Public Private Partnerships (PPPs) and Economic Growth: A Sectoral Analysis from Developing Countries

Abstract

The constraints placed on budgetary requirements of governments have shifted attention to public and private partnerships in financing infrastructure projects, which are at the heart of service delivery in developing countries. Thus, understanding the empirical links that exist between infrastructure investment using PPPs and economic growth, is essential for policy formulation for developing economies. This paper examines the effect of PPP investments on economic growth in 39 developing countries from 1997 to 2016 within the traditional growth model. Using the system GMM estimation technique, the study first analysed the effect of total PPP investment on economic growth, measured in GDP per capita. Secondly, PPP investment was disaggregated into the three PPP sectors, namely energy, transport, and water and sanitation. While we find aggregate PPP investment to positively contributes to economic growth, PPP investments in energy, transport, and water and sanitation either had a negative or insignificant effect on economic growth. The policy implications of the findings are discussed.

Keywords: PPPs, Economic Growth; Developing Countries

JEL Classification: H49, H54, O47, and O50

1.0 Introduction

It is estimated that between 2013 and 2030, developing countries will account for more than 90% of the global population (Consultancy.uk, 2015). This population requires access to energy, water and sanitation, telecommunication, education and health. To deal with these needs amidst the growing pressures of urbanisation and other economic development constraints, would require huge infrastructural projects. When well planned, funded and maintained, a developed infrastructure could support a country's competitiveness, economic growth and improve its population's standard of living. However, budgetary constraints have limited the ability of governments to deliver on the required infrastructure investments in most developing economies.

Funding is indeed one of the largest constraints in the expansion of public infrastructure . The United Nations (2014) assessed that countries in the Sub-Saharan Africa region needed to invest US$93 billion annually to meet their respective development goals. However, actual investment wanly amounted to US$45 billion. This implies a funding gap of nearly US$50 billion per year. For the developing world, an estimated investment of US$836 billion annually or 6.1% of current gross domestic product (GDP) was required from 2014 to 2020 to meet new infrastructure demands and to maintain the current levels of services (World Bank Group, 2017). This highlights the fact that infrastructure needs far exceed the financial resources currently available from the traditional ways of funding public infrastructure.

The traditional way of funding infrastructure has been done through government investments for infrastructure in line with the inherent public-goods nature of infrastructure. However, government resources, especially in the developing economies, are increasingly becoming strained, with rising debt-to-GDP ratios and widening budget deficits (World Bank Group, 2017). To address this shortfall, there has been a conscious drive to partner with the private sector for effective and cost-efficient delivery in financing infrastructural projects in developing economies (Trebilcock & Rosenstock, 2015). This is done through the Public-Private Partnership (PPPs) models, which have gained traction in the field of development finance. According to the World Bank's private participation in infrastructure investment (PPI) database, PPP investments have increased significantly between 2001 and 2015 in developing countries, classified as low income, lower middle income, and upper middle income.[1] Among developing countries, particularly in Africa, the adoption of the PPPs as a funding mechanism for infrastructure development is increasing, particularly for the development of both core economic and social infrastructure.[2] Most importantly, the new 2030 Agenda for Sustainable Development in developing countries gives impetus to the role of PPPs in providing the essential infrastructure that will be critical in achieving their Sustainable Development Goals (SDGs).

The importance of public infrastructure in stimulating economic growth is well documented (Aschauer, 1989; Dintilhac *et al*., 2015; Estache & Garsous, 2012b; Estache *et al.*, 2005), with two-thirds of the empirical literature between 1989 and 2007 providing support for the positive effect of infrastructure investments on economic growth (Straub 2008 as cited in Trebilcock & Rosenstock, 2015). The available evidence on the private sector and infrastructure development have been limited to the identification of the determinants of the success of PPP investments

[1] The World Bank classifies these regions according to Gross National (GNI) Income per capita. The low-income group refers to countries with a GNI per capita of US$1 025 or less in 2015, lower middle-income countries are those with a GNI per capita of between US$1 026 and US$4 035, whilst upper middle-income countries fall between US$4 046 and US$12 475.

[2] Mutambatsere (2017) classifies economic infrastructure as infrastructure in the energy, water, transport and Information and Communication Technology (ICT) sectors and social as infrastructure in the health and education sectors, among others.

(e.g. Babatunde *et al.*, 2012; Basilio, 2017; Hammami, Ruhashyankiko, & Yehoue, 2006). However, as highlighted by Dintilhac *et al.* (2015), there are not many empirical studies that assess the impact of infrastructure investment through PPP models on economic growth and most studies are based on case studies evaluating particular projects (e.g. Tang, Shen, & Cheng, 2010 and Kwak, Chih, & Ibbs, 2009) rather than giving an overall robust empirical analysis of projects in general.

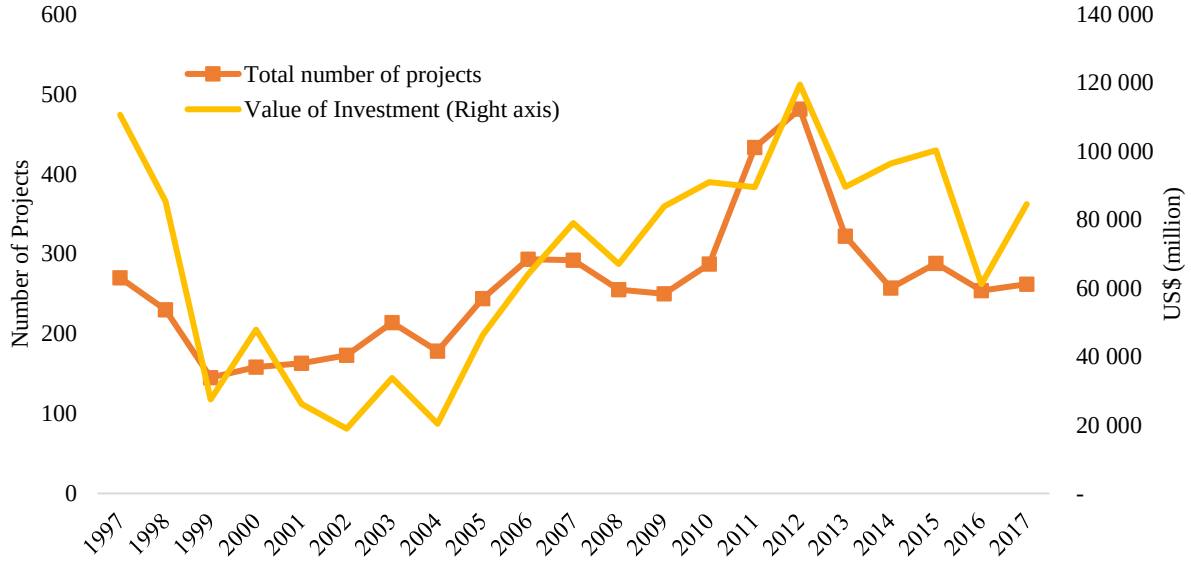
Against this background, this paper examines the role of PPPs in stimulating economic growth in developing economies through the delivery of infrastructure projects using the traditional growth model. Using the World Bank's PPI database, the study focused on a sample of 39developing countries classified in its database, covering the period between 1997 – 2016. The paper employed the system generalized method of moments (GMM) to estimate the panel data model. Compared to the literature, this paper also considers the sectoral effect of PPPs in energy, water and sanitation and transportation on economic growth, which provides the first empirical evidence on the sectoral effects of PPPs investments on economic growth.

The rest of the paper is organized as follows; Section 2 presents an overview of PPPs in developing countries, Section 3 reviews the empirical literature on PPPs and economic growth while Section 4 describes the empirical strategy employed in achieving the objectives. Sections 5 and 6 present the discussion of findings and conclusion, respectively.

2.0 Overview of PPPs in Developing Countries

In this section, data is used from the World Bank's PPI project database over the period 1994-2017 to analyse trends in PPPs in developing countries. This analysis focuses on PPP projects that had reached financial closure over the period being reviewed. The analysis only includes data available of a certain number of projects and the value of the investment into such projects over an analysed period. The values represent committed investment and not necessarily actual expenditure as some of the commitments may have been cancelled or distressed over the analysed period.

Figure 1: Total Investment Commitments in Developing Countries from 1997 to 2017



Source: Data from the World Bank's Private Participation in Infrastructure database, 2018

It will be noted from Figure 1 that when viewed annually, the value of committed investments varied significantly, with the values being less than US$20 billion in some years and more than US$ 100 billion in others. The highest number of projects embarked on was in 2012, with over 480 projects recorded. Overall, committed investments of a PPP nature in these countries exhibited an increasing trend over time but at the same time were very volatile from one year to the next. Geographically, the database shows that the top three countries with the highest number of PPP projects over the period under review were China, India, and Brazil, which collectively accounted for over 57% of all projects.

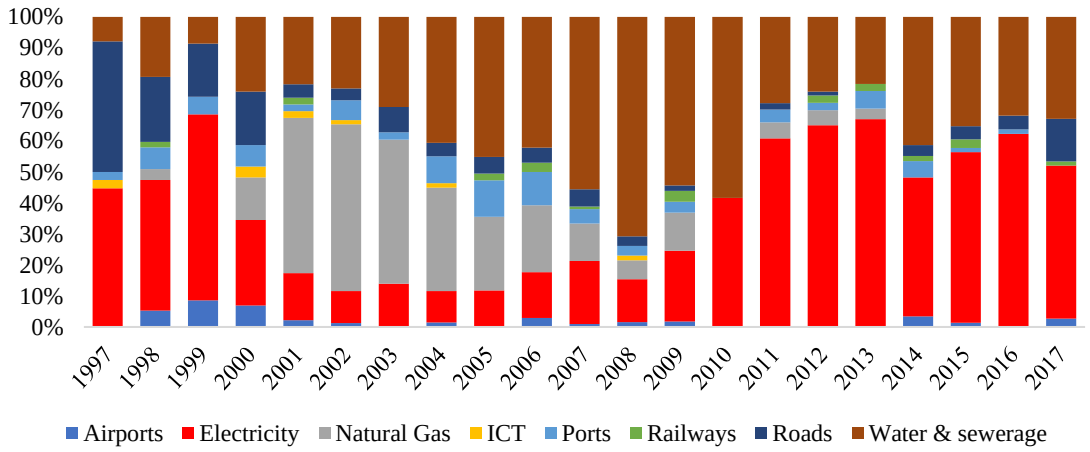
Table 1: Cumulative Values and Number of PPP Investments in Developing Countries by Sector

Sector	1997-2006		2007-2016	
	US$ Million	Number	US$ Million	Number
Transport Sector	**29 096.4**	**147**	**24 721**	**61**
Airports	2 660.2	14	413	6
Ports	9 611.6	46	4 970	25
Railways	3 584.6	7	10 812	10
Roads	13 240.0	80	8 526	20
Energy Sector	**31 754.3**	**957**	**30 840**	**370**
Electricity	28 115.3	779	30 023	334
Natural Gas	3 639.0	178	817	36
ICT	**12 585.6**	**6**	**436**	**1**
Water & Sanitation	**4 973.1**	**193**	**7 500**	**288**

Source: Data from the World Bank's Private Participation in Infrastructure database, 2018

Table 1 shows that that in developing countries, the energy sector attracted most PPP investment in the past two decades, with $31 754 million invested during the period 1997-2006 and $30 840 million in the period 2007-2016. The highest value of commitments and the highest number of projects were in the electricity sub-sector in both decades. Transport was the sector which attracted the second highest value of PPP commitments. During the 1997-2006 period, investment in roads had the highest value of commitments, whilst PPP investment in railways dominated between 2007 and 2016. The water and sanitation sector attracted the least value of PPP investment commitments, although the number of projects was the second highest, after the energy sector. Following this trend, Shediac, Hammami, Abouchakra, & Najjar (2008) determined that it illustrated the "public good" nature of the project. They argue that the provision of services to which the public had an inherent right, such as water, was considered a public good. As such, it proved less attractive to private investors because a public good has a low return on investment.

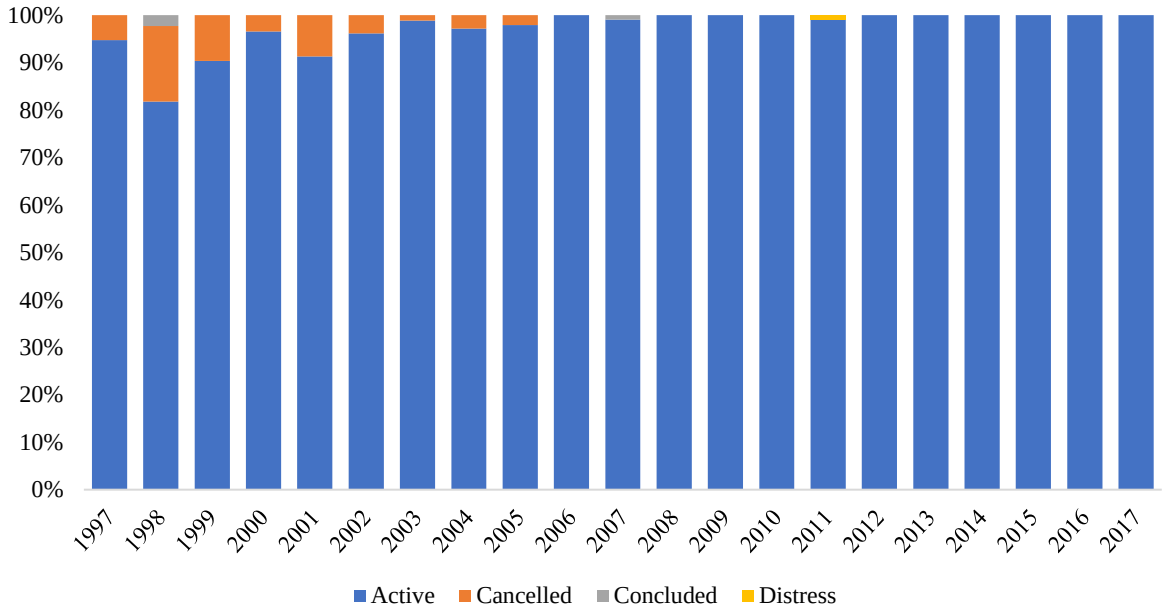
Figure 2: The Share of Total Number of Projects by Year of Financial Closure



Source: Data from the World Bank's Private Participation in Infrastructure database, 2018

Figure 2 illustrates that the share in categories of the total number of projects varied somewhat over the period under assessment. However, at a glance, the highest share recorded was in the electricity and water and sewerage sector. On the other hand, the natural gas sector recorded notable shares between 2001 and 2004.

Figure 3: Status of PPP Projects by Year of Financial Closure



Source: Data from World Bank's Private Participation in Infrastructure database, 2018

As seen in Figure 3, most infrastructure projects in this group of countries that had reached financial closure over the period under assessment were in an operational phase and very few projects had been cancelled. The share of cancelled projects was only recorded between 1997 and 2005. Similarly, the share of completed projects was significantly low and only recorded in 1998 and 2007.

3.0 Empirical Studies

Theoretically, the transmission from infrastructure investments to economic growth is broadly classified under the direct and indirect channels. Through the direct channel, the transmission to economic growth occurs through the simple productivity effect within a standard production function (Straub, 2008). Such investments, which includes roads, electricity access, telecommunications among several others, create the platform for further investments from the private sector to increase the stock of new investments (Khan and Reinhart,1990; Straub, 2008). Under the indirect channel, Straub (2008) highlights private capital availability, adjustments cost, labour productivity, human development and economies of scale and scope as outcomes of infrastructure investments that adds to growth. However, it should also be acknowledged that the interplay between the sources infrastructure finance ultimately influences its impact on growth. First, public investments can have a positive effect on growth by crowding-in private investments. On the contrary, public investments also have the potential to crowd-out private investments in infrastructure,

The empirical evidence on the effects of infrastructure investments on economic growth has mostly been estimated using the endogenous growth model theory (Barro, 1990; Button, 1998; Khan & Reinhart, 1990). The literature can be categorized into two categories, the effect of public and private investments and PPP investments in stimulating economic growth.

In the first strand, Khan & Reinhard (1990) and Checherita (2009) documented evidence of a positive effect of private investments. First, Khan & Reinhard (1990) examined the separate effects of private and public investments on growth on a cross-sectional sample of 24 developing countries and found a greater positive effect of private investments on growth. Checherita (2009) analysed the determinants for investments on three levels (private, public and PPP) in a sample of developing countries and found a positive effect of private investments in infrastructure on economic growth. However, no evidence was found in support of a positive effect of PPPs on growth in a sample of 7 Latin American countries. In Malawi, Makuyana & Odhiambo (2019) also find a greater positive effect of private investment on economic growth compared to public investments, the authors also find evidence to support the crowding-in effect of public investments in infrastructure over the study period. Using a VAR model over the period 1998-2013, Pimentel et al. (2016) examined the macroeconomic impact of investment in PPP, private and public investments in Portugal on GDP growth. The results showed that whilst public and private investment has a positive effect on GDP while investment in PPP reduces the Portuguese GDP, which also crowds out private and public investment. Cross country studies by Nazmi & Ramirez (1997) and Ntembe et al (2018) on Mexico and Malawi document evidence of the positive effect of both public and private investments on economic growth. However, Nazmi & Ramirez (1997) finds evidence of crowding-out of private investments, consistent with Makuyana & Odhiambo (2019).

In the second strand, Zangoueinezhad and Azar (2014) investigated the links between the scale and nature of the PPP's contribution as propellers for economic growth. The authors find PPP projects, either by number, value or type, to be associated with higher GDP growth, which occurs through capital inflows to create long term employment and increases in consumption to stimulate wealth creation. In the same paper, Matsolo (2018) also document a positive effect of the number of PPPs on economic growth on as a sample of Sub-Saharan countries from 1994 to 2015.

Generally, there seems to be a paucity of research on the relation between PPPs and their impact on economic growth in developing countries. However, understanding the economic impact of PPPs in developing countries is critical, particularly because governments are increasingly using PPP models, amidst constraint public budgets, to facilitate infrastructure delivery to meet the demands of the growing population. The focus of this study is, therefore, to empirically examine the impact of PPPs investment on economic growth in developing countries in general. In the presence of seemingly a small body of empirical knowledge that exists in this research area, this study seeks to contribute by providing an empirical understanding of how PPP investment in infrastructure affects economic growth in developing countries. Different from other similar empirical studies, this study uses a traditional growth model and focuses on a relatively large panel of 39 developing countries. In addition, the research investigates which PPP sector – energy, transport or water and sanitation - has the most effect on economic growth.

Table 2: Summary of Empirical Studies

Author (s)	Country (ies)	Sample Period	Main Findings
Khan & Reinhard (1990)	24 developing countries	1970 – 1979	This study finds that private sector investment plays a much larger and thus, more important role in economic growth than does public investment. However, this finding only reflects on the direct effects of private and public investment on economies. Thus, it is possible that public investment has a positive indirect effect on growth.
Nazmi & Ramirez (1997)	Mexico	1950 – 1990	The paper finds a similar effect of private and public investments on output growth. However, the effect of private investments on output was crowded out by public investments.
Checherita (2009)	140 developing countries	1990 – 2005	Using a convergence growth model which he expands to include other types of investment, the author finds no evidence of a significant impact of PPP investment on economic growth.
Zangoueinezhad & Azar (2014)	Brazil, China and India	1990 – 2009	The study finds that if PPPs are evaluated by the number of projects they are involved in, their value and type of project, an assumption can be made that they promote a higher rate of GDP growth over the long-term.
Pimentel et al (2016)	Portugal	1998 – 2013	The results show that investment in PPP has a crowding-out effect on private and public investment and has a negative impact on GDP in Portugal.
Ntembe et al (2018)	Cameroun	1977 – 2015	Positive effects of both public and private investments on economic growth in the short run and long-run.
Matsolo (2018)	SSA	1994 – 2015	The paper finds a positive effect of the number of PPPs on economic growth.
Makuyana & Odhiambo (2019)	Malawi	1970 – 2014	The paper finds a greater positive effect of private investments on economic growth compared to public investment. Most importantly, public investment was found to crowd-in private investments.

Source: Author's design from cited sources

4.0 Empirical Strategy

4.1 Data and Sample size

The study will use the World Bank's Private Participation in Infrastructure (PPI) database.[3] PPIs are somewhat different from PPPs, however, Thomson (2005) argues that they often overlap resulting that the terms can be used interchangeably. The PPI database covers infrastructure projects in the energy, telecommunications, transportation and water sectors, dating as far back as 1993. Out of roughly 118 countries classified as developing economies by the PPI database, 39 countries were selected (see **Table A1** in the Annexure) mainly because of the availability of infrastructure data. The sample period chosen is 1997 to 2016. This would ensure that there are sufficient data points for the panel to be as closely balanced as possible.
The study will consider two ways of capturing the prevalence of PPPs. First, it will use the US$ value of PPP investment. Secondly, PPP investment will be disaggregated into sectors, focussing on the energy, transport and water and sanitation sectors.

4.2 Analytical Framework

4.2.1 Regression Equation

With growth regressions, the problem of omitted variables that are related to the unobservable effects such as the initial level of technology often exists (Ding & Knight, 2009). Given this problem, there is a likelihood that the variations in technical efficiency across countries are correlated with explanatory variables. Consequently, this often results in estimates that are biased and inconsistent. As a result, this study employs a panel data model which accounts for these unobserved country-specific effects (Ding & Knight, 2009). Specifically, it employs a dynamic panel model in the sense that it contains a lagged dependent variable. Bond, Temple, and Hoeffler (2001) emphasise that the inclusion of lags of regressors eliminates the problem of endogeneity associated with growth regression.

Adopted from Bond, et al (2001), the growth equation for our panel data model is as follows:

$$\Delta y_{i,t} = (\chi - 1) y_{i,t-1} + \chi'_{i,t}\beta + \mu_i + \epsilon_{i,t} \qquad i = 1 \ldots, N \text{ and } t = 2 \ldots, T$$

where $\Delta y_{i,t}$ is GDP per capita growth rate, $y_{i,t-1}$ is its lagged value, x_{it} is a vector of growth explanatory variables, μ_i is the country's specific fixed effect and $\epsilon_{i,t}$ is the error term. The above equation can be rewritten as follows, representing a dynamic panel data model, with a lagged dependent variable on the right-hand side:

$$y_{it} = \alpha\, y_{i,t-1} + x'_{it}\beta + \mu_i + \epsilon_{it} \qquad i = 1,,N \text{ and } t = 2, \ldots, T$$

Based on this equation, we first have to analyse the impact of PPP investment on economic growth (measured in GDP per capita growth in purchasing power parity prices) and we control for the roles that government, DFIs and the private sector play in PPP investments. Secondly, we shall consider the model in which the impact of PPP investment on economic growth is analysed in three different sectors in which PPP investments are made namely the energy[4], water & sanitation and transport sectors.[5] Reflecting on these considerations, the following basic dynamic models are proposed:

[3] The database covers contractual agreements for public infrastructure projects in low and middle-income countries. The projects have also reached financial closure and private parties assume operating risks. Projects are not entirely privately owned, financed or operated; some projects have public participation as well. Lastly, investment amounts reflect the total investment commitment entered into by the project entity at contract signature or financial closure.

4 Energy consists of electricity generation, transmission, and distribution; natural gas transmission and distribution.

[5] The sectors were chosen based on the fact that they are the largest sectors under PPP investment and data is availability.

$$GDPPC_{i,t} = \beta_1 GDPPC_{i,t-1} + \beta_2 PPP_{i,t} + \beta_3 GCF_{i,t} + \beta_4 PoP_{i,t} + \beta_5 INF_{i,t} + \beta_6 M3_{i,t} + \beta_7 GovRev_{i,t} + \beta_8 CrExt_{i,t} + \mu_i + \varepsilon_{i,t}$$ **(Eq. 1)**

Where i and t denotes country and year respectively; $GDPPC$ is the GDP per capita growth rate, PPP investments are in US$; GCF denotes gross capital formation, PoP is population growth rate, INF represents inflation rate, $M3$ is broad money supply, $GovRev$ is government revenue and $CrExt$ credit extension to the private sector. μ_i and $\varepsilon_{i,t}$ respectively, refer to the country's fixed effects and the error term. The definition, sources and measurement of the variables are described in Table 3.

The distribution of PPP investments into energy (PPP_E), water and sanitation (PPP_WS) and transportation sectors (PPP_TR) are used to formulate equations 2, 3 and 4 respectively. This is done to identify the most productive sectors for PPP investments.

$$GDPPC_{i,t} = \beta_1 GDPPC_{i,t-1} + \beta_2 PPP\_E_{i,t} + \beta_3 GCF_{i,t} + \beta_4 PoP_{i,t} + \beta_5 INF_{i,t} + \beta_6 M3_{i,t} + \beta_7 GovRev_{i,t} + \beta_8 CrExt_{i,t} + \mu_i + \varepsilon_{i,t}$$ **(Eq. 2)**

$$GDPPC_{i,t} = \beta_1 GDPPC_{i,t-1} + \beta_2 PPP\_WS_{i,t} + \beta_3 GCF_{i,t} + \beta_4 PoP_{i,t} + \beta_5 INF_{i,t} + \beta_6 M3_{i,t} + \beta_7 GovRev_{i,t} + \beta_8 CrExt_{i,t} + \mu_i + \varepsilon_{i,t}$$ **(Eq. 3)**

$$GDPPC_{i,t} = \beta_1 GDPPC_{i,t-1} + \beta_2 PPP\_TR_{i,t} + \beta_3 GCF_{i,t} + \beta_4 PoP_{i,t} + \beta_5 INF_{i,t} + \beta_6 M3_{i,t} + \beta_7 GovRev_{i,t} + \beta_8 CrExt_{i,t} + \mu_i + \varepsilon_{i,t}$$ **(Eq. 4)**

4.2.2 Description and Measurement of Variables in the Regression Model

As mentioned previously, in the convergence growth model, output per worker depends on the initial value of GDP per capita, investment (in this case, investment is expanded to include PPP investment and gross fixed capital formation) and population growth (measured as working-age population). Furthermore, the model is expanded to include other control variables. Section 2.1 tells us that the role of government is considered important in PPP investment. Amongst other things, the reason given for the government's involvement is to relax its budget constraint through private financing of the public infrastructure. As such, government revenue reflected as a percentage of the GDP will be used (Checherita, 2009). The role of the private sector will be proxied by credit extension to the private sector, reflected as a percentage of the GDP. This variable will be representative of resources channelled to the private sector (Kodongo & Ojah, 2016). Finally, multilateral institutions, including DFIs, also play a role in PPP investment as they provide financial support through lending, equity contributions and the issuance of financial guarantee products. As financial intermediaries, DFIs also strengthen economic efficiency and growth by assisting in the allocation of capital to the best users (Kodongo & Ojah, 2016). To measure the involvement of DFIs, broad money supply is used as a proxy for DFIs (Kodongo & Ojai, (2016).

Table 3: Summary of Proposed Variable Description

Variable Name	Abbreviation	Unit of Measurement	Definition	Data Source
Dependent variable				
GDPPC	GDPPC	Per cent	GDP per capita based on purchasing power parity (PPP). Data used are in constant 2011 international dollars.	World Bank's World Development Indicators database
PPP Variables				
PPP investment	PPP	US$	Investment on contractual arrangements for public infrastructure projects that have reached financial closure. Private sector assumes operating risks.	World Bank's Private Participation in Infrastructure database
PPP in the Energy Sector	PPP_E	US$	Energy sector includes infrastructure investment in electricity generation, transmission and distribution as well as natural gas transmission and distribution.	World Bank's Private Participation in Infrastructure database
PPP in Water and Sanitation Sector	PPP_WS	US$	Water includes investment in portable water generation and distribution, sewerage collection and treatment.	World Bank's Private Participation in Infrastructure database
PPP in Transport	PPP_TR	US$	Transport includes airport runways and terminals, railways, toll roads, bridges, highways and tunnels, port infrastructure, superstructures, terminals and channels.	World Bank's Private Participation in Infrastructure database
Control Variables				
Gross Capital formation	GCF	Per cent of GDP	This was previously known as gross domestic investment. It includes expenditure on fixed assets of the economy plus net changes in inventory levels. Fixed assets include land improvements, plant machinery and equipment purchases.	World Bank's World Development Indicators database
Population growth	PoP	Per cent	Annual population growth rate. The population includes all residents regardless of legal status or citizenship.	World Bank's World Development Indicators database
Broad money supply	M3	Per cent of GDP	Broad money is currency found outside banks and demand deposits but not central government deposits.	World Bank's World Development Indicators database
Government Revenue	GovRev	Per cent of GDP	Government revenue consists of taxes, social contributions, grants receivable and other revenue.	International Monetary Fund's World Economic Outlook database
Inflation	Infl	Percent, year on year	Annual percentages of average consumer prices, based on year-on-year changes.	International Monetary Fund's World Economic Outlook database
Credit extension to the private sector	CrExt	Per cent of GDP	This refers to credit provided to the private sector such as financial resources provided by financial corporations.	World Bank's World Development Indicators database

Source: The World Bank and IMF, 2018.

4.4 Estimation Technique

By estimating growth models with panel data, various studies have adopted first-differenced GMM. This was first applied by, amongst others, Holtz-Eakin, Newey and Harvey (1988). However, Blundell and Bond (1998) propose a system GMM estimator. Bond et al (2001) go further and compare the first-differenced GMM estimator with a system GMM estimator in a Solow growth framework. They criticise the former estimator on the basis that with the empirical growth model, first-differenced GMM estimator may worsen endogeneity problem associated with growth models. Instead, they endorse a system GMM as a more efficient estimator and one that can be applied to dynamic panel data models. Bond et al (2001) argue that the system GMM estimator is far more plausible than other estimators when it comes to dynamic panel data models. This would lead to making unbiased estimates because it accounts for unobserved country-specific effects and using instrumental variables (IVs) which controls for endogeneity in growth models. They emphasise that even in the presence of measurement error, IVs allows for consistent estimation.

Whilst no accurate guidance is given on what an appropriate safe number of instruments is, Roodman (2009) proposes mechanisms to test for the existence of excess instruments through the Sargan and Hansen tests. In addition, the general rule of thumb is that the number of instruments should not exceed the number of groups (countries) in the model (Labra & Torrecillas, 2018). In the GMM System, Sargan and Hansen are available directly when the xtabond2 command is used. The Sargan test verifies the validity of the instruments used in the model (Roodman, 2009). The null hypothesis of the test is set up as 'over-identification in the model exists'. If the probability is higher than 5%, no evidence is available that would reject the null hypothesis, meaning that the used instruments in the estimations are valid. Thus, there would be no over-identification in the model. Labra and Torrecillas (2018) add that if the probability is close to 1, it does not imply that the instruments are valid, but rather that the asymptotic properties of the test have not been applied. Similarly, the null hypothesis for the Hansen test says that "all restrictions of identification are valid" meaning that over-identification does exist. Rejection of the null hypothesis when the probability value is more than 5%, implies that the used instruments are valid.

In order to identify whether serial correlation exists amongst the errors, the Arellano and Bond (1991) Second Order Autocorrelation (AR2) test is used. As with the Sargan and Hansen, the Arellano and Bond test is available directly when using the xtabond2 command. The null hypothesis is set up as "Autocorrelation exist amongst the error terms". If the probability of the AR2 test is not significant, it means that there is no serial correlation amongst the residuals.

5.0 Results

5.1 Descriptive Statistics

Table 4 below summarises descriptive statistics of variables used in the model. The analysis of the data shows that all variables in the model have outliers. For this reason, the outliers have been winsorized as follows. Total PPP investment, PPP investment in the energy, transport and water and sanitation sectors, broad money supply, credit extension to the private sector, inflation, and population growth have all been winsorized at 10% percentile. GDP per capita, government revenue, and gross capital formation were winsorized at 5% percentile. On average, developing countries sampled for this study spend over US$900 million on PPP investment as shown by the mean of the PPP variable. The minimum and maximum values lie between US$40 million and US$3 092 million. When disaggregated by sectors, expenditure on energy, water and sanitation and transport averaged US$652 million, US$329 million and

US$425 million respectively. This indicates that the energy sector is the most attractive for PPPs in developing economies.

Gross capital formation as a percentage of the GDP averaged 23.1%, whilst population growth, government revenue as a percentage of GDP and inflation, averaged 1.5%, 22.6% and 6%, respectively. The average credit extension to private sector stands at 43% which suggests that a noticeable amount of financial resources is channelled to the private sector. Broad money supply as a percentage of the GDP averaged 55.6%, with the minimum value being 22.3% and the maximum 112.3%.

Table 4: Summary of Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GDPPCg	780	2.9	2.8	-2.7	8.1
PPP	487	909.6	996.1	40.3	3092.3
PPP_E (US$ million)	372	652.5	666.1	37.0	1935.7
PPP_WS (US$ million)	121	329.5	340.5	16.4	991.7
PPP_TR (US$ million)	211	425.1	401.5	23.4	1195.3
GFC (% of GDP)	780	23.1	6.5	14.9	39.1
Population growth rate	780	1.5	0.7	0.2	2.7
GovRev (% of GDP)	763	22.6	7.6	11.2	36.2
Inf	775	6.0	3.6	1.3	12.7
M3 (% of GDP)	755	55.6	28.2	22.3	112.6
CrExt (% of GDP)	768	43.0	28.3	12.3	101.8

Notes: *GDPPCg= GDP per capita growth rate= PPP=PPP investment (US$ million); PPP_E= PPP investment in energy sector (US$ million); PPP_WS=PPP investment in water & sanitation sector (US$ million); PPP_TR= PPP investment in transport sector (US$ million); GFC=Gross capital formation (% of GDP); PoP=Population growth rate; GovRev=Government revenue (% of GDP); Inf=Inflation rate; M3=Broad money supply (% of GDP); CrExt=Credit extension to private sector (% of GDP). Source: Author's calculation.*

Table 5 illustrates the correlation matrix. The larger the absolute value of the coefficient, the stronger the relationship between the variables. A larger value implies that multicollinearity between variables exits which means that the variables in the regression model are highly correlated. As a rule of thumb, it can be taken that anything below 0.7 is generally acceptable. Anything above 0.8 in absolute terms will be regarded as high (Kennedy, 1993). Variables that seem to be highly correlated are PPP investment in general and PPP investment in energy. The estimated coefficient between credit extension to the private sector and broad money supply indicates a high level of association. Hence, the two variables have not been included in the same estimation, but rather reflected in a stepwise manner.

Table 5: Correlation Matrix

Variables	1	2	3	4	5	6	7	8	9	10	11
1 GDPPCg	1										
2 PPP	0.065	1									
3 PPP_E	0.043	0.874**	1								
4 PPP_WS	0.054	0.335**	0.338**	1							
5 PPP_TR	0.167***	0.692***	0.298**	0.237***	1						
6 GFC	0.501***	0.200***	0.136***	0.152	0.369**	1					
7 PoP	-0.195**	0.041	-0.035	0.208***	0.009	-0.708	1				
8 GovRev	-0.042	0.325**	0.289**	0.155	0.092	-0.039	-0.439	1			
9 Inf	-0.119***	-0.123***	-0.091	-0.112	-0.083	-0.230**	-0.042	0.001	1		
10 M3	0.170**	0.293**	0.292**	0.232***	0.225**	0.437**	-0.135***	0.143**	-0.397**	1	
11 CrExt	0.076	0.193**	0.146***	0.273**	0.191**	0.434**	-0.089*	0.184**	-0.413**	**0.860****	1

*Note: GDPPCg = GDP per capita growth rate PPP=PPP investment (US$ million); PPP_E= PPP investment in energy sector (US$ million); PPP_WS=PPP investment in water & sanitation sector (US$ million); PPP_TR= PPP investment in transport sector (US$ million); GFC=Gross capital formation (% of GDP); PoP=Population growth rate; GovRev=Government revenue (% of GDP); Inf=Inflation rate; M3=Broad money supply (% of GDP); CrExt=Credit extension to private sector (% of GDP). Source: Author's calculation; *p>0.1, **p>0.01, ***p>0.05***.*

5.2 Regression Results

Table 6 shows the results of the estimated effects PPP investment has on the economic growth of the selected developing countries (Equation 1). Due to the observed strong collinearity between credit extension to the private sector and broad money supply, two different models are estimated. The results in column (a) include all other independent variables except the credit extension to the private sector while column (b) includes all other independent variables except the broad money supply variable.[6] From Table 6, it is observed that the number of groups is greater than the number of instruments used on all occasions. Furthermore, all models have passed the Sargan, Hansen and AR (2) tests avoiding over-identification of instruments in the model. This indicates that the instruments used are valid when explaining the impact of PPP investment on economic growth.

The positive coefficients of PPP investment in both column (a) and (b) imply that PPPs contribute positively to economic growth at a 10% level of significance. This finding supports the complemental effect of public and private infrastructure investments on economic growth and consistent with the findings of Zangoueinezhad and Azar (2014) and Matsolo (2018).

Gross capital formation, which is a variable that measures investment other than PPPs have been found to be insignificant in explaining economic growth. This result is similar to the findings of Checherita (2009) who investments (other than PPPs) in seven Latin American countries over the period 1990-2001 as insignificant in explaining economic growth. Government revenue and the inflation rate in column (a) and (b) exhibit a negative relationship with economic growth and are statistically significant at 5%. Government revenue which is a proxy for higher tax burdens, suggests that the higher the tax burden, the more difficult it may be for the government to raise taxes further in order to cover bulk expenditure that likely contributes to economic growth such as infrastructure investment (Checherita, 2009). Inflation is as expected, negatively associated with economic growth as it erodes the value of money that could be spent on areas that contribute to GDP growth.

[6] In all models used in this paper, other estimation techniques such as differenced GMM, OLS and Fixed Effects (least square dummy variable) models were also attempted. However, they did not satisfy the standard requirements of credible models.

Contrary to expectations, credit extension to private sector in column (b) shows a negative relationship with economic growth. This is in line with Bayliss (2002), Birdsall and Nellis (2003) and Foster (2004) who argue that the involvement of the private sector in providing public infrastructure does not always demonstrate meaningful and positive effects on overall economic growth as the private sector in most cases is generally just concerned with profits, costs and prices. In this study, other variables that have been found insignificant in explaining economic growth are M3 and population growth.

Table 6: PPP Investment and Economic Growth in Developing Countries

	System GMM	
	(a)	**(b)**
GDPPC L1	0.7895**	0.7510**
Ln_PPP	0.7704*	0.8282*
Ln_GFC	-1.8528	-1.6303
Ln_GovRev	-1.5281***	-1.6103***
PoP	-0.2283	-0.3031
Inf	-0.1275***	-0.1140***
Ln_M3	-0.5926	-
Ln_CrExt	-	-0.5507*
Cons	9.7561***	8.7727***
AR (1): p-value	0.000	0.000
AR (2): p-value	0.572	0.636
Sargan test: p-value	0.89	0.827
Hansen test: p-value	0.872	0.816
No. of instruments	23	23
Countries	39	39
Observations	489	499

Note: Ln= log of variables. PPP=PPP investment (US$ million); PPP_E= PPP investment in energy sector (US$ million); PPP_WS=PPP investment in water & sanitation sector (US$ million); PPP_TR= PPP investment in transport sector (US$ million); GFC=Gross capital formation (% of GDP); PoP=Population growth rate; GovRev=Government revenue (% of GDP); Inf=Inflation rate; M3=Broad money supply (% of GDP); CrExt=Credit extension to private sector (% of GDP). GMM = Generalised Methods of Moments.,. p>0.1, p>0.01**, p>0.05*** Source: Author's calculation;*

4.2.1 Sectoral Effect of PPPs on Economic Growth

Table 7 illustrates the results of the estimated effects by sector of PPP investment on economic growth. Due to data unavailability, 17 countries were dropped, decreasing the number of countries in the panel to 22. Model (a) includes all variables, except the credit extension to the private sector while model (b) includes this variable but excludes the broad money supply variable.

Contrary to expectations, the results show that out of the sampled group of developing countries, none of the selected sectors contributed positively to economic growth. In both model (a) and (b), PPPs in the energy and transportation sectors exhibit a negative relationship with economic growth, whilst PPP investment in water and sanitation is not statistically significant in explaining economic growth. While these findings run contrary to expectations, it is consistent with observations in the Odongo and Ojah (2016) who found the level of infrastructure investments and infrastructure quality to have a negative effect on economic

growth in Africa. A plausible explanation can be deduced from Estache and Garsous (2012a), who highlight the fact that time dimension plays a critical role in carrying out infrastructure investment studies (whether they be PPPs or traditional infrastructure investment). All things being constant, studies that cover long periods of time are more likely to show a positive impact of infrastructure investment on growth and output. The reason for this is that infrastructure generally, has a unique cash flow profile that has high short-term costs and a slow but long-term income flow. Investments in the energy and transport sectors are often built on revenue forecasts with over 30 years of lead time.[7]

Table 7: Sector PPPs and Economic Growth

	Energy Sector (Eq.2)		**Water & Sanitation Sector (Eq. 3)**		**Transport Sector (Eq. 4)**	
	(a)	**(b)**	**(a)**	**(b)**	**(a)**	**(b)**
GDPPC L1	0.2687*	0.2721***	0.4462	0.5513	-0.4863	-0.3162
Ln_PPP_E	-0.9005*	-0.8079*				
Ln_PPP_WS			0.0805	0.0879		
Ln_PPP_TR					-2.5337*	-2.4721*
Ln_GFC	4.3219***	3.6672*	4.8913**	5.2971***	21.1159***	17.059*
Ln_GovRev	0.8875	0.7523	0.5902	1.0209	2.4926	2.1868
PoP	-0.0628	-0.3807	-0.6092	-0.5001	1.2184	0.6282
Inf	-0.1139*	-0.1417	-0.1281***	-0.1331*	-0.0935	-0.1083
Ln_M3	0.2404	-	0.4929	-	-1.8568	-
Ln_CrExt	-	-0.4699	-	-0.7417	-	-1.5484
Constant	-8.3480	-3.2040	-12.7786*	-15.1748*	-47.4606*	-35.5553
AR (1): p-value	0.003	0.003	0.251	0.231	0.058	0.046
AR (2): p-value	0.573	0.549	0.336	0.248	0.58	0.484
Sargan test: p-value	0.281	0.313	0.177	0.317	0.417	0.469
Hansen test: p-value	0.651	0.567	0.503	0.283	0.787	0.851
No. of instruments	21	21	14	14	14	14
Countries	22	22	13	14	22	22
Observations	263	271	93	94	196	199

Note: PPP=PPP investment (US$ million); PPP_E= PPP investment in energy sector (US$ million); PPP_WS=PPP investment in water & sanitation sector (US$ million); PPP_TR= PPP investment in transport sector (US$ million); GFC=Gross capital formation (% of GDP); PoP=Population growth rate; GovRev=Government revenue (% of GDP); Inf=Inflation rate; M3=Broad money supply (% of GDP); CrExt=Credit extension to private sector (% of GDP). , Ln=log of variables,. p>0.1, p>0.01**, p>0.05***. Source: Author's calculation;*

Indeed, the time dimension in this study could well be what had resulted in the inconsistent results in comparison with prior studies that have assessed the impact of PPPs on sector economic growth. Add to that, the results could also have been influenced by poor data availability when PPP investment is allocated to a specific sector. Chechrita (2009) highlights the fact that, because some projects by sector are not included in the PPI database because they are initiated by the local sphere of government and thus are not publicly available, they are likely to be excluded from the database. This results in uneven data availability.

[7] Naturally, the time dimension factor should also hold for aggregate PPP investment. The fact that it does not hold, could be attributed to more observations and data points that could have worked in aggregate PPP investment's favour. With PPP sectors, a few observations were excluded due to data challenges.

6.0 Conclusion and Policy Recommendations

Governments, particularly in developing countries, are continuously faced with the challenge of expanding infrastructure to keep up with population growth and rapid urbanisation. This challenge arises from the fact that public resources are strained as governments face high budget deficits and rising debt to GDP ratios. At the same time, development institutions alone have not succeeded in narrowing this gap. As a result, governments have resorted to sourcing private sector funding in order to expand public infrastructure. This is generally done in a form of PPPs. Whilst the use of PPPs is a growing trend in developing countries, there are, unfortunately, not many empirical studies that have assessed the impact of PPP investment on economic growth on a whole.

In the absence of such studies, this paper attempts to investigate the effects of PPP investment on economic growth in various developing countries. The study carries out this analysis in two ways. First, it analyses total PPP investment in value terms and how that affects economic growth, measured in GDP per capita. Secondly, the paper disaggregates PPP investment by sector, focusing on the three most popular PPP sectors – energy, transport and water & sanitation – and examine which PPP sectors have the strongest influence on economic growth.

The results in this study show that when controlling for the government's tax burden, population growth and private sector involvement, PPP investment positively contributes to economic growth. The finding is consistent with the studies by Zangoueinezhad and Azar (2014) and Shediac, et al (2008) who found that PPP investments are indeed associated with a higher rate of economic growth. When disaggregating PPP investment by sector, the study finds that none of the selected sectors positively contribute to economic growth in the sampled developing countries. As far as sector investment is concerned, PPP investment in the energy and transport sectors were found to contribute negatively to growth while PPP in the water and sanitation sector was found to be insignificant when it comes to explaining economic growth. With regards to the water sector, Shediac et al. (2008) maintain that that projects designed for a higher degree of public good such as water are generally associated with lower returns because it is considered an essential resource that must be provided at affordable prices. The result is that these projects are less attractive for PPP investment. The inconsistent results found in past empirical studies on investment in the energy and transportation sectors could be explained by Estache and Garsous's notion of time dimension which states that when carrying out empirical infrastructure studies, the time period does play an important role when arriving at the results of the study. Studies that cover longer time periods are more likely to find a positive impact of infrastructure on both growth or output.

PPPs are becoming a necessary solution for strengthening infrastructure and generating economic growth in developing countries. As the case is with public investment, understanding the empirical links that exist between infrastructure investment using PPPs and economic growth or output, is becoming essential. However, the only way that studies of such nature will succeed, depends on the availability and credibility of data used to carry out empirical studies. In other words, data needs to be consistently available over a long period of time. How data is reported is also important as it affects the credibility of the model and the results produced by it. When the model and the results are credible, studies such as these could enhance debate in developing countries on how best to use PPP models as propellers for economic growth.

It is, therefore, recommended that those that are at the forefront of researching and providing PPP investment data, ensure that the availability of such data is improved and that the shortcomings of inconsistency in the reporting thereof be corrected to ensure that meaningful

and accurate conclusions could be drawn from it. A major limitation of this study was to obtain adequate PPP investment data. In some cases, data was not recorded resulting in producing an unbalanced panel. Furthermore, the frequency of data was found to be inconsistent, particularly when it came to determining the value of PPP investment. Data also contained large outliers because investment values per country were significantly higher in one year and almost zero in the other. Finally, and as the World Bank had reported, data is provided by public sources such as local or small-scale operators. Therefore, such data may be omitted or may not always be accurate in order to provide the information required by researchers.

The implication thereof is that the results could have been influenced by the challenges facing data collection. However, if the data shortcomings are corrected and the availability thereof is improved, some areas of PPP investment research can in future be expanded. Firstly, the impact on the level of income and growth on development in sample countries could then be analysed. Secondly, the disaggregation of PPP investment by sector could be expanded to the level of subsectors. It would then be possible to analyse which of such subsectors (i.e. electricity, natural gas or renewable energy) are the most productive. Lastly, another area that could be explored is by differentiating PPP investment from the type of project in which investment is made. In other words, analysing the different types of projects. For example, management and lease contracts, greenfield and brownfield projects could be analysed in order to find out which of them had the most impact on economic growth.

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APPENDIX

Table 1: List of Panel Countries and Region

Country	Region
Algeria	Middle East and North Africa
Argentina	Latin America and the Caribbean
Bangladesh	South Asia
Bolivia	Latin America and the Caribbean
Brazil	Latin America and the Caribbean
Bulgaria	Europe and Central Asia
Cambodia	East Asia and Pacific
China	East Asia and Pacific
Colombia	Latin America and the Caribbean
Costa Rica	Latin America and the Caribbean
Dominican Republic	Latin America and the Caribbean
Egypt	Middle East and North Africa
Gabon	Sub-Saharan Africa
Guatemala	Latin America and the Caribbean
Honduras	Latin America and the Caribbean
India	South Asia
Indonesia	East Asia and Pacific
Jordan	Middle East and North Africa
Kenya	Sub-Saharan Africa
Malaysia	East Asia and Pacific
Mexico	Latin America and the Caribbean
Morocco	Middle East and North Africa
Nepal	South Asia
Nigeria	Sub-Saharan Africa
Pakistan	South Asia
Panama	Latin America and the Caribbean
Peru	Latin America and the Caribbean
Philippines	East Asia and Pacific
Romania	Europe and Central Asia
Russian Federation	Europe and Central Asia
South Africa	Sub-Saharan Africa
Sri Lanka	South Asia
Tanzania	Sub-Saharan Africa
Thailand	East Asia and Pacific
Turkey	Europe and Central Asia
Tunisia	Middle East and North Africa
Uganda	Sub-Saharan Africa
Ukraine	Europe and Central Asia
Vietnam	East Asia and Pacific

Source: PPI Database, 2018