to the constancy of the world interest rate. Second, the capital-output ratio goes to its steady state value instantly due to the rapid capital flows that equate the international and domestic interest rates. Third, along the steady state growth path, consumption, capital, output and pollution all grow at constant rates. However due to international trade in goods and financial assets, the growth rate of consumption can differ from the growth rate of the capital stock. In a benchmark case in which consumption and capital grow at common rate (like in for instance, Blanchard and Fisher, 1989), the aggregate stock of international debt grows at the same rate as capital and consumption which then pins down the growth rate of the debt-capital ratio to zero. In addition to this, we examined two possible deviations from this benchmark case. In the first deviation from the benchmark, we allow consumption to grow faster than the capital stock and hence the small open economy serves as net exporter of capital in the international capital markets. This deviation from the benchmark scenario is possible if the agents in the economy have strong aversion to pollution and hence demand tougher environmental standards. The second possible deviation is the reverse case where capital grows faster than consumption and hence the small economy becomes a net importer of capital in the international capital markets. This deviation is possible if the agents in the economy have low aversion to pollution and thus demand less stringent environmental regulation.

2.2 Summary of Paper II
Though the theoretical basis of the natural resource curse hypothesis is weak, it appears to be an accepted hypothesis from a number of empirical studies on the

12

subject. According to the monotonicity property of production functions, output is non-decreasing in inputs, implying that more input is at least as good as less. If the aggregate production function inherits this property that underlies its micro level counterparts, then having more natural resources should not decrease output and hence not the growth rate. It is therefore hard to explain the seemingly empirical regularity with sound economic theory. Previous theories to explain the curse centre on political economy (institutional economics), uncertainties and macroeconomic volatility, the Dutch disease effect and the human capital accumulation effect.

The objective of this paper is to offer an alternative theoretical explanation of the resource curse hypothesis using the directed technical change modelling framework of Acemoglu (2002) that will complement the existing theories in explaining the resource curse hypothesis. Using the North-South extension of this model, we argue that the curse may be the result of the skill/capital-biased technological change, that makes technologies (developed to suit the needs of the skilled/capital-abundant North) inappropriate for the natural resource/unskilled labour-abundant South. This channel of transmission has become more relevant in explaining the curse of natural resources as it is evident that the direction of technical change over the last 60 years or so has been skilled-biased (Acemoglu, 1998; 2002). This coupled with the lack of intellectual property right protection in Southern countries have made new technologies inappropriate for the South. The reason is that new technologies are purchased by Northern firms only. The Southern firms only steal.

Our investigations revealed the following. First we showed that under constant technology: (1). the relative price of the manufacturing output is a decreasing function of both the relative abundance of human and physical capital endowments of the North; (2). the relative wage is a positive function of the relative abundance of human capital, but the effect of relative abundance of physical to natural capital depends on whether the production factors are substitutes or complements. If the factors are substitutes (complements) then the relative wage decreases (increases) in the relative abundance of physical capital; (3). the relative price of physical capital is a negative function of the relative abundance of physical capital, but the effect of relative abundance of human capital to raw labour depends on whether the production factors are substitutes or complements. If the factors are substitutes (complements) then the relative price of physical capital decreases (increases) in the relative abundance of physical to natural capital; (4). the relative profitability of manufacturing sector complementary innovations is a positive (negative)

function of both the relative abundance of human and physical capital, given that the elasticity of substitution is greater (less) than one.

When the direction of technology is endogenized, we found that the relative bias in equilibrium technology in favour of the manufacturing sector depends positively on the relative abundance of human capital to raw labour and the relative abundance of physical to natural capital, irrespective of the size of the elasticity of substitution. The relative wage function will be upward sloping for a given level of relative abundance of physical capital if the elasticity of substitution is sufficiently low. If the production factors are substitutes (complements), then the relative wage decreases (increases) in the relative abundance of physical capital. We also found that the relative price of physical capital is directly proportional to the ratio of natural to physical capital.

What implications do these findings have on technology adoption in the resource abundant South? Our analysis revealed the following findings, with regard to the above question. First, we show that the direction of technology adoption and the bias of equilibrium technology depend on both the factor supplies in both the North and the South. The equilibrium bias of technology in the South is a positive function of both the relative abundance of skill and physical capital endowments of the North. Second, if the elasticity of substitution is greater (less) than one, then the relative abundance of human and physical capital in the North decreases (increases) the wage inequality in the South. The relative abundance of natural capital in the South amplifies these effects. It is important to note however, that these effects depend on the degree of property rights protection. In the case of perfect protection, the factor endowments of the South have no effect on the skill premium in the South. In the opposite case of complete lack of property rights protection, the factor endowments of the North have no effect on wage inequality (skill premium) in the South. The effect of the factor endowments in the South on the relative return to physical capital also depends on the elasticity of substitution between the two sectors. If the elasticity of substitution in larger (less) than one, then the relative return to physical capital is lowered (increased) by the relative abundance of unskilled labour and natural capital in the South. The relative return on physical capital also increases (decreases) in the skill endowments of the North if and only if the derived elasticity of substitution is less (greater) than one. Also, the relative abundance of physical capital in the North decreases (increases) the premium to physical capital in the South, given that the elasticity of substitution between sectors is smaller (larger) than one.

When we allowed for trade in final good between the North and the South, we obtained the following results. First, we showed that the relative price of

14

manufacturing output increases in the world supply of raw labour and natural capital if the elasticity of substitution between goods is larger than zero. This means that exogenous increases in natural resource supplies or unskilled labour results in unfavourable terms of trade effects for the Southern countries, for a given state of technology. Furthermore, the effect of equilibrium bias of technology on the terms of trade is negative irrespective of the magnitude of the elasticity of substitution. If the elasticity of substitution is less (greater) than one, then the negative effect of an increase in the technological gap between the two sectors on the terms of trade becomes stronger (weaker). Second, the equilibrium bias of technology is a function of both the world resource endowments and the factor endowment of the North. Interestingly, the equilibrium bias of technology increases with the world endowments of unskilled labour and natural capital. Since the South is relatively rich in these factors, trade between the North and the South increases the bias in technological change in favour of the manufacturing sector. Third, the skill premium in the global economy is also dependent on both the world resource endowments and the factor endowments of the North. In particular, wage inequality in the integrated world economy increases in unskilled labour and natural capital endowments of the North. Also, an exogenous increase in the world supply of unskilled labour increases the wage inequality. Since the South is rich in unskilled labour, an integration of the North and the South into a single large economy will result in increased wage inequality. Finally, the relative price of natural capital is also dependent on world factor endowments and the factor endowments of the North. The human and physical capital abundance of the North increases the relative price of natural capital. However, the effect of the world supply of natural capital is to decrease its relative price, discouraging further resource-sector specific innovations.

2.3 Summary of Paper III

Theoretically, natural resources abundance is expected to promote long-run economic growth. However, a large number of empirical studies have shown that resource-rich countries have performed poorly in terms of growth compared to resource-poor countries. This negative relationship between natural resource intensity in the composition of a country's output and the growth rate of per capita income has been dubbed the curse of natural resources.

One common feature of papers that have empirically attempted to study the curse of natural resources hypothesis is the use of cross-country and panel data

for large number of countries endowed with different types of resources, whose growth impact might differ. In order to understand the impact of resource endowment on economic growth, country case studies are also needed. Unfortunately, country-case studies on the subject that uses econometric techniques are uncommon in the literature, with the exception being Sala-i-Martin and Subramanian (2003), Iimi (2006) and Hussain, Chaudhry and Malik (2009). This paper aims to fill part of the gap in the literature by expanding the scope of country-case studies on the subject by seeking evidence in favour or against the curse of natural resources hypothesis for Ghana. The main contribution of this paper is its application of time series econometric methods and different indicators of natural resource abundance (share of agriculture in GDP and per capita crop land, cocoa, labour force in agriculture, gold, diamond, bauxite and manganese) to examine the contribution of natural resource to the growth and development process of Ghana since 1960. Time series studies have the advantage that if the variables are cointegrated, then the parameters can be estimated consistently even if none of the variables is exogenous.

The case of Ghana can be justified on at least two counts. The first is that it is on record that Ghana is one of the most naturally endowed countries in the world. Ghana is one of the world leaders in cocoa, timber and minerals exports. In spite of this, the country has remained poor with annual GDP growth averaging about 3% per annum over the period 1960-2008. It is interesting to note that the average growth rate for the period 1960-1983 was only 0.90% while the average rate of real GDP growth is about 5.0% for the period 1984-2008. The second reason is that Ghana has recently discovered crude oil in commercial quantities. This suggests that there is hope for Ghana becoming a commercial crude oil producer. The announcement of the discovery put smiles on the faces of many Ghanaians, at least for the reason that the discovery and extraction of the oil will accelerate the long awaited elevation of Ghana from low-income country to middle-income country status in the immediate run and possibly high income status in the long run. But this hope may be a mirage if the resource curse hypothesis has a support from the Ghanaian data.

To test the hypothesis that natural resource abundance is bad for growth, we estimated variants of the following model:

$$GDP_t = \alpha_0 + \mathbf{x'}\boldsymbol{\beta} + \mathbf{R'}\boldsymbol{\lambda} + \varepsilon_t \tag{1}$$

where x is the vector of control variables (consists of: Capital (proxied by the ratio of gross domestic capital formation to GDP), the labour force, trade

openness, government consumption expenditure, financial development, distortions to agricultural incentives and two dummies to control for democratic governance and structural shifts) and R is the vector of proxy indicators for resource abundance (this vector is a subset of the following list of indicators: the share of agriculture in GDP, agricultural labour force, real primary commodity exports, per capita cropland, the volume of annual cocoa production, the volume of annual gold production, the volume of annual diamond production, Volume of manganese production and the volume of bauxite) assumed to be uncorrelated or only weakly correlated with each other and ε_t is the stochastic term assumed to be uncorrelated with the exogenous regressors. Since no single proxy can adequately represent natural resource abundance, we allow for more than one proxy in one model, contrary to the one-dimensional approach in the previous literature. In all we use eight proxy measures of resource abundant indicators for the analysis Due to the high correlation between labour force in agriculture and the total labour force; we did not include the former in our final estimations. We however created four composite indexes from the first eight measures of resource abundance using principal components analysis. In all the equations that were estimated, the log of real GDP was the dependent variable.

In estimating the model in equation (1), we first determine the order of integration of the individual series. To achieve this, I applied the Phillips-Perron (1988) [here after PP] and Elliot, Rothenberg and Stock (1996) [here after DF-GLS] tests for unit roots. The PP test is preferred to the traditional Augmented Dickey-Fuller (ADF) test because of its use of non-parametric methods to adjust for serial correlation and endogeneity of regressors thereby preventing the loss of observations implied by the ADF test. It also allows for the possibility of heteroskedastic error terms (Hamilton, 1994). We further augmented these tests with the Zivot and Andrews (1992) [here after ZA] which controls for up to one endogenous break in the series. Our analysis revealed the following results. First, using the ZA test, the PP test and the DF-GLS test for unit roots, we found that most of the variables analysed in this paper are integrated of order one [i.e. I(1)]. Based on the PP and the DF-GLS test, the unit root null was rejected at the levels of the series for only bauxite, inflation and the variable created from the third principal component of the resource abundant indicators. However, the null hypothesis of unit root was flatly rejected for all the series in their first differences. The ZA test gave further confirmation to this test. We thus treat the variables under investigation as a mixture of I(0) and I(1) series.

We therefore proceeded with our investigation using the Phillips and Hansen (1990) fully modified least squares estimator that controls for both non-stationary and endogenous regressors. The results from our estimations indicate that only per capita cropland has significant negative effect on real GDP over the period that we study. The other resource abundance indicators – the share of agriculture in GDP, annual cocoa production, gold and manganese, all have statistically significant positive effects on growth. Diamond has positive coefficients, but was found to be statistically significant in only one out of four specifications in which it appeared. Similar results was obtained on bauxite, which has negative coefficients in all four specifications in which it showed up, but was only statistically significant in one equation. Interestingly, using the real primary commodity exports as our measure of resource abundance, following Sachs and Warner (1995, 2001), we found statistically positive coefficient on this variable. The set of control variables also proves to be useful determinants of growth, particularly, labour, capital, financial development, size of the public sector and distortions to incentives in the agricultural sector.

In order to ensure that our estimates are robust, we use principal components analysis to create four composite indexes from the eight individual resource abundant indicators used, excluding the real primary commodity exports. The results we obtained from this exercise confirmed our earlier findings in which the indicators entered the equation explicitly. In particular, per capita cropland maintained its negative and significant relationship with real GDP, while the other indicators maintained their positive relationship, except the share of agriculture in GDP, which assumed negative relationship, based on the results from the regression using the variables from the principal components analysis.

On the whole, the results in this paper do not support the resource curse hypothesis. I did not find sufficient evidence that natural resource abundance has had a harmful growth effect on the Ghanaian economy since only per capita cropland has significant negative effect on growth. My argument here is that the negative coefficient on cropland is an indicative of the fact that this factor experiences diminishing returns.

2.4 Summary of Paper IV

One of the requirements for joining the Economic Community of West African States (ECOWAS) common currency zone is single-digit rate of inflation. Unfortunately, inflation has persistently remained above a single-digit mark in

Ghana. The Bank of Ghana has made inflation targeting one of the key objectives of the monetary policy framework. Despite the Bank's position on inflation, it has in many cases failed to attain the end of year targeted rate of inflation. The question begging to be asked then is "why has the Ghanaian inflation persistently remained above the policy target?" This paper sheds light on this question by providing robust evidence on the determinants of inflation in Ghana.

Though there are earlier empirical studies on inflation in Ghana (see for instance Asafu-Adjaye, 2008; Ocran, 2007; Sowa, 1996, 1994), there is still scope for further empirical investigations on drivers of inflation in Ghana. First, earlier studies have approached the subject using error correction techniques which can only predict short run impact of the regressors. In cases where an attempt has been made to capture long run effects, OLS estimators are used (see Sowa, 1994; 1996). Ocran (2007) used the Johansen multivariate to estimate the long run parameters. However, the small sample properties of this estimator are not known with any certainty since simulation studies are usually based on sample sizes of 500 or more. The reliability of his estimates is doubtful and their policy relevance is in disrepute. We address these concerns in the present paper. We employ the ARDL approach to cointegration to estimate both the long and short run multipliers of the key drivers of Ghanaian inflation. This estimator has good small sample properties which makes appropriate for our sample. Further, we augment our model with nominal interest rate (a key variable in modern monetary policy used by many central banks) and fiscal deficit. These variables emerged as significant determinants of inflation in both the short and long run.

The model of interest in this paper takes the following parametric form:

$$\ln P_t = \delta + \beta_1 \ln y_t + \beta_2 \ln E_t + \beta_3 \ln M_t + \beta_4 \ln r_t + \beta_5 \ln FD_t + \beta_6 \ln P_{t-1} + \varepsilon_t \quad (2)$$

where P_t is the consumer price index (CPI), y_t is real income, proxied by the real gross domestic product (real GDP), E_t is the exchange rate, measured as cedi per dollar, M_t is money supply, r is the nominal interest rate, FD_t is a measure of fiscal deficit and is the usual stochastic term while subscript t is time index.

In estimating an inflation model for Ghana, the following steps are taken in achieving this. First, we test for unit root of the variables using the Phillips-Perron (1988) test. The Phillips-Perron (PP) test is preferred to the traditional Augmented Dickey-Fuller (ADF) test because of its use of non-parametric

methods to adjust for serial correlation and endogeneity of regressors thereby preventing the loss of observations implied by the ADF test. It also allows for the possibility of heteroskedastic error terms (Hamilton, 1994). To test for cointegration we use the bounds testing approach proposed by Pesaran et al. (2001) within the autoregressive distributed lag (ARDL) framework. One of the advantages of using ARDL bounds test is that it is applicable regardless of the stationarity properties or irrespective of whether the regressors are purely I(0) or I(1), or mutually integrated and robust for cointegration analyses with small sample study (Pesaran et al., 2001).

Our investigations revealed the following findings. First, the unit root test clearly shows that all the series are non-stationary in the levels except M2+ (when a linear trend term is included) and fiscal deficit which is stationary at the 10% level when no trend and trend are included in the PP equation. The Zivot and Andrews (1992) (ZA test) test results indicates acceptance of the null hypothesis of unit root without structural break for almost all series except nominal exchange rate and nominal interest rate. After first order differencing however, all the variables achieved stationarity at conventional significance levels. Thus we have a case of a mixed order of integration of (I(1) and I(0)) variables and hence justify the use of the ARDL cointegration technique.

Second, the cointegration results show the rejection of the null hypothesis of no cointegration when inflation is normalized in each of the models estimated given that the calculated F-statistics exceed the upper bound critical values at either 1% or 5% significance levels. Specifically, modelling inflation with narrow money (M1) confirmed cointegration at the 5% level while inclusion of broad money aggregates (M2 and M2+) shows rejection of no cointegration at the 1% level. There is therefore a strong evidence of a long-run steady state relationship between inflation and its covariates and that real output, nominal exchange rate, money supply, interest rate and fiscal deficit are long-run forcing determinants of Ghanaian inflation.

The estimations of the long and the short run models revealed the following findings. The results from our long run model indicate that real income and the exchange rate all have statistically negative effect on inflation in Ghana. The negative effect on the exchange rate suggests that currency depreciation has depressing effect on inflation. This is quite surprising since currency depreciation is expected to fuel price inflation. Fiscal deficit also has a negative coefficient and insignificant in the ARDL specifications but highly significant in the fully-modified ordinary least squares (FMOLS) and the dynamic ordinary least squares (DOLS) estimations. However, money supply and the interest rate (main monetary policy variables) all have significant positive

20

effect on inflation, a finding consistent with our a priori expectations. A number of empirical studies on Ghana have arrived at similar conclusion.

Consistent with the long-run results, inflation is negatively related to output growth and highly significant in two out of the three alternative specifications used depending on how money supply is measured. Exchange rate depreciation in the short-run has positive effects on inflation confirming the theory contrary to the long-run results. However, it is not statistically significant and its impact appears rather weak particularly in the model with M2+. Monetary expansion seems to be the most potent driver of inflation in the short-run, followed by nominal interest rate and fiscal deficit. Ocran (2007) also found nominal interest rate and money supply growth as critical factors driving inflation in the short-run.

The results also show the error correction terms are all correctly signed (negative) and statistically significant at the 1% level ensuring the attainment of long-run equilibrium following a system shock. The coefficient of the error correction term measures the adjustment speed of inflation to long-run equilibrium due to changes in the inflation covariates. Furthermore, the forecast evaluations of all the three different estimators indicate that our models really fit the data well. Thus inflation dynamics in Ghana has strong linkages with real income, the exchange rate, money supply, the interest rate and fiscal deficit. A successful anti-inflation policy will thus require instituting monetary and fiscal discipline alongside removing structural bottlenecks in the economy.

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