

Private and Public Investment Linkages: Some Evidence Using Sectoral Level Data

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Abstract

This study empirically investigates the relationship between public and private investment in Pakistan at the aggregate and sectoral level, including the sectors of Agriculture, Manufacturing, Finance, Construction, Transport & Communication and Mining & Quarrying. For this purpose, annual time series data is utilized from 1971 to 2019 except for the Agriculture sector covering the period of 1981-2019 as data for previous years is not available from any published sources. Multivariate co-integration approach and ECM are employed to empirically analyze the existence of long-run and short-run association among public and private investment. The results indicate a long run complementary type relationship of public investment with private investment at both the aggregate and sectoral level except for the Finance sector. The short-run analysis supports this long-run positive association at an aggregate level and four sectors, excluding Transport & Communication and Agriculture sector where the results were insignificant. Our results and generally declining share of public investment highlight that the government is playing its role as an “enabler” (or facilitator) of private investment in terms of association between public and private investment.

Keywords: Public Investment and Private Investment; Crowding in; Crowding out.

JEL Classification: C50, E22, E62

1. Introduction

According to economic theory, investment is a factor of production, so it can increase production and, depending on whether marginal returns are decreasing or not it can affect the level or rate of growth of output (Fournier, 2016). In general, the higher the investment rate, the higher the production level (Solow, 1956). In the Solow model, investment does not imply a permanent growth effect due to diminishing returns. Besides the effect on the level of economic activity (GDP), a key conclusion in the endogenous growth literature with a constant or increasing

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rate of return to scale is that the accumulation of physical and human capital plays a vital role in long-term growth. (Lucas Jr, 1988; Romer, 1990).

As mentioned by one of the pioneer studies on public investment (P), Aschauer (1989), the effect of public investment on growth is most likely positive and depends on the extent to which private investment is crowded in or crowded out. If public investment complements the private capital (e.g. through roads connecting enterprises, reducing the cost of transportation, facilitating the flow of goods and services), increased public investment can stimulate private investment (Aschauer, 1989; Blejer & Khan, 1984; Munnell, 1992; Ramirez, 1994). This relates to situations where the private rate of return is lower than the social rate of return, for example as Arrow (1962) examined it in the case of knowledge production, considered to be a public good in general and that can benefit all.

Likewise, another study by Romer (1986) shows that state intervention can lead to welfare benefits with positive externalities. In other words, the rate of return on investment expected by the private sector reflects only the private rate of return, so without government intervention, the investment ratio will be lower than the social optimum: indicating a role for public investment. On the other hand, if private and public capital are substitutes, increasing public capital may reduce private investment (Al-Majali, 2018; Bahal, Raissi, & Tulin, 2018; Mahmoudzadeh, Sadeghi, & Sadeghi, 2017; Morrissey & Udomkerdmongkol, 2012; Phetsavong & Ichihashi, 2012). The crowding-out may be partial, therefore overall investment still increases. If one unit of public investment replaces the one unit of private investment, total investment remains unchanged. This can occur when public investment is focused on certain functions that do not increase the return on private investment (for example, investments in public companies in sectors with no externalities). In this scenario of crowding out, growth effects can even be negative if public investment is less effective than private investment.

There are four types of public investment: infrastructure, human capital, R & D investment, and business investment. The gross fixed capital formation consists of physical assets, intangible assets such as software, and tangible fixed assets including military spending to support civilians such as hospitals. On the other hand, "purchasing military weapons and their support systems" is not part of gross fixed capital formation. In the literature, a number of channels linking public investment spending to private investment have been identified [e.g., (Aschauer, 1989; Blejer & Khan, 1984; Buiter, 1977; Erenburg & Wohar, 1995; Ramirez, 1994) Barth and Cord, 1980; Primarily, as already mentioned public investment can lead to more output which in turn generates more physical and financial resources

in the economy. Additionally, public spending on infrastructure such as roads, railroads, highways, sewage, education, and power plants, and water systems often lowers private-sector costs. Such type of infrastructure investment by the public sector complements private investment and improves private capital productivity. However, in some cases, the impact of public investment on private investment can be negative. For example, if the public and private sectors compete for the same resources of the economy, the availability of credit to the private sector is diminished while the cost of financing private investment increases. It can crowd out the investment in the private sector. Subsidized state-owned economic enterprises are often financed through the printing press, external debts and deficit spending (Erden & Holcombe, 2006). In a situation of high budget deficit, the financing of public investment will lead to less credit availability and/or higher interest rates which in turn can crowd out the private sector from profitable investment opportunities. Further, public investment can replace private investment when both produce those goods and services that compete directly in the market, specifically a case when government subsidizes such public production. As mentioned, different offsetting and competing roles are played by public investment in terms of its impact on investment in the private sector therefore, the net impact of public investment on private investment in general and at the sectoral level is an empirical question.

Government can finance its expenditures through different ways from domestic sources like financing through issuing government bonds, tax collection, and printing of new money (Bell, 2000). Government investment expenditures financed through open market operations can diminish the loanable funds reserves available to the private sector for investment purposes (Diamond, 1965; Emran & Farazi, 2009; Hyder & Qayyum, 2001; Looney, 1995; Mitra, 2006; Shafik, 1992). If public expenditures are financed by taxes, then higher taxes drop the after-tax returns to PRI. Moreover, it will reduce disposable income and consumption, which in turn adversely affects investment by the private sector. As already mentioned, PI expenditures may adversely affect PRI by decreasing the availability of saving for PRI. Thus, this mode of financing may also crowd out the PRI from the home capital market (David & Scadding, 1974; Seater, 1993).

In general, the available empirical evidence also shows mixed results as some studies show crowding in while others indicate crowding out of private

investment⁴. In the case of Pakistan, a number of researchers analyze the effect of PI on PRI, e.g., Hussain, Muhammad, Akram, and Lal (2009), Saeed, Hyder, Ali, and Ahmad (2006), Rashid (2006), Naqvi (2002), Hyder and Qayyum (2001), Looney (1995) reported a crowding-in effect of public capital formation. However, Saghir and Khan (2012), Hyder and Qayyum (2001), Haque and Montiel (1993) found the crowding-out effect in the case of Pakistan.

When we look at the previous international studies, we observe that most of them have focused on the linkages of public and private investment at the aggregate level. See, for example, Canh and Phong (2018), Dreger and Reimers (2015), Foye (2014), Gjini and Kukeli (2012), Furceri and Sousa (2011), Hatano (2010), Erden and Holcombe (2006), Mitra (2006), Naqvi (2002), Voss (2002), Laopodis (2001), Erenburg (1993), Serven (1996), Bajo-Rubio and Sosvilla-Rivero (1993), and Haque and Montiel (1993). Similarly, most of the studies in Pakistan such as Fatima (2012), Saghir and Khan (2012), Hussain et al. (2009), Rashid (2006), Naqvi (2002), and Hyder and Qayyum (2001) have also worked on the aggregate level. Yet a few studies such as Ahmad and Qayyum (2008), Saeed *et al.* (2006) and Looney (1995) have used sector level data but they analyzed only one or two sectors. Therefore, there is still a gap in the literature which required to be filled by conducting a detailed research on the linkages of public and private investment at disaggregates level in Pakistan because the effect can differ across different sectors depending upon the positive/negative externalities generated by public investment in that sector. Moreover, the sectoral level analysis will be more informative and will provide more clear insight to the policy maker as focus of public sector should be on the sectors with positive externalities indicating complementary type relationship between public and private investment. Therefore, this study comprising analysis on both aggregate as well as sectoral level will be more informative.

This study mainly tries to analyze the impact of public investment on private investment at an aggregate level and at the sectoral level in the case of Pakistan because the relationship may vary across sectors depending upon the extent and nature of externalities, size of public investment, and the difference between private and social rate of return due to government intervention. Further, we will examine

⁴For examples the studies showing crowding in are Rashid (2006), Serven (1996), Erenburg (1993), Aschauer (1989), and Blejer and Khan (1984). Similarly, those studies that show crowding out are Gjini and Kukeli (2012), Cavallo and Daude (2011), Furceri and Sousa (2011) and Voss (2002).

whether there are differences in this relationship over the short and long run at the aggregate and sectoral levels.

Six sectors are considered in this study depending upon the availability of annual data. The aggregate and sectoral level data on public and private gross fixed capital formation is taken from *Pakistan Economic Survey* (2019-20 and earlier issues). The included six sectors are: Agriculture, Manufacturing, Finance, Construction, Transport & Communication and Mining & Quarrying. The period considered in the study is from 1971-2019 except for the Agriculture sector covering the period of 1981-2019 as data for previous years is not available from any published sources. On average these six sectors cover 75 percent of total private investment and 60 percent of aggregate public investment over the spanned period.⁵ Considering the preliminary findings of stationarity, Johansen test of cointegration, etc., the techniques of VECM is utilized for overall and sectoral analysis.

The rest of the paper is structured into five sections. Section 2 presents the review of literature and section 3 explains the estimation methodology, data, variable definitions and data sources. Section 4 reports empirical results and discussions. Section 5 briefly presents conclusions and some policy implications.

2. Literature Review

On the theoretical side, a number of models exist on investment behavior that relate to developing countries. Due to certain restrictions, the traditional models no longer apply to developing countries. The conventional accelerator model may be best suited for investment behavior in developed countries, but the existence of liquidity constraints and lack of perfect capital markets make it is less applicable to developing countries. Gjini and Kukeli (2012) highlighted the theoretical linkages between public and private investment and important theories of investment. These theories are Expected Profit Theory, Marginal Efficiency Theory, Accelerator Theory, Neo-classical Theory, Ricardian Equivalence Theory and Neoliberal Approach.

According to marginal efficiency theory, investment should be undertaken when the marginal efficiency of additional investment is greater than the cost of financing. If the cost of financing is higher than its marginal efficiency (i.e., interest rates are higher than the return on investment) then it would be more profitable to lend the available funds at the prevailing interest rate, rather than investing for productive purposes. Thus, the relationship between public and private investment can be established under the marginal efficiency theory of investment. Specifically,

⁵ Further details about data are given in data and variable section.

public investment affects private investment through the interest rate channel. In particular, increases in government investment may lead to a decrease in the available funds, as a result, this channel pushes interest rates up. Thus, private investment decreases.

The Acceleration principle proposed by Clark (1917) states that the “desired level of capital stock is proportional to output”. Thus, investment is proportional to the output growth in all the periods. Government and private investment increase as stock of capital increases which enhances further growth via the accelerator effect.

The flexible accelerator model was developed by Koyck (1954). This model shows the relationship between investment and output, “the greater the gap between desired capital stock and existing capital stock, the higher would be the rate of investment”. The hypothesis of this model is based on investors plan to minimize the gap between actual capital stock and desired capital stock. Two channels are developed in this context. The first channel is capital accumulation, where, the output of the economy increase due to an increase in government investment. This channel leads to an increase in private investment. The second channel refers to the cost of capital when the government investment increases it leads to an increase in the cost of borrowing for private investors. As a result, private investment and capital stock will decrease.

Jorgenson (1971) developed the Neo-Classical theory and it is a modified version of the flexible accelerator model. According to this approach, the desired capital stock is proportionate to the output and cost of capital which in turn depends on the interest rate, tax structure, and price of capital goods. The key element of the investment model is the interest rate so it adversely affects private investment. Neo-Classicals believe that an increase in public investment decreases the amount of funds available for private investors because competition will lead to an increase in the interest rate and decrease in private investment. Thus, government financing pushes the interest rate up and private investment decreases.

First time Keynes (1936) considered investment as an independent variable. Keynes's theory of investment has two aspects. First, if the expected future profit rate is larger than a great chance of investment because investment is feasible. The second aspect is linked with a higher rate of interest which is associated with the relationship of public and private investment. Interest rate rises due to an increase in public investment, which means that the cost of borrowing is high for private investors hence adversely affects private investment. However, Keynesians claim that the positive effect of an increase in public investment is greater due to

multiplier effects than the negative effect in terms of reduction in private investment. Given this, the output of an economy increases with an increase in public investment. The two opinions have been made about crowding out, such as the full crowding out and partial crowding out. The full crowding out occurs only in exceptional cases when the negative effects of reduced private investment cancel out the positive effect of increases in public investment and thus, the output of the economy remains the same.

Ricardian Equivalence theory was developed in the 19th century by David Ricardo. The main idea behind this theory is, when a government tries to boost the demand by increasing government expenditures through debt financing, the demand remains the same because the people are willing to save their excessive money to pay the increase in future taxes to pay off the debt. Ricardian equivalence theory is contradictory to Keynes's theory of investment. The major criticism of Ricardian equivalence is on its unrealistic assumptions⁶. Ricardo gives justification for the crowding-out effect. As stated by him, government expenditures need to be financed, at present or in the future through taxes. In the future the taxes will be high that will lead to a decrease in disposable income. Thus, with the decrease of disposable income people will have less money to invest. This will adversely affect private investment (Xu & Yan, 2014).

The latest approach which describes the importance of financial expansion and the rate of interest in the progress of economic development is called the Neoliberal approach. The advocates of this approach McKinnon and Shaw (1973) reported that the real interest rate and investment might have a positive relationship because a higher real interest leads to increase savings. When saving is high the availability of funds for private investment is high. This is known as MacKinnon and Shaw's hypothesis. This hypothesis is established on the assumption of limitations in the volume of financial resources instead of the cost of financing. In the context of developing countries, public investment plays an important role in economic growth.

The neoliberal approach has established a positive relationship between the real rate of interest and investment, on the other hand, this is contradictory with the Neo-classical framework. A higher real rate of interest may decrease the investment but implicit (realized) investment may increase due to an increase in the availability of funds. This phenomenon is known as the "Conduit effect".

⁶ "The assumption of (a) Existence of perfect capital markets. (b) The individual has ability to borrow and save at any time. (c) The individual is willing to save for increase in unseen future taxes."

In sum, the Marginal theory of investment and Neo-classical theory established the negative relationship between public investment and private investment. The availability of funds is limited. The competition for attaining funds increases interest rate and as a result, private investment falls. Moreover, the Flexible accelerator theory and Keynes theory also suggest a negative relationship between public and private investment due to the cost of borrowings. However, the Accelerator and Flexible accelerator theory suggested a positive relationship between public and private investment due to the accumulation of capital stock. The neoliberal approach is contradictory with the Neo-classical theory of investment because the Neoliberal approach explained the positive relationship between an increase in interest rate and investment through saving channel. But the Neo-classical approach supports the crowding-out effect.

There is a huge amount of empirical literature that has analyzed the influence of PI on PRI like Canh and Phong (2018), Dreger and Reimers (2015), Foye (2014), Gjini and Kukeli (2012), Erden and Holcombe (2006), Naqvi (2002), Hyder and Qayyum (2001), and Ghura and Goodwin (2000) have investigated the determinants of investment in cross-national data taken from Asia, Sub-Saharan Africa, and Latin America. In the sample of 31 developing countries by considering, PRI is motivated by raises in PI, improvements in financial intermediation, a decrease in credit for the public sector and interest rate. Moreover, Naqvi (2002) and Hyder and Qayyum (2001) have analyzed the linkage between the PI and PRI of Pakistan at the aggregate level. The capital formation of the public sector has shown a significant positive impact on PRI. Hyder and Qayyum (2001) have tested the crowding-out hypothesis through the error correction model (ECM). The results confirmed the positive relation between PI and PRI. Rashid (2006) examined the association among PI and PRI in Pakistan at the aggregate level by using the Johansen cointegration approach, impulse response functions and variance decompositions. The empirical results suggested the complementary or positive relationship based on the ECM.

Further, Canh and Phong (2018) have investigated the influence of PI on PRI and economic growth for 18 developing countries from a period of (1995-2015). In this study, they concluded that PI has a direct effect on PRI in the long run. Moreover, Foye (2014), and Dreger and Reimers (2015) both have also supported the crowding-in effect of PI on PRI.

Gjini and Kukeli (2012) investigated the PI and PRI linkages for 11 Eastern Economies, comprising of six developing and five developed economies. The analysis confirmed direct linkages between PI and PRI. The marginal outcome of

PI on PRI remained positive and started to decrease when the economy moved from developing to the more developed economy. The inadequate financial resources for PRI have appeared more relevant to developing countries. Increasing the availability of credit has a direct effect on PRI (Aschauer, 1989; Cavallo & Daude, 2011; Erden & Holcombe, 2005; Ghura & Goodwin, 2000; Ramirez, 1994; Wai & Wong, 1982).

Furceri and Sousa (2011) analyzed 145 countries and their findings suggested that government spending inversely affected both PRI and private consumption. The government spending effects on consumption and investment have seemed to rely on different factors like democracy, corruption, political stability, income and interest rate. Cavallo and Daude (2011) have investigated the association between PI and PRI covering the data of 116 developing countries. Their findings have shown that on average PI crowded out the PRI. Saghir and Khan (2012) have conducted a study on Pakistan's economy. They concluded that government investment negatively affected PRI. The effect of PI on PRI at the aggregate level as well as disaggregate level is examined by Pereira (2001) and Saeed *et al.* (2006). Specifically, Pereira (2001) estimated the VAR model with the variables like private gross domestic product, PRI, PI and private employment for US economy and PI and PRI were further disaggregated into highways, education, electric and gas facilities, sewage, water supply, hospital building and development structure. On average level, he found that PI had crowded in effect on PRI. At disaggregate level the crowding in effect was strong on industrial equipment and transportation equipment.

Kollamparambil and Nicolaou (2011) analyzed the South African economy. They found that the association among PI & PRI and GDP. They observed the direct effect of PI on GDP. However, they found the indirect effect of PI on PRI. Hence, PI decreased mainly in the transport, equipment, and machinery sectors. In contrast, PI increased in construction. Fujii, Hiraga, and Kozuka (2013) examined the effect of PI on PRI at the sector level and found that the effects on sectoral capital investments varied from industry to industry because of different policy implications. Some sectors have shown a negative effect of PI on PRI due to misallocation of resources but on the whole, crowding in effect dominated.

All of the above literature shows inconclusive results about the nature of association between PI and PRI at both theoretical level and empirical level (at national as well as international level). However, it would be interesting to analyze the nature of this relationship at the sectoral level in Pakistan to investigate similarities/dissimilarities in this association.

3. Methodology and Data

Pesaran and Smith (1998) suggested the Vector Error Correction Model (VECM) to explore the association between PI and PRI.

$$\Delta y_t = \sum_{i=1}^{p-1} \Gamma_{iy} \Delta z_{t-i} + \Pi_y \Delta z_{t-1} + \lambda_y \Psi_t + \alpha_{1y} t + \alpha_{0y} + \xi_t \quad (1)$$

$$t = 1, 2, 3, \dots T$$

$$\Delta x_t = a_{0x} \sum_{i=1}^{p-1} \Gamma_{ix} \Delta x_{t-i} + \zeta_t \quad (2)$$

y_t = vector (2×1) of endogenous variable at I (1) including fixed PI and fixed PRI.

x_t = vector of (2×1) exogenous variable at I (1) including real interest rate, GDP and percentage of debt to GDP.

$$z_t = (y', x')$$

Ψ_t = vector of exogenous variable at I (0) which are not included in the intercept.

t = time trend

Δ = difference operator

α_{0y} = represent intercept

ξ_t and ζ_t = disturbance terms

This model assumes that a response from Δy_t to Δx_t , but no response in level form. Therefore, Δx_t is given in equation (2). Two variables are taken as endogenous for example, fixed PI and PRI variables and these three are considered as exogenous including interest rate, output, percentage share of debt to GDP.

3.1. Data, Variable Definition and Data Sources:

To estimate the impact of PI on PRI at a sectoral level, this study uses the 49 years annual data from 1971 to 2019 for six sectors because the data for this period is available for only six sectors. Data on fixed PI, fixed PRI at current prices and Gross Domestic Product (GDP) were collected from various issues of the Economic Survey of Pakistan, and data on the interest rate was collected from International Financial Statistics (IFS).

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Table 3.1: Variables Description

Variable	Description
GDP	GDP is used as a control variable which shows the market value of all finished goods and services which are produced in a country within the year. We obtained the nominal GDP of Pakistan from the <i>Economic Survey of Pakistan</i> . It is measured in Millions of Rupees.
Interest rate	The percentage call money rate is used as another control variable in the estimation process. It is taken from <i>International Financial Statics</i> .
Fixed PI	The gross fixed public capital formation at current market prices is used as an endogenous variable in our estimation process at both aggregate as well as at sectoral level. It is measured in Millions of Rupees. This information is obtained from various issues of <i>Economic Survey of Pakistan</i> ,
Fixed PRI	The gross fixed private capital formation at current market prices is used as an endogenous variable in our estimation process at both aggregate and sectoral level. It is measured in Millions of Rupees. Data is gathered from various issues of the <i>Economic Survey of Pakistan</i> .
Debt-to-GDP	The percentage share of total debt (including both internal and external debt) to GDP is used as another control variable in the analysis. Data is gathered from various issues of the <i>Economic Survey of Pakistan</i>

The following figures indicate the changing behavior of percentage share of public and private investment relative to total investment of Pakistan at an aggregate level and the similar percentage shares of public and private investment relative to the relevant total sectoral investment in each of the six sectors over the sampled time period⁷. Figure 3.1 shows that as compared to the 1970s, where the share of public investment shows an increasing trend, for the rest of the period it shows a decreasing trend in general with little fluctuations. Reverse is the case with a share of private investment. The aggregate private investment varies between the minimum value of 36.3% in 1976 to the maximum of 93% in 2010 and likewise, public investment from 7% in 2010 to 63.7%. At present, the share of private investment is 91.7% and that of public investment is 8.3%, while at the start of the sampled period (1971) these shares were 57.9 and 42.1 percent, respectively. So, in general, private investment shows a general increasing trend after 1976 and public investment a decreasing one.

⁷ The figures showing public and private investment in logarithmic format aggregate and sectoral level are given in the Appendix.

Figure 3.1: The Share of Public and Private investment at Aggregate Level

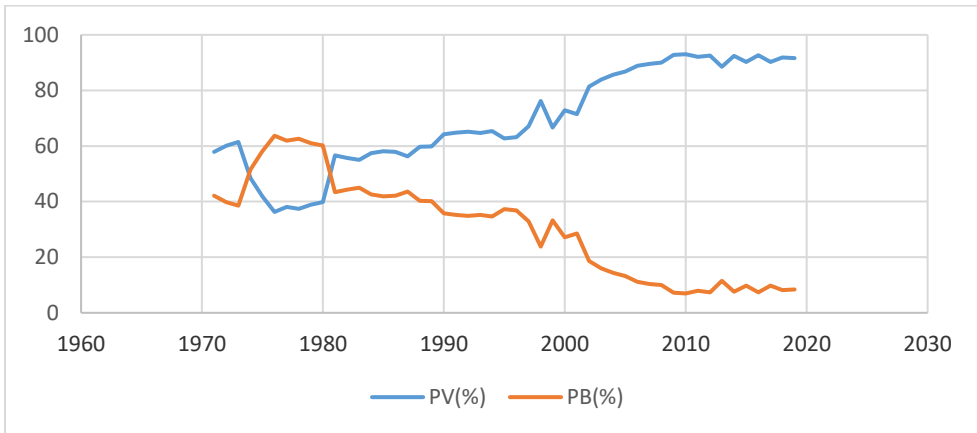


Figure 3.2: The Share of Public and Private Investment in Mining and Quarrying

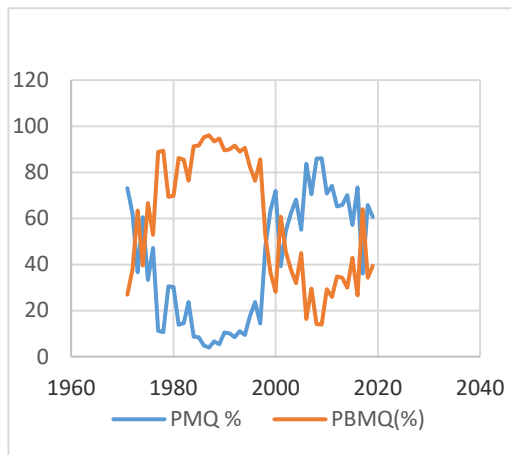
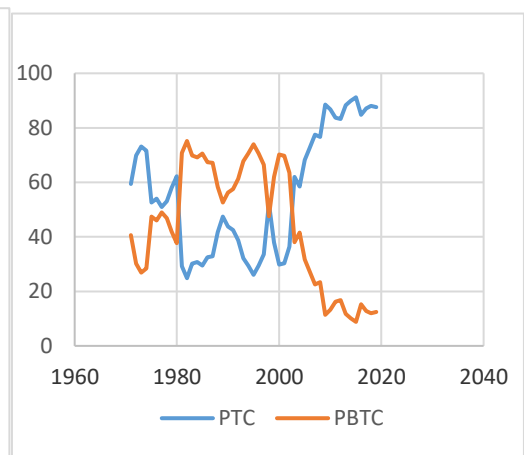


Figure 3.3: The Share of Public and Private Investment in Transport and Communication



In the case of Mining and Quarrying the share of public investment shows varying but generally rising trend till 1987 (with the maximum value of 96.1%) then generally falling till 2000 and then a huge increase to 60.7 % in 2001. Later on, it decreased again till 2009 (reaching the least value of 13.9%) and then increasing again and depicting huge variations in the last four years. The behavior of private investment is reverse of it in terms of growth and fall. In 2019 the share of public investment is approximately 61% and that of private investment is approximately 39% of total investment in this sector. Similarly, PI and PBI in the sector of Transport and Communication show cyclical type of relationship till 2003

with starting shares of 59.45 and 40.6 percent of private and public investment, respectively. After 2003 private investment in general shows an increasing trend with little variations reaching the share of 86.6 % and public investment a reverse trend reaching the share of 12.4%. So, at present share of private investment is far higher than public investment.

The share of PI and PBI in the Construction sector indicates huge variations over the sampled period. In 1971 the share of the private sector was just 0.39 percent only compared to 99.61 percent of public investment. The share of PBI reached the minimum of 16.4 percent in 2001 then rising to 52.9 % till 2013 and then falling to 7% in 2019. As Figure 3.4 shows, the share of private investment after 1992 increased the share of public investment and remained higher than it except in 2013.

In the Agriculture sector (Figure 3.5) share of public investment varied between a minimum of 0.013 and a maximum of 32.18 percent in 1996. In general, throughout the spanned period share of private investment remained much higher than public investment.

Figure 3.4: The share of Public and Private Investment in Construction

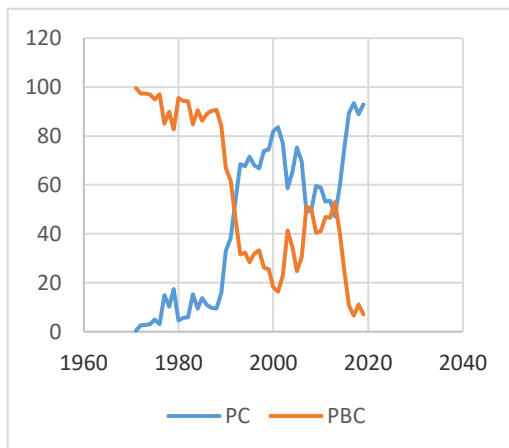
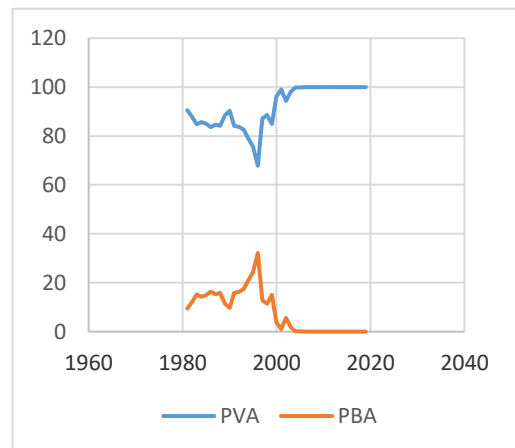


Figure 3.5: The share of Public and Private Investment in Agriculture



In both the sectors of Manufacturing and Finance, in general, the share of private investment remained much higher than the share of public investment except for 1976-81 where the share of public investment was more than private investment in case of Manufacturing and 2000-03 where public investment in the Finance sector was more than 10%.

Figure 3.6: The share of Public and Private investment in Manufacturing

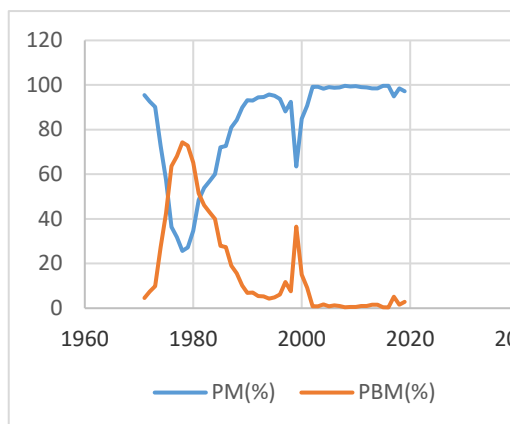
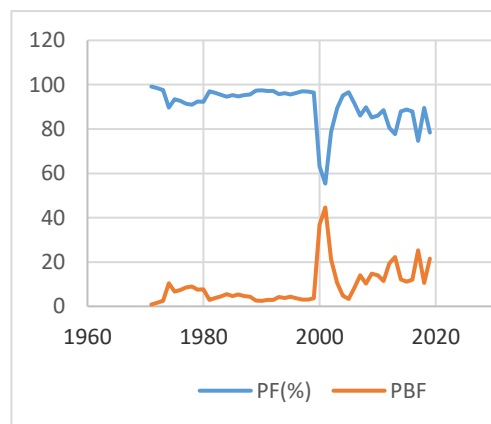


Figure 3.7: The share of Public and Private investment in Finance



4. Preliminary Findings, Results and Discussion

The descriptive statistics including mean, standard deviation, minimum and maximum value of each variable are given in Table 4.1.

Table 4.1: Descriptive Statistics

Variables	Number of Observation	Mean	Standard Deviation	Min	Max
Interest rate (%)	49	8.601	2.377	2.140	12.470
Log Output	49	14.374	1.981	10.829	17.452
Debt to GDP (%)	49	71.591	2.474	51.970	101.73
Log of Overall Public Investment	49	10.910	1.353	7.755	12.759
Sector-wise Public Investment (Log)					
Transport and Communication	49	9.433	1.747	5.568	11.356
Mining and Quarrying	49	7.742	2.376	1.945	11.043
Manufacturing	49	8.019	1.228	4.219	10.448
Finance	49	6.811	1.801	1.609	9.737
Construction	49	8.203	0.848	6.331	9.899
Agriculture	39	6.458	1.693	3.784	9.160
Log of Overall Private investment	49	11.918	2.234	8.169	15.149
Sector-wise Private investment (Log)					
Transport and Communication	49	9.768	2.256	6.249	13.201
Mining and Quarrying	49	7.181	3.046	2.890	11.415
Manufacturing	49	10.556	2.063	6.926	13.196
Finance	49	9.409	1.398	6.234	11.016
Construction	49	7.656	2.519	1.386	11.319
Agriculture	39	11.128	1.800	8.494	13.953

For all sectors except the Agriculture sector, data span from 1971 to 2019. However, in the case of the Agriculture sector, the data utilized starts in 1981 due to the non-availability of prior data from published sources. Therefore, we have only 39 observations available for the Agriculture sector. The mean value of the interest rate is 8.601% which shows the high cost of borrowing for investment. Further, the maximum value of the interest rate is also very high. Further, the average value of debt to GDP is 71.6% due to the high volume of both domestic and foreign debt. Among control variables, the highest dispersion was observed for the debt to GDP.

Further, when we compared public investment and private investment in different sectors, the highest mean value of public investment is realized for the sector of Transport and Communication and the lowest is observed for the sector of Agriculture, while the average value of private investment is the highest in case of Agriculture sector and the lowest in Mining and Quarrying sector. Regarding standard deviation, the highest dispersion in public investment is apparent in Mining and Quarrying and lowest in Construction. However, in the case of private investment highest variability is observed in Mining and Quarrying and the lowest in the Finance sector.

The Augmented Dicky Fuller (ADF) test results for testing the stationarity of variables included in the study are reported in table 4.2. where “i” indicates intercept and “i+t”, indicates intercept and trend. Unit root analysis shows that at a level all variables are non-stationary but at first difference the concerned variables become stationary.

Table 4.2: Unit Root Test

Variable	Symbol	Level		1 st Difference	
		ADF(i)	ADF(i+t)	ADF(i)	ADF(i+t)
Interest rate	<i>I</i>	-2.624	-3.374	-5.669***	-5.598***
Output	Lgdp	-2.474	-1.646	-5.673***	-6.559***
Debt to GDP	Dtgdp	-2.446	-2.444	-8.536***	-8.609***
Public investment Overall	Lpb	-2.167	-2.460	-7.338***	-7.788***
Sector-Wise Public Investment					
Transport and communication	Lpbtc	-1.874	-1.754	-7.461***	-7.831***
Mining and quarrying	Lpbmq	-2.664	-2.487	-10.429***	-10.858***
Manufacturing	Lpbm	-2.058	-2.185	-3.336**	-3.376**
Finance	Lpbf	-0.824	-2.664	-4.931***	-5.223***
Construction	Lpbc	-2.443	-2.518	-7.172***	-7.152***
Agriculture	Lpba	-1.288	-1.81	-7.126***	-7.018***
Private investment Overall	Lpv	-1.206	-1.174	-7.179***	-7.425***
Sector-wise Private investment					
Transport and communication	Lptc	-0.419	-2.929	-5.235***	-5.177***
Mining and quarrying	Lpmq	-0.889	-1.295	-8.033***	-8.028***
Manufacturing	Lpm	-2.336	-0.820	-5.989***	-7.666**
Finance	Lpbf	-2.019	-2.861	-5.990***	-6.163***
Construction	Lpc	-2.443	-3.248	-9.594***	-9.575***
Agriculture	Lpa	-0.023	-1.818	-5.473***	-5.418***

As all the variables used in this study are integrated of the same order I (1) so indicate the possibility of cointegration capturing the long-run relationship. These results are consistent with the studies of Oriavwote and Oyovwi (2014); Saeed 2006; Bose and Haque (2005); Kustepeli (2005), Monadjemi and Huh (1998), Rossiter (2002).

The optimal lag length for estimation of the VAR model which is a prerequisite for applying Johansen Cointegration is presented in Table 4.3. The VAR model is estimated for 1 to 4 lags for annual data. We used the Schwartz criteria for optimal lag selection. In general, Schwartz criteria supports the optimal lag length of 1 for cointegration models except for the sector of Agriculture with an optimal lag length of 2.

Table 4.3: Lag Selection through Schwartz Criteria

Sectors	Lags	0	1	2	3	4
Aggregate level	SC	-0.804	-1.903*	-1.732	-1.520	-1.425
Transport and Communication	SC	2.447	0.966*	0.982	1.229	1.338
Mining and Quarrying	SC	4.953	3.775*	3.987	4.285	4.432
Manufacturing	SC	3.176	1.670*	2.001	2.208	2.505
Finance	SC	3.122	2.356*	2.526	2.643	2.877
Construction	SC	3.492	2.341*	2.669	2.852	2.712
Agriculture	SC	2.138	1.482	1.251*	1.332	1.551

Johansen co-integration test results showing the existence of long-run association among variables are given in table 4.4. Mostly the Trace statistics and Maximum Eigen statistics show the same results but in some cases, these results differ. However, Trace statistics is preferred because it produces more accurate results as compared to Maximum Eigen statistics. (Asari *et al.*, 2011; Rashid, 2006). In our analysis, we are using one cointegration vector despite two co-integrating vectors, because the highest Eigenvalue is associated with the first Cointegration equation and it also relates to the stationarity of the variables. (Oriavwote & Oyovwi, 2014; Rashid, 2009).

Table 4.4: Johansen Co-integration Test Results

	Trace Statistics (Co-integrating Vectors)	Max-Eigenvalue (Co-integrating Vectors)
Aggregate Level	2	2
Transport and Communication	2	No
Mining and Quarrying	1	1
Manufacturing Sector	2	2
Finance Sector	1	2
Construction	1	1
Agriculture	1	1

In table 4.5 normalized cointegration coefficients representing the long-run relationship between public and private investment are reported. These results indicate a long run complementary type association among public and private investments at the aggregate level and in almost all the sectors except the sectors of Finance. This result is consistent with literature such as Gjini and Kukeli (2012), Ang (2009), Hatano (2010), Erden and Holcombe (2006), Rashid (2006), Mitra (2006), Naqvi (2002), Hassan, Othman, and Karim (2011), Pereira (2001), Mitnik and Neumann (2001), Monadjemi and Huh (1998), and Erenburg (1993). Our results in general support the accelerator theory of investment which indicates that the increase in growth because of public investment further attracts investors to invest by enhancing their confidence in the economy and thus, private investment increases.

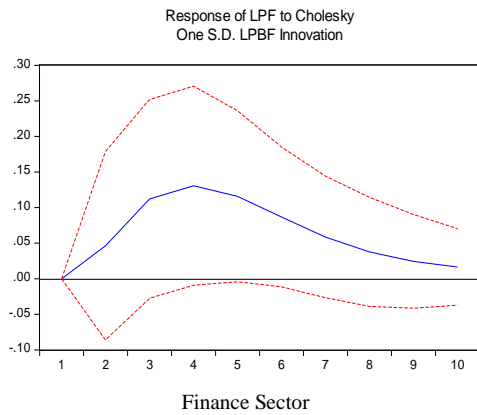
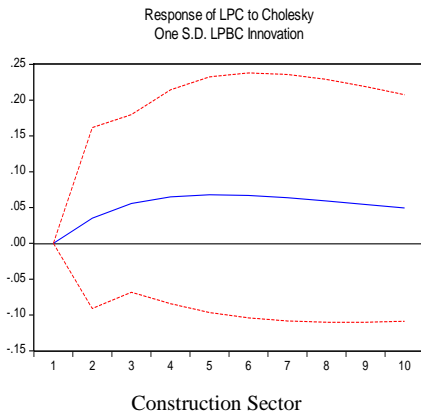
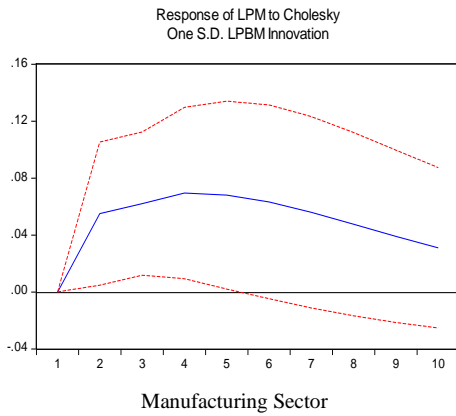
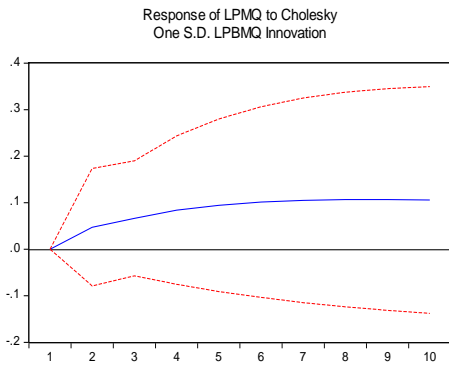
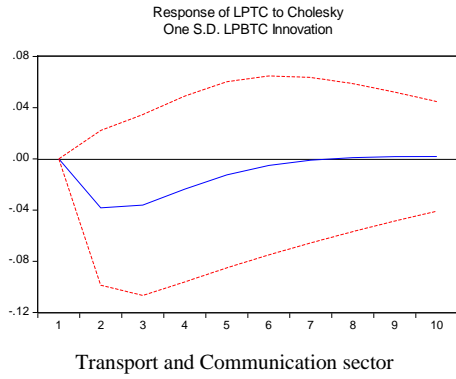
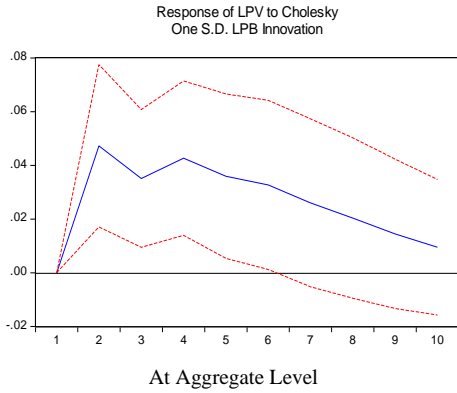
Table 4.5: Normalized Cointegration Coefficient

Sectors	PI	PRI	Log-Likelihood
Aggregate Level	1.000	2.636* (0.570)	61.178
Transport and Communication	1.000	0.305* (0.131)	0.884
Mining and Quarrying	1.000	3.832* (0.890)	-53.576
Manufacturing Sector	1.000	0.917* (0.196)	-22.134
Finance Sector	1.000	-3.030* (0.563)	-39.702
Construction	1.000	0.984* (0.332)	-14.472
Agriculture	1.000	1.643* (0.032)	-1.484

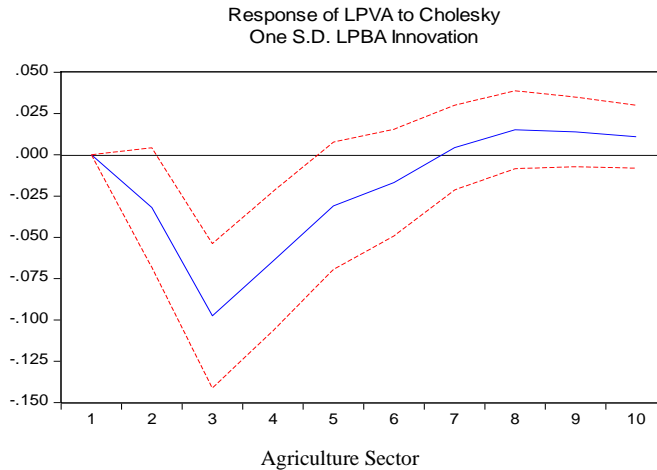
For the short-run effect, Figure 4.1 presents the results of the impulse response function, showing the effect of one standard deviation shock in public investment at the aggregate and sectoral level on relevant private investment at the aggregate and sectoral level.

At the aggregate level, one standard deviation shock to public investment shows that the entire confidence interval is above zero and in the short-run fluctuating pattern exists but in the medium to long run decreasing pattern is observed. The overall relationship is still positive and significant because the confidence interval does not intersect the zero line. This means it supports the crowding-in effect. At the sectoral level, all the sectors show crowding in effect except the sector of Transport and Communication and the Agriculture sector where the confidence interval in both sectors intersect the zero line that is why it is insignificant.

Figure 4.5: Impulse Response Function (IRF) Results



Private and Public Investment Linkages:
Some Evidence Using Sectoral Level Data



Moreover, in Transport and Communication sector and Agriculture sector the short-run response is negative because the confidence interval is below the zero lines but in long run, the confidence interval intersects the zero line and in the agriculture sector the confidence interval turns positive but the overall effect is insignificant. The results, in general, support the crowding-in effect which is consistent with (Afonso & Aubyn, 2008; Monadjemi & Huh, 1998; Rashid, 2006; Xu & Yan, 2014). This channel of public investment crowding in private investment indicates that initially, private investors can be hesitant due to uncertainty and risk, but more public investment and externalities associated with it facilitate and encourage the confidence of private investors. PI not only crowds in PRI but may also enhance its productivity (Hyder & Ahmed, 2004).

The results of the Vector Error Correction Model are shown in Table 4.6. The error correction term, EC (-1), is inversely significant at the aggregate level and across four sectors including Mining and Quarrying, Manufacturing, Finance and Construction which means that there exists a significant long-run association among public and private investment. The significant value of the coefficient of error correction term with a negative sign indicates that a short-term variation will lead to establishing a long-run relationship among variables.

The results of the study reveal that there is the existence of the short-run association in four sectors and at the aggregate level. The sectoral analysis shows that the speed of convergence was the highest in the Construction sector and the lowest speed of convergence was observed at the aggregate level.

Table 4.6: Vector Error Correction (VEC) Model

Sectors	EC(-1)	F	R ²
Aggregate Level	-0.005** (0.002)	4.689	0.582
C	0.250 (0.081)		
Dlpdtgdp	-0.829*** (0.235)		
Di	-0.019** (0.009)		
Dlgdp	0.427** (0.171)		
Transport and Communication	-0.022 (0.016)	3.645	0.396
C	0.261 (0.149)		
Dlpdtgdp	-0.721** (0.313)		
Di	0.014 (0.018)		
Dlgdp	0.985** (0.494)		
Mining and Quarrying	-0.028* (0.010)	5.245	0.345
C	0.252 (-0.296)		
Dlpdtgdp	-0.054** (0.027)		
Di	-0.009 (0.043)		
Dlgdp	0.531 (2.102)		
Manufacturing	-0.009** (0.003)	5.163	0.427
C	-0.095 (0.097)		
Dlpdtgdp	-0.034** (0.015)		
Di	-0.032** (0.013)		
Dlgdp	1.507 (0.658)**		
Finance	-0.078*** (0.028)	4.713	0.427
C	0.847 (0.259)		
Dlpdtgdp	-1.206 (1.080)		
Di	-0.039** (0.017)		
Dlgdp	5.713* (2.010)		
Construction	-0.096** (0.048)	3.882	0.22
C	0.237 (0.280)		

Private and Public Investment Linkages:
Some Evidence Using Sectoral Level Data

Dlpgdp	-0.222			
	(1.070)			
Di	0.056			
	(0.037)			
Dlpgdp	-0.081			
	(1.937)			
Agriculture	-0.013	3.560	0.27	
	(0.014)			
Dlpgdp	-0.488			
	(0.426)			
Di	-0.007			
	(0.014)			
Dlpgdp	1.542			
	(0.726)*			

Note: In parenthesis are the values of standard error. ***,**,* indicate significance at 1%, 5% and 10% level of significance.

Regarding the control variable, the variable of debt as a percentage of GDP has a significant adverse effect on private investment at an aggregate level and in the sectors of Mining & Quarrying, Manufacturing and Transport & Communication while it has an insignificant effect on the rest of the sectors. This negative effect indicates that the higher debt service payments associated with a large external debt reduce the funds available for investment. Further, high levels of existing debt reduce the incentives for further investment, because much of the forthcoming returns from the investment must be used to repay existing debt and therefore acts as a tax on domestic investment (Borensztein, 1990; Froot & Krugman, 1990).

The control variable of GDP which is used as a proxy for overall or aggregate demand has a significant positive effect on private investment at the aggregate level and at the sectoral level, this positive effect is statistically significant in Manufacturing, Finance, Transport and Communication, and Agriculture.

The control variable of interest rate proxying financing cost to invest has a significant negative effect on aggregate private investment and private investment in the sectors of Manufacturing and Finance. For the remaining sectors, the effect of interest rate is generally negative but insignificant.

5. Conclusion

The results of this study obtained through the Johansen Cointegration and VECM show that at the aggregate level public investment complements private investment in the long run. Likewise, at the sectoral level, our results generally support that public investment crowds in private investment in the long run

excluding the sector of Finance, where crowding out of private investment was observed.

The short-run dynamics observed through impulse response function remained consistent with long-run analysis at the aggregate level and in four sectors including Mining and Quarrying, Manufacturing, Finance and Construction. In the Transport & Communication sector and Agriculture sector, the short-run relationship between public and private investment was insignificant.

The share wise figures indicate that the share of public investment in total investment was generally declining at the aggregate level and sectoral level. The general crowding in private investment shown by our results may be the result of welfare benefits with positive externalities arising from public investment (Romer, 1986). There are four types of public investment: infrastructure, human capital, R & D investment, and business investment. Primarily, as already mentioned public investment can lead to more output which in turn generates more physical and financial resources in the economy. Additionally, public spending on infrastructures such as roads, railroads, highways, sewage, education, power plants and water systems often lowers private-sector costs. Such type of infrastructure investment by the public sector complements private investment and improves private capital productivity. The crowding out observed in the Finance sector seems to indicate that the public and private investors compete for the joint ventures.

Further, the nature of both types of investment is mainly different. Private investment is primarily undertaken for profit-seeking purposes. However, public investment is generally for the welfare and development of the country like investment in physical and social infrastructure. However, private investors may not participate normally in long term and risky projects (useful for the country) but the government does undertake such projects for the reason that such projects are generally required for long term growth of the economy. So, our results and generally declining share of public investment highlight that the government is playing its role as an “enabler” (or facilitator) of private investment in terms of association between public and private investment.

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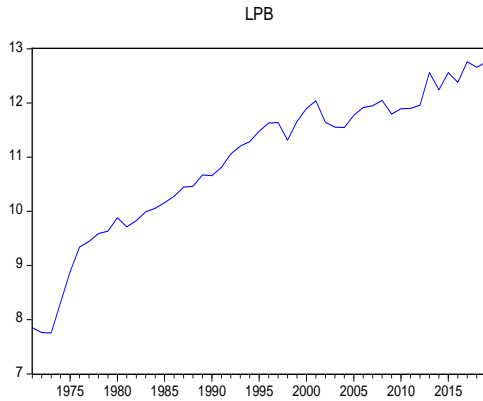
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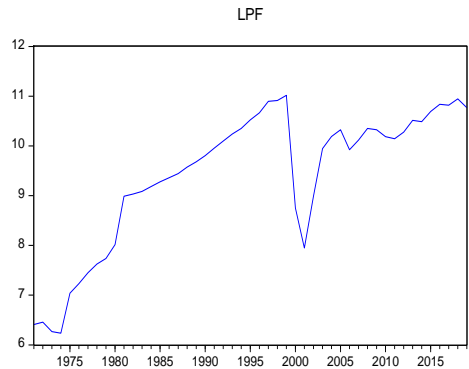
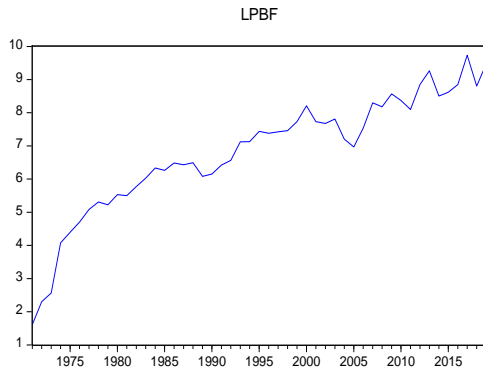
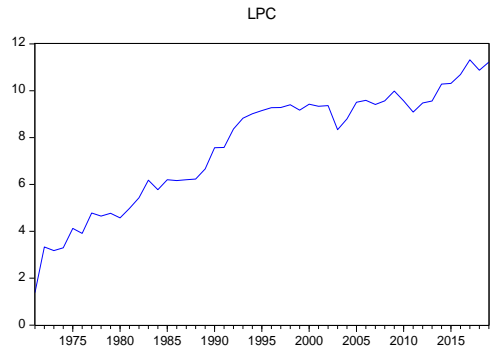
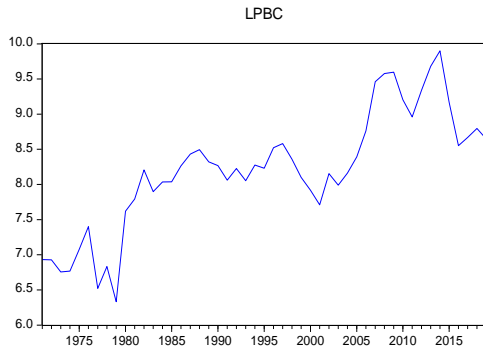
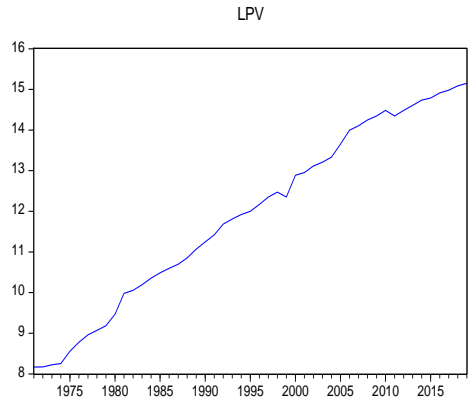
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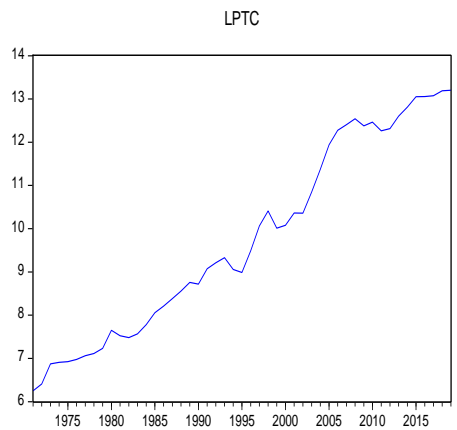
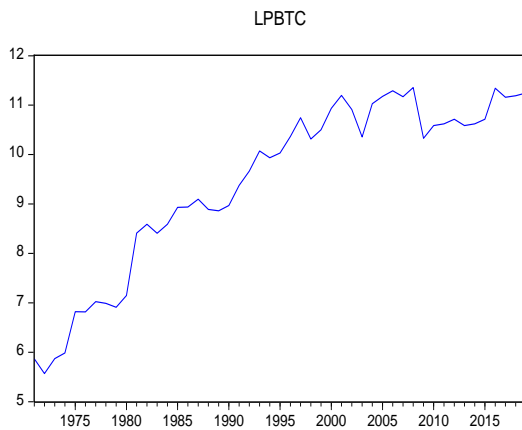
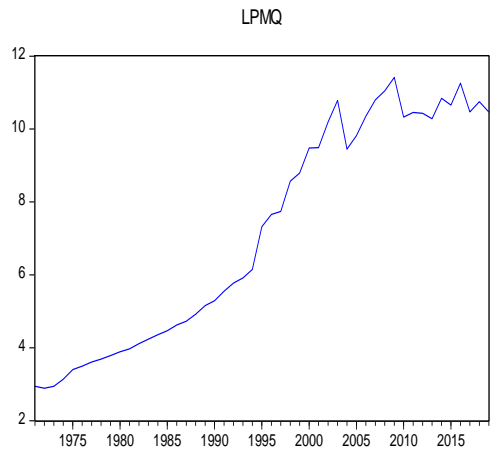
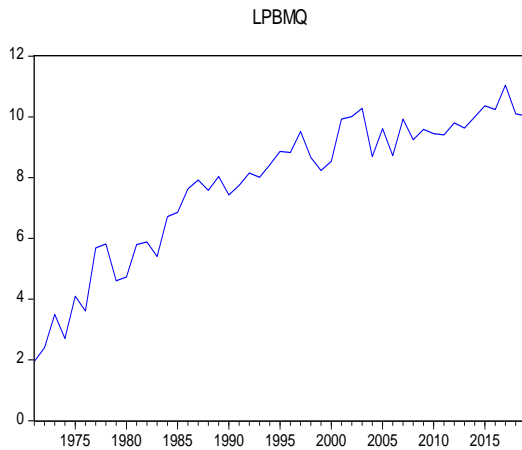
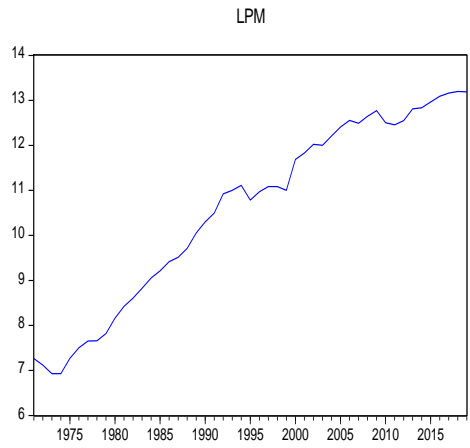
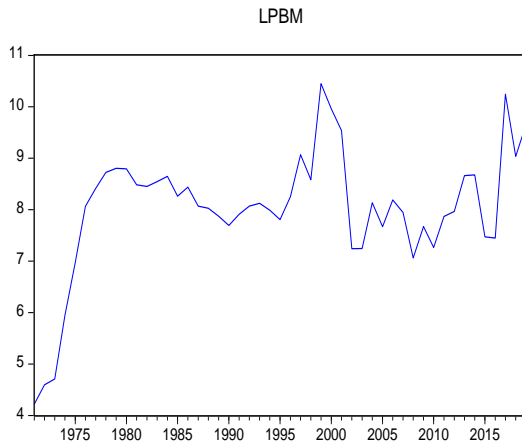
Appendix

Public Investment



Private Investment





Private and Public Investment Linkages:
Some Evidence Using Sectoral Level Data

