Public Infrastructure, Private Capital Formation and Growth in Tanzania

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ABSTRACT

Using time series data over thirty years' period (1990-2020) and applying vector autoregressive (VAR) model, this study investigates the impact of infrastructure investment and stock into private capital formation (investment), private capital stock and economic growth in Tanzania. The descriptive statistics shows that, on average, total government expenditure is three times larger than capital expenditure, accounting to about 31 percent; and of the capital expenditure, infrastructure expenditure account to about 41 percent; while of the infrastructure expenditure, spending on roads and bridges construction account to more than 60 percent. The findings show that increasing public infrastructure investment negatively affect private capital formation in short run due to dominance of the crowding-out effect but turn positive in medium term due to the dominance of crowding-in effect. Increased public infrastructure investment also raises private capital stock, even though, the effects are lower in magnitude and short-lived. The impact of increased public infrastructure capital stock on private capital stock is positive, both private investment and private capital stocks positively affect real GDP growth, implying crowding-in effects of public infrastructure capital stock, and the complementarity rather than substitution effect between the two. In addition, the finding show that public infrastructure capital stock stimulates growth through private capital formation, such that increase in capital stock has a positive but decreasing effect. The lower in magnitude and short-lived effects for most findings are reflective of the unfavourable environment for private investment in Tanzania. Hence, reducing unproductive public capital expenditure and improving the quality need to be accompanied by reforms aimed at limiting the investment to infrastructure capital that crowd-out the private sector.

1. INTRODUCTION

Economists disagree about many things, but one proposition that attracts widespread agreement is the analysis of economic growth, that countries should devote substantial efforts to increasing the quantity and improving the quality of their stock of physical capital to advance growth. Following that, private sector is conceived as an engine of growth in term of its contribution to physical capital formation that is instrumental in enhancing growth. This is not a new phenomenon, as it can be tracked back to the classical political economy of 19th century; where in the 1940s the Harrod-Domar growth model provided the intellectual underpinning of the central importance of increasing the share of output a country devoted to savings and transformed into physical capital (Arthur Lewis, 1991). Since then, other economists such Robert Solow in 1960s with standard neoclassical theory of growth and thereafter Romer, M. P.; Lucas, R. E. and Lee, J. W. in 1980s and 1990s with the endogenous growth theory have built upon these thinking, and increasingly emphasized the importance of stock of physical capital as one major component of growth, in addition to technology and human capital both for developed and developing countries (Robert, S. 1957; Romer 1986, 1990; Lucas, 1988; Lee, 1993).

It is within this backdrop that developed and developing countries alike have over a long period of time pursue policies and programs and take measures to enhance physical capital formation. One such important measures has been to increase the share of public spending (investment) and public capital stock in infrastructure to foster private investment and physical capital formation, both of which increase real output and growth. Thus, the channels through which public infrastructure affects private investment and physical capita formation involve both 'flow' effects (which operate through aggregate demand, relative prices, and the financial sector (i.e. interest rates and credit)) and 'stock' effects (which operate both through the demand and the supply sides). Economic theory suggests that an increase in public investment on infrastructure has positive demand effects and can contribute to the economy's potential output by increasing the stock of public capital (De Jong, *et al.*, 2017). At the same time an increase in public investment on infrastructure can have negative effect, as can act as a substitute for private investment; when the increase in public investment in infrastructure displaces private capital formation (Blinder and Solow, 1973).

On the stock of public capital, the argument goes that public capital in infrastructure increase the marginal productivity of private inputs, hence increasing the perceived rate of return on, and demand for private capital; may as well affect the growth of the private capital formation through lowering the costs of production (Aschauer, 1989; Barro, 990; Agénor, 2006). While public capital in infrastructure may increase the marginal productivity of existing factor inputs (both capital and labour), thereby lowering marginal

production costs and increasing the level of private production (the scale effect on output); this then may lead, through the standard accelerator effect, to higher private investment (Chirinko, 1993). These are referred as crowding-in effects of public capital and investment in infrastructure on private investment and physical capital formation.

Public spending (investment) in infrastructure may also affect private capital formation indirectly, through changes in output and relative prices. The effect on the price of domestic consumption goods relative to the price of imported goods, that is, the (consumption-based) real exchange rate. This relative price effect may be particularly important in developing countries where a large fraction of capital goods used by the private sector are imported. Besides the effect of changes in domestic prices and the real exchange rate induced by an increase in the flow of public investment in infrastructure, it may as well affect private investment through both demand- and supply-side effects on output. For instance, while the increase in domestic prices may lower private sector real wealth and thus expenditure such that firms may revise their expectations of future demand and lower investment outlays, through a 'reverse' accelerator effect; the real appreciation may lead to a shift in resource allocation toward the non-tradable goods sector, thereby stimulating investment in that sector and depressing capital formation in the tradable goods sector (Agenor, P., 2005; Jong, J., 2017).

On the other hand, the public investment might act as a substitute for private investment; when the increase in public spending in infrastructure displaces private capital formation broadly on a shilling-for-shilling basis, irrespective of the mode of financing the public infrastructure (Blinder and Solow, 1973). In addition, there could be a partial loss of private capital formation due to the increase in the interest rates emanating from the pre-emption of real and financial resources by the government through bond-financing of public infrastructure (Straub, 2008; Chakraborty, 2004).Thus, the crowding out effect of public investment in infrastructure occurs, especially if these investments are made through an increase in distortionary taxes, which may increase incentives for private agents to evade taxation, or reduce the expected net rate of return to private capital, and therefore the propensity to invest (Atukeren, 2004). Also, it may occur if infrastructure investment is paid for by borrowing on domestic financial markets, as a result of either higher domestic interest rates (in countries where market forces are relatively free to operate) or a greater incidence of rationing of credit to the private sector (Buiter, 1977; Ram, 1986; Straub, 2008).

Furthermore, if an investment-induced expansion in public borrowing raises concerns about the sustainability of public debt over time (that is, the perceived risk of default), and strengthens expectations of a future increase in taxation, the risk premium embedded in interest rates may increase and the increase may have a compounding effect on private investment. Private investors may revise downward their investment plans because of

anticipated hikes in tax rates to cover for the increase in government investment (Devarajan, 1991; Khan and Kumar, 1997). Following all these, the effect of public infrastructure (capital and spending) on economic growth through private investment and physical capital formation is well documented in the empirical literature for developing as well as developed countries. Many authors have empirically tested the crowding-out and crowding-in effect of public capital and spending in infrastructure and found contradictory results (Agénor, 2006; De Jong, *et al.*, 2017).

The main question this research addresses is - what has been the effect of public spending and public capital in infrastructure on private investment and physical capital formation, and by extension on economic growth for the case of Tanzania? Has government spending on public infrastructures such as transport, construction, water, energy, communication, to mention a few, crowd-in or crowd-out private sector investment and physical capital formation, and by extension impair economic growth. Tanzania, as most other developing countries, have experiment with different policies and programs, and take measures to enhance private sector investment and physical capital formation and so growth, presents a unique experience and a case to study the effects of public infrastructure (capital and spending) on private investment and physical capita formation. To get the understanding of economic policies, reforms and performance in Tanzania over a long period of time one need to specify three major episodes': 1961 to 1966, the post-independence period with an open and private sector led economy; 1967 to 1985, the state controlled economy with inward looking policies hence the ensue debt and economic crises of late 1970s and early 1980s; and the structural adjustment era with a series of market economy reforms from 1986 onwards. This helps reflect the changes in focus of government spending on public infrastructure hence public capital on infrastructure and so their effect on private sector investment hence physical capital formation over a long period of time in Tanzania.

During the first six years after independence (1961-66), the economy was fairly open, and market oriented with no specific policy instruments to allocate foreign exchange or regulate prices. The country therefore inherited a fairly vibrant private sector that mainly focuses on processing industries. Public spending on infrastructure during this period on average accounted to about 15 percent of total expenditure and about 5 percent of GDP, while the physical capital formation makes about 13 percent of GDP. However, the country started to initiate a series of development policies guided by African Socialism ('Ujamaa') following the Arusha Declaration of 1967, where massive nationalization followed and by the early 1970s the government had control of almost all sectors: banking and major industries became state-owned; international trade and private retail trade were controlled by state agencies; administered prices (through the National Price Commission) largely replaced market prices; and monopoly government marketing boards replaced peasant cooperatives. All these strategies were formulated in the

framework of pursuing socialist development principles which included marginalization of the role of the private sector investment (Kim, S. K. and Mabele, R., 1979; Bigsten, A., and Danielson, A., 2001).

As the result, public spending, and so public capital stock rather than private investment and private physical capital stock significantly dominated during this period. For instance, public capital in infrastructure as a share of GDP was at about 8 percent and capital expenditure as a share of GDP at about 17 percent. On the other hand, the private investment as a share of GDP from 1967 – 1980 was at 11.3 percent lower than for the public investment at about 13.2 percent; however, that changes as the private investment was at 12.5 percent from 1981 – 1985 while public investment at 8.1 for the same period. The same picture is portrayed when looking at private investment as the share of gross fixed capita formation, as it was 45.9 percent from 1967 – 1980, lower than for public investment at about 54.1 percent; however, it changed and rose to about 60.7 percent from 1981 – 1985 while hat for public investment was at 39.3 for the same period (Kim, S. K. and Mabele, R., 1979; Bigsten, A., and Danielson, A., 2001).

Even though, the ensuing economic crisis of late 1970s and early 1980s led to structural adjustments (SAPs) reforms, where among other things, market and private sector reforms were top in agenda. Initially the government responded to these difficulties by proposing its own policy reforms but soon adopted a series of economic recovery measures as sponsored by the IMF and World Bank (Morrissey, 1995). Although investment increased in mid 1980s to early 1990s, most of this was directed to infrastructure and growth of private sector investment in productive activities was limited. The private investment as share GDP increased to 17.6 between 1986 – 1995 and that for the public investment was at 10.2 for the same period. As the result, the private investment as share of gross fixed capital formation was 62.4 percent from 1986 – 1995 and that for the public investment was at 37.6 for the same period. Capital infrastructure, that include electricity, water supply, construction and transport accounted to about 10.3 5 during this period while capital expenditure as share of GDP accounted to about 20.2 percent in the same period (Kim, S. K. and Mabele, R., 1979; Bigsten, A., and Danielson, A., 2001). The early 1990s were a period of failed or stalled reforms that aimed at getting price right and stabilization; and it is from 1995 onwards, when meaningful reforms began where the focus has been on enhancing the role and participation of private sector and investment in the economy.

More recently, however, there have been observed increases in public spending on infrastructure in the last 10 years, especially from 2010 onwards, mostly driven by the growth of the construction sector, on roads and bridges, water and energy supply. Private investment as share of GDP rose from 15 percent in 2000 to about 25 percent in 2010 and thereafter to as high as 30 percent in 2020s; at the same time public investment as

share of GDP remains on average at about 13 percent. While capital expenditure as share of GDP has been at around 5 percent, capital expenditure as total expenditure rose from 30 percent in 2010 to about 45 percent in 2020. When we decompose the infrastructure into sub-sectors, we saw that most subsectors experienced exponential growth between 2010 and 2020. For instance, roads and bridges construction spending as share of total capital, increasing from 23 percent in 2010 to about 33 percent in 2017 and thereafter declined to 27 percent in 2020; and the same trend, though lower percent is also observed into water and energy supply (MoFP, various budget books).

These observations are instructive of the strong commitment on the part of the Government to implement various large-scale infrastructure projects. However, there is a realization also that such infrastructure investments require huge amounts of funds at a time when the development financing landscape has also changed with donor support in fast decline. The Government of Tanzania has responded to financing shortfalls by resorting to high-cost commercial borrowing. Theoretically, this calls for a careful trade-off in the financing structure to ensure that financing costs are manageable, are within the limits of the budget capability, and have minimum crowding-out effect for other public sector spending and private sector investment (including credit to the private sector).

We consider the effect of an increase in public spending and so public capital in infrastructure on private investment and physical capital formation, and on growth in Tanzania against the background of changed development financing landscape. Based on updated estimates of the public spending and public capital in infrastructure on private investment and physical capita formation and growth, we estimate the growth (and probably the output) response to a public capital impulse, using VAR models, for the period that cover time the period from 1990 – 2021.

2. A REVIEW OF LITERATURE

The debate on the relative impact of the association between public spending (capital and investment) and private capital formation (physical and investment) on economic growth largely depends on whether public investment is crowding-out or crowding-in private investment in the economic growth process. Public capital and investment in infrastructure can expedite the new private capital formation, thereby promoting economic growth through its impact on private sector economic activities (i.e. private physical capital formation) (Eberts, *et al.,* Merriman, 1991; Wang, 2005).

Crowding-In Effect: one of the analogies for crowding-in effects, also referred as complimentary relationship, is that the increase in public capital formation stimulates aggregate demand and in turn increases private investment. Another link for the existence of the crowding-in effect is that a higher stock of public capital, in particular infrastructure, may increase the rate of return of private investment projects. Thus, the public capital (as opposed to public investment) in infrastructure may stimulate private physical capital formation due to its effects on private activities in numerous ways. By financing the infrastructure, public spending has strong impact on marginal productivity on private capital and labour; hence raises the perceived rate of return on, and increase in demand for, physical capital by the private sector (Aschauer, 1989; Barro, 990). Thus, public infrastructure stimulates growth through private capital formation, such that increase in capital stock has a positive but decreasing effect on the marginal product of all factors, such as capital and labour.

Besides the argument that public capital in infrastructure increases the marginal productivity of private inputs, hence increasing the rate of return on, and demand for, private capital (Agénor, 2006). The other way through which public capital in infrastructure may affect economic growth through the private capital formation, is through the costs of production. As the result of public capital in infrastructure, the cost of production decreases and the level of private production increases (Agénor, 2006). This implies that increase in public capital in infrastructure reduces the cost of production in the private sector, which leads to an increase in the output of the private sector. Through adjustment costs, the availability (and quality) of public capital in infrastructure affects some of the costs that firms may incur when investing. For instance, a better road network may reduce expenses associated with the construction of a new factory or the transportation of heavy equipment; the same can be said to access to services such as telecommunication and electricity. By lowering production costs and raising the expected

rate of return, public capital in infrastructure may have a strong impact on private capital formation, and by extension on growth (Turnovsky, 1996; Cohen and Paul, 2004).[1]

Furthermore, on adjustment costs, Straub (2008) argues that there are two channels through which the enhancement of the stock of infrastructure capital reduces the adjustment cost of private capital. First, by reducing the logistic cost of private investment, and second, an improving public infrastructure allows for more flexible private investment in devices, such as electricity generators, for more productive investments in machinery (Reinikka and Svensson, 2002; Alby *et al.,* 2010), Lee *et al.,* 1996). In addition, efficient and reliable services of stock of infrastructure reduce the firm's investment in substitution factors of production and thereby release the resources for productive investment. All the above are real (direct) crowding-in channels, there however indirect channels too.

An improvement in the stock of public capital in infrastructure may as well affect the rate of total factor productivity growth, independently of its effect on private capital accumulation, indirect channels. Public investment and capital in infrastructure may also affect private capital formation indirectly, through changes in output and relative prices. While public capital in infrastructure may increase the marginal productivity of existing factor inputs (both capital and labour), thereby lowering marginal production costs and increasing the level of private production (the scale effect on output) This then may lead, through the standard accelerator effect, to higher private investment (Chirinko, 1993). And if there are externalities associated with the use of some production factors (such as learning-by-doing effects resulting from a high degree of complementarity between physical capital and skilled labour), a positive growth effect may also result.

Public infrastructure can also affect private investment indirectly through its 'flow' effect on the price of domestic consumption goods relative to the price of imported goods, that is, the (consumption-based) real exchange rate. An increase in public investment in infrastructure for instance will raise aggregate demand and domestic prices (in addition to stimulating output). If the nominal exchange rate does not depreciate fully to offset the increase in domestic prices, the domestic-currency price of imported consumption goods will fall in relative terms (that is, the real exchange rate will appreciate), thereby stimulating demand for these goods and dampening domestic activity. The net effect on output may be positive or negative, depending on the intra-temporal elasticity of substitution between domestic and imported goods. If this elasticity is low (as one would expect in the short run), the net effect on output may be positive, so that private investment may indeed increase. At the same time, to the extent that the increase in government spending on infrastructure raises the price of domestic capital goods, and the switch in private consumption demand toward imports translates into a nominal

[1]The positive effect of public capital on the marginal productivity of private inputs may hold not only for infrastructure but also for public capital in education and health, which may enhance the productivity of labour.

appreciation, the domestic-currency price of imported capital goods will fall in relative terms, resulting in a drop in the user cost of capital and an increase in private investment. This relative price effect may be particularly important in developing countries where a large fraction of capital goods used by the private sector are imported.

Besides these effects changes in domestic prices and the real exchange rate induced by an increase in the flow of public investment in infrastructure may affect private investment through both demand- and supply-side effects on output. On the demand side, the increase in domestic prices may lower private sector real wealth and thus expenditure; if this effect is sufficiently large (relative to the increase in public spending) to entail a fall in domestic absorption, firms may revise their expectations of future demand and lower investment outlays, through a 'reverse' accelerator effect. On the supply side, the real appreciation may lead to a shift in resource allocation toward the non-tradable goods sector, thereby stimulating investment in that sector and depressing capital formation in the tradable goods sector. The net effect may be a lower growth rate of output, and thus lower investment as a result of an expected reduction in demand growth. At the same time, however, if the nominal exchange rate is flexible, and if it does not depreciate fully in response to the increase in domestic prices (as a result of an increase in the demand for imported goods), the real cost of imported intermediate inputs may fall – thereby stimulating output and private investment.

Crowding-Out Effects: the crowding-out argument stems from thesis that the public investment might act as a substitute for private investment. Theoretical literature identifies two variants of crowding-out effect in an economy – real and financial. The real (direct) crowding out occurs when the increase in public investment displaces private capital formation broadly on a dollar-for-dollar basis, irrespective of the mode of financing the public infrastructure (Blinder and Solow, 1973). The financial crowding-out effect relates to partial loss of private capital formation, due to the increase in the interest rates emanating from the pre-emption of real and financial resources by the government through bond-financing of public infrastructure; hence, the source of financing of public infrastructure matters (Straub, 2008; Chakraborty, 2004). Thus, the crowding out effect of public investment in infrastructure occurs, especially if these investments are made through taxation or through borrowing from domestic financial institutions.

One, the crowding-out effects tend to occur if the public sector finances the increase in public investment in infrastructure through an increase in distortionary taxes, which may increase incentives for private agents to evade taxation or reduce the expected net rate of return to private capital, and therefore the propensity to invest (Atukeren, 2004). However, the initial rise in infrastructure investment crowds out private investment but could potentially stimulate additional private investment if additional public investment increases the marginal product of private capital. The long-term net effects of an increase

in public investment, therefore, depend on the relative importance of these two effects (Otto and Voss, 1994).

Two, the other effect of public investment on infrastructure on private capital formation may occur if the increase in public infrastructure investment is paid for by borrowing on domestic financial markets, as a result of either higher domestic interest rates (in countries where market forces are relatively free to operate) or a greater incidence of rationing of credit to the private sector (Buiter, 1977; Ram, 1986; Straub, 2008).[2]

Three, if an investment-induced expansion in public borrowing raises concerns about the sustainability of public debt over time (that is, the perceived risk of default), and strengthens expectations of a future increase in taxation, the risk premium embedded in interest rates may increase. By raising the cost of capital and negatively affecting expected after-tax rates of return on private capital, this increase may have a compounding effect on private investment. Private investors may revise downward their investment plans because of anticipated hikes in tax rates to cover the increase in government investment.

In summary, literature highlights two channels through which public investment in infrastructure crowd out private investment, as follows: public investment can delay private investment and, ultimately, economic growth when public investment is financed through borrowing from the external and internal financial markets. Debt financing of public investment increases the cost of capital and reduces the expected return on private capital after tax. This slows down the new capital growth rate of the private sector and the economic growth (Devarajan, 1991; Khan and Kumar, 1997). Public investment can also displace private investment if it produces goods and services that compete with the private sector (Devarajan, 1991).

However, it is important to note the direction, and the strength of the various effects can vary over time and depend to on the environment in which private investors are operating. For example, the relationship between public and private investment may be one of substitution (i.e. crowding-out effect) in the short run, and one of complementarity (i.e. crowding-in effect) the long run, depending on how productive public investment is. That is, in the short term, the crowding-out effect may predominate (because the pool of resources available to finance public and private investment is limited), whereas the complementarity effect may prevail in the long term, as a result of strong supply-side effects. Furthermore, it is worth noting that there may be a feedback effect through public investment itself; indeed, to the extent that the rise in private investment stimulates

[2] Any component of government expenditure (not only infrastructure investment), as long as it is financed through domestic borrowing, may lower private investment by driving interest rates up or increasing the incidence of credit rationing.

output and leads to higher tax revenue, public investment may increase further, because of the additional resources at the disposal of the public sector.[3]

Empirical Evidence: The influence of public infrastructure on economic growth through private physical capital formation is well documented in the empirical literature for developing countries. Many authors have empirically tested the crowding-out and crowding-in effect of public capital and investment in infrastructure and found contradictory results. For instances, Ramirez (1994), Greene and Villanueva (1990), Buiter (1977), Aschauer (1989), and Erenburg (1993) found that public investment and private investment have a complimentary relationship; while Blejer and Khan (1984), Cebula (1978), Shafik (1992), Parker (1995), Ostrosky (1979), Tun Wai and Chong (1982), Sunderrajan and Takur (1980), Pradhan, *et.al.*, (1990), Krishnamurty (1985), Kulkarni and Balders (1998), and Alsenia (2002) did find evidence for crowding out between public and private investment. Appendix Tables A1 - A2 summarize both the crowding-in and crowding-out effects for selected studies.

[3]Thus, using dynamic models is essential to study the relationship between public infrastructure and private capital formation, beyond the need to account for gestation lags. At the same time, it is important to control for indirect effects that operate through changes in output, the real exchange rate, and possibly interest rates or credit. These dynamic and feedback effects are key reasons for choosing a VAR framework for our empirical analysis.

3. TANZANIA CONTEXT: ECONOMIC INFRASTRUCTURE AND PHYSICAL CAPITAL FORMATION

Overview of Major Infrastructure Policies

The function of economic infrastructure as seen by development theorists is mainly one of linking internal as well as external markets, hence facilitating investment, production and commerce. As the result, the ability of the economy to absorb investment and indeed grow is very much dependent on the adequacy (and quality) of provision of economic infrastructure. Adequate economic infrastructure, however, is a necessary but not sufficient condition for economic development; other factors such as physical capital formation, skilled manpower, technological development and social infrastructure being required in addition. Importantly, there is as well an important interaction between economic infrastructure and the performance of the other factors, in particular with the private investment and physical capital formation, both of which are key to growth and economic development.

In addition to providing preliminary insights from policies and measures taken, efforts are made to associate the trend and patterns in economic infrastructure with private investment and physical capital formation, and by extension to real output and growth. This is important as Tanzania, like most other low-income countries, has a problem of physical capital accumulation. Prior to 1967 most of dominant positions in the economy were controlled by foreign capital and the inherited economic infrastructure were meant to serve the needs of colonial economy. One consequence was continuous outflow of resources from the country (i.e. capital flight).

The First Five Year Plan, 1964/69, was therefore based on the assumption that private foreign investment, operating relatively freely, would constitute a significant part of total capital formation. The results were disappointing, however, and the expected level of investment did not materialize. Therefore, Tanzania began to formulate its own unique path to development. The Second Five Year, 1970/74, represented a sharp break from an overreliance on the private sector. The Arusha Declaration in 1967 meant, among other things, to eradicate or reduce this drain; even though, the problem of inadequate capital accumulation has continued unabated to date. Third Five Year Plan, 1975/80, assumed as given government participation or control in all major areas of investment and the continuation of the system of wage and price control throughout the economy (BoT, 1982).

In attempt to deepen its productive forces to address the shortages and accelerate physical capital accumulation, since the dawn of independence, Tanzania, as a country, have taken measures both at policy, programs and projects to enhance physical capital

formation and economic development. As the result, this then entails an expansion of physical infrastructure in the form of improved transportation and communication, power (energy), construction, investment in irrigation work (water), and ICT.

Thus, continued emphasis has been placed on the economic infrastructure after independence. All plan documents put emphasis on the development of infrastructure as precondition for expansion of production and absorption of new investment. This was especially noted for the case of sparsely distributed agricultural activities. Movement of food and crops between regions, movement of inputs to production sites and output to internal and external markets required efficient transportation. Planned allocation of resources in the three plans earmarked about two-third of total development expenditure to economic infrastructure. Given that Tanzania is a relatively large country and sparsely populated, the pressure on resources to provide infrastructure given the colonial record of neglect was immense (Kim, S. K. and Mabele, R., 1979; BoT, 1982).

In seeking to drive Tanzania towards a modern economy, in line with Tanzania's Vision 2025 (of being a semi-industrialized middle-income country by 2025), a key focus has been on implementation of various infrastructure projects at an accelerated pace to support the growth that this vision contemplates. Notable infrastructure projects that the Government of Tanzania is implementing include the following: (). Infrastructure-driven development will certainly foster economic growth. However, to achieve sustainable results, they need to be well-planned, carefully implemented, closely monitored and make financial sense. In tandem with this, and because most of these mega projects are financed by the Government, there is a need to constantly monitor benchmarks related to the level of the resultant debt and ensure transparent and public accountability of invested resources.

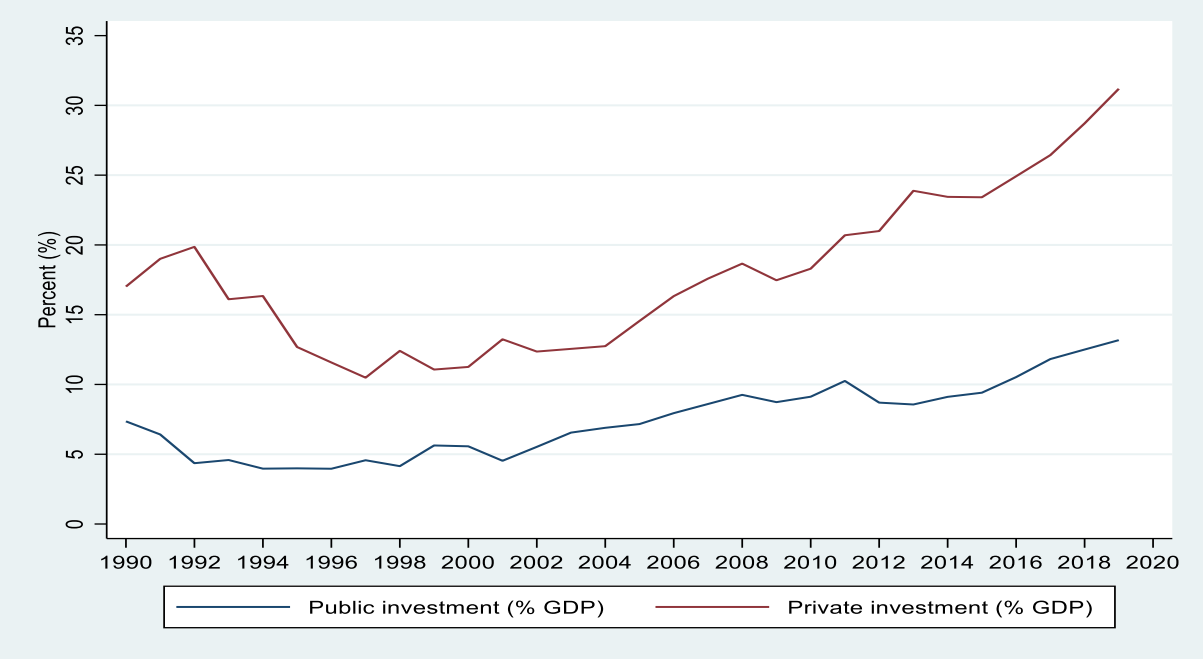
Economic Infrastructure and Capital Formation: Trend and Performance

Like in other developing countries, investment in infrastructure accounts for a large fraction of total capital (development) investment. In the early stages of development, transport, construction, energy, and water requirement increase much faster than the rate of growth of GDP, and Tanzania is no exception to this. Investment in economic infrastructure between1966 and 1974 averaged 55 percent annually of public sector's fixed capital formation. Over the three five-year plan period (1964 – 1980) allocation of planned investment expenditure to economic infrastructure averaged 41 percent of public sector's investment expenditure annually. Government expenditure on economic infrastructure over the period 19963 – 1977 on averaged claimed a share of 16 percent of total budget, while during 1968 – 1974 the share of total government expenditure going to economic infrastructure averaged 18.3 percent. This high share reflects the fact that economic infrastructure financing is done solely by government due to the public nature of benefits ensuing from its use and that capital expenditure on infrastructural

projects are quite sizeable. While planned allocation of resources during the three plans (i.e. 1964 – 1980) earmarked about 2/3 of the total development expenditure to economic infrastructure, its contribution to Gross Domestic Product (GDP) averaged 8 percent (Kim, S. K. and Mabele, R., 1979; BoT, 1982).

Thus, looking at the economic infrastructure as a whole government resource allocation increased rapidly during the first three five years plans, especially from 1967 – 1974, reflecting government's concern over improving the national transport network and removing transportation bottlenecks. The latter period during the period was characterized more by the concern to increase the supply of both water and electricity, and more specifically the expansion of hydroelectric schemes (Kim, S. K. and Mabele, R., 1979; BoT, 1982). The ensuing economic crisis of late 1970s and early 1980s led to structural adjustments (SAPs) reforms, where among other things, market and private sector reforms were top in agenda. Although investment increased in the 1990s, most of this was directed to infrastructure and growth of private sector investment in productive activities was limited.

Figure 1: Tanzania public and private investment (in percent of GDP)

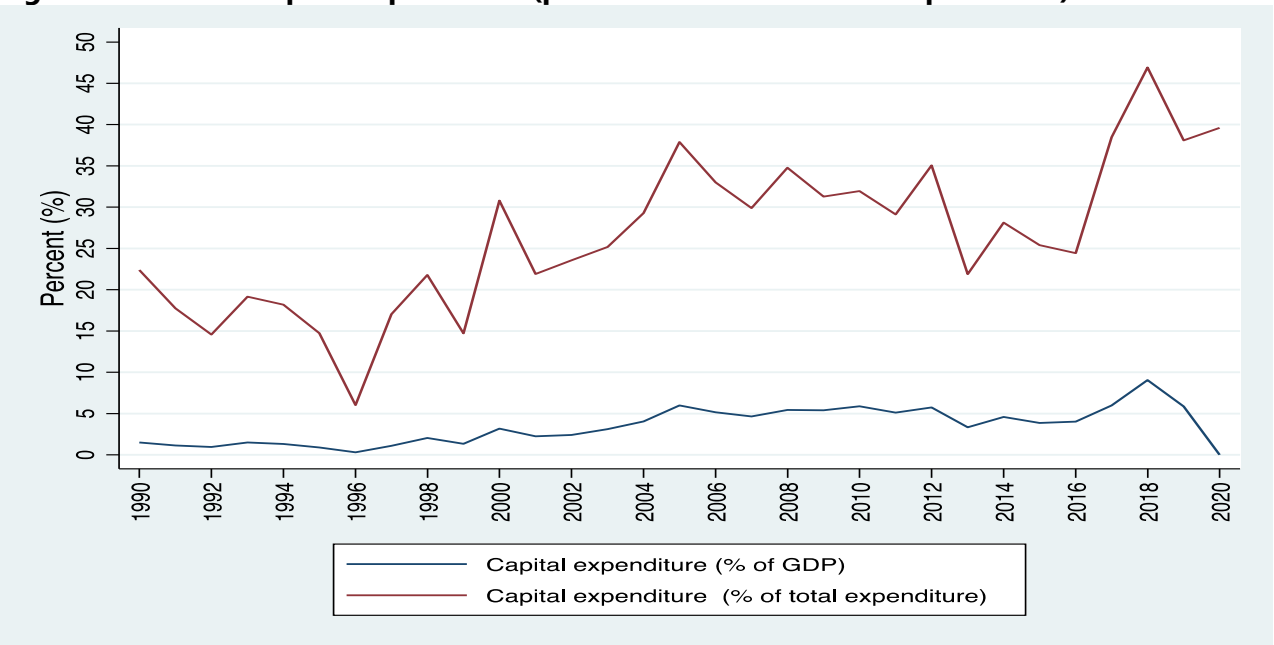


Source: Author's Own Compilation Based on Various Data Sources

As shown in Figure 1, the early 1990s (1990 – 1995) were a period of failed or stalled reforms that aimed at getting price right and stabilization, as public investment as a share of GDP averaged to 5 percent and of private investment average 17 percent, three more times than that of public investment. It is from 1995 onwards, when meaningful reforms

began where the focus has been on enhancing the role and participation of private sector in investment, production and commerce in the economy. As shown, there have been a steady growth of both public and private investment as share of GDP to 10 percent for public investment and 21 percent for private investment in 2011; and rising even further to 13 percent for public investment and 31 percent for private investment in 2019. An interesting point at this juncture is to establish to what extent the public investment, especially that goes to infrastructure, determines private capital formation, so is the public and private capital stock, both of which are key determinants of the private physical capital formation.

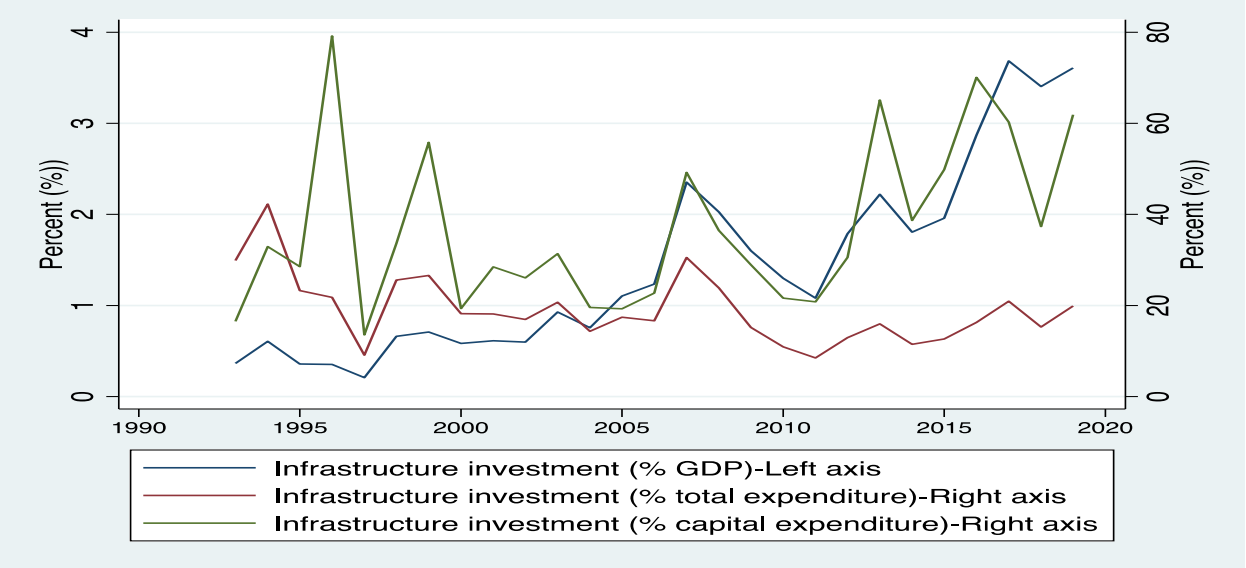
Figure 2: Tanzania capital expenditure (percent of GDP and total expenditure)



Source: Author's Own Compilation Based on Various Data Sources

As shown in Figure 2, capital expenditure increased from 2 percent as share of GDP and from 18 percent as share of total expenditure in early 1990s to 6 percent and 32 percent respectively in 2010, and further to 9 as share of GDP and 47 of total expenditure in 2018. At the same time, infrastructure expenditure, as share of capital and total expenditure, and as share of GDP has also increased overtime. As shown in Figure 3, public expenditure on infrastructure as share of GDP has increased from about 0.4 percent in early 1990s to 2.4 percent in 2007, and then to 4 percent in 2019.

Figure 3: Infrastructure expenditure (percent total expenditure and development expenditure)

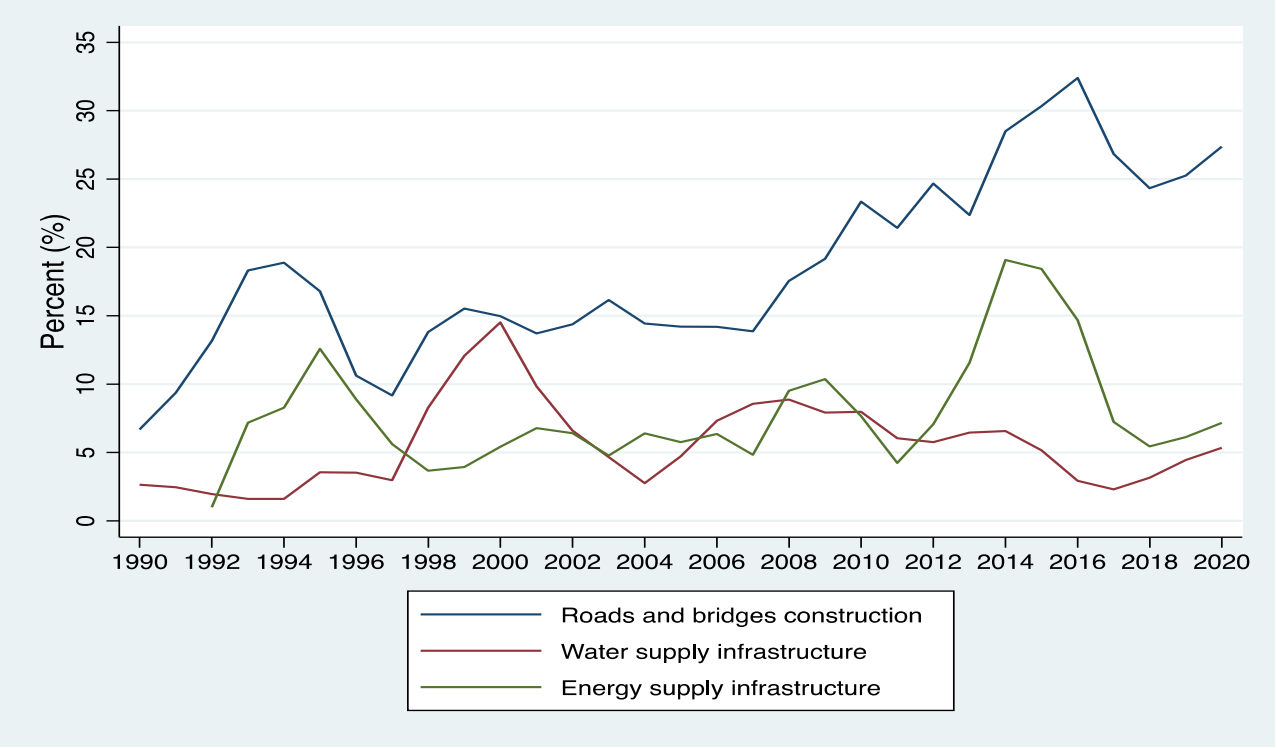


Source: Author's Own Compilation Based on Various Data Sources

During the same period infrastructure expenditure as share of capital expenditure rise from 26 percent in early 1990s to 49 in 2007, while as share of total expenditure has been at about 31 percent in early 1990s and so in 2007. While infrastructure expenditure as share of total expenditure collapse to 16.2 percent in 2016 before increasing to 25 in 2019; at the same time there have been significant increase in share of infrastructure expenditure on development expenditure, as it reaches 70 percent in 2016 before modestly dropped to 62 percent in 2019 (significant increase was observed between 2014 to 2019).

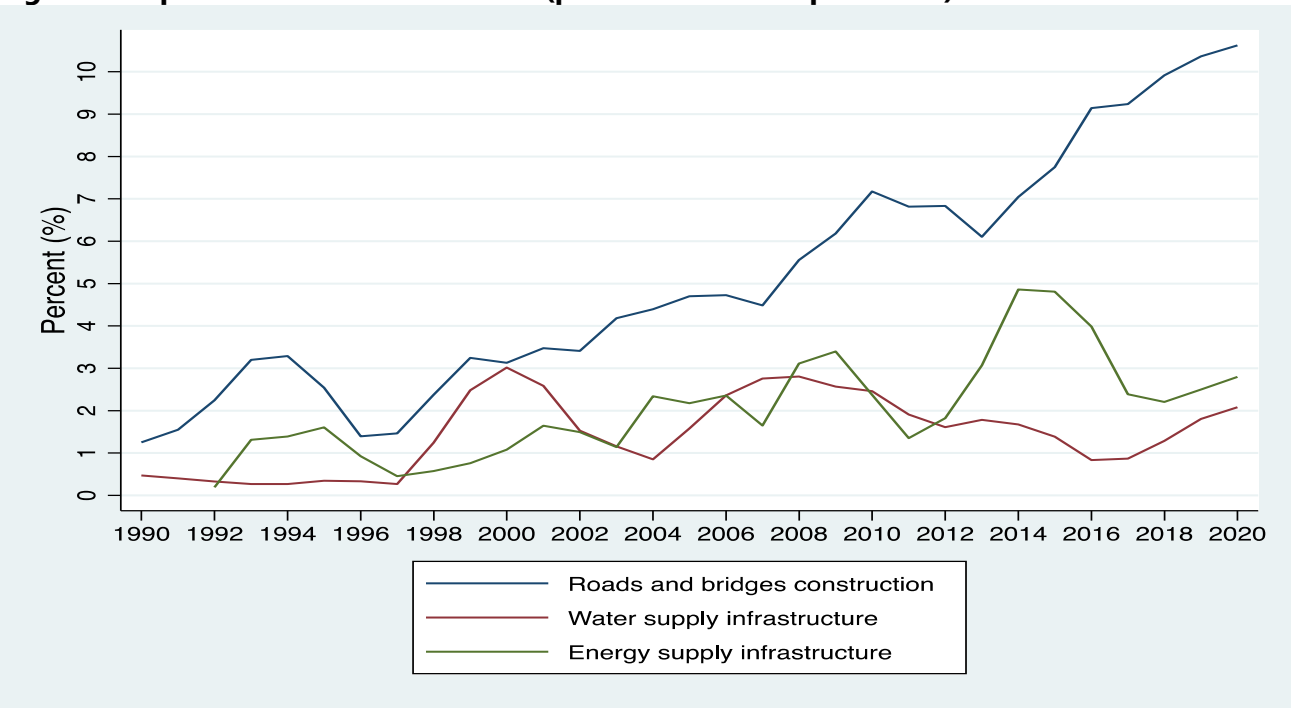
In Figures 4 and 5, we further decompose infrastructure expenditure as share of capital expenditure and total expenditure into its major subsections: roads and bridges, construction, water and energy supply. As shown, spending on roads and bridges construction as share of capital expenditure accounted for the largest share and rising from 6 percent in 1990 to 11 percent in 2010 and increased further to 21 percent of total capital expenditure in 2019. The same is the case when looking at roads and bridges construction spending as share of total government expenditure, rising from 1 percent in 1990 to 4 percent in 2010 and increased further to 9 percent of total capital expenditure in 2019. Construction expenditure have also shown substantial increase over time from about 2.4 percent in 1990 to 10 percent in 2010 and then further to 24 percent in 2019. Water and energy supply on the other hand have not seen significant increase over time.

Figure 4: Expenditure on infrastructure (percent of capital expenditure)



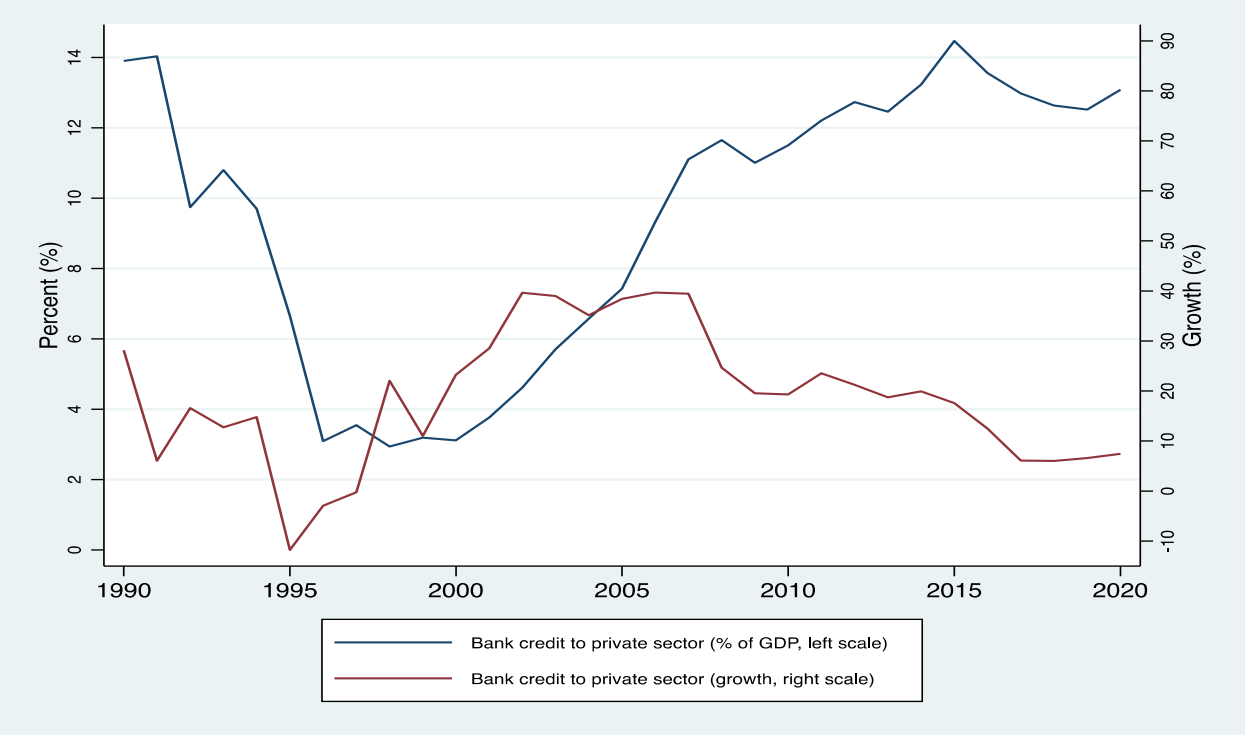
Source: Author's Own Compilation Based on Various Data Sources
Notes: Three year moving average

Figure 5: Expenditure on infrastructure (percent of total expenditure)



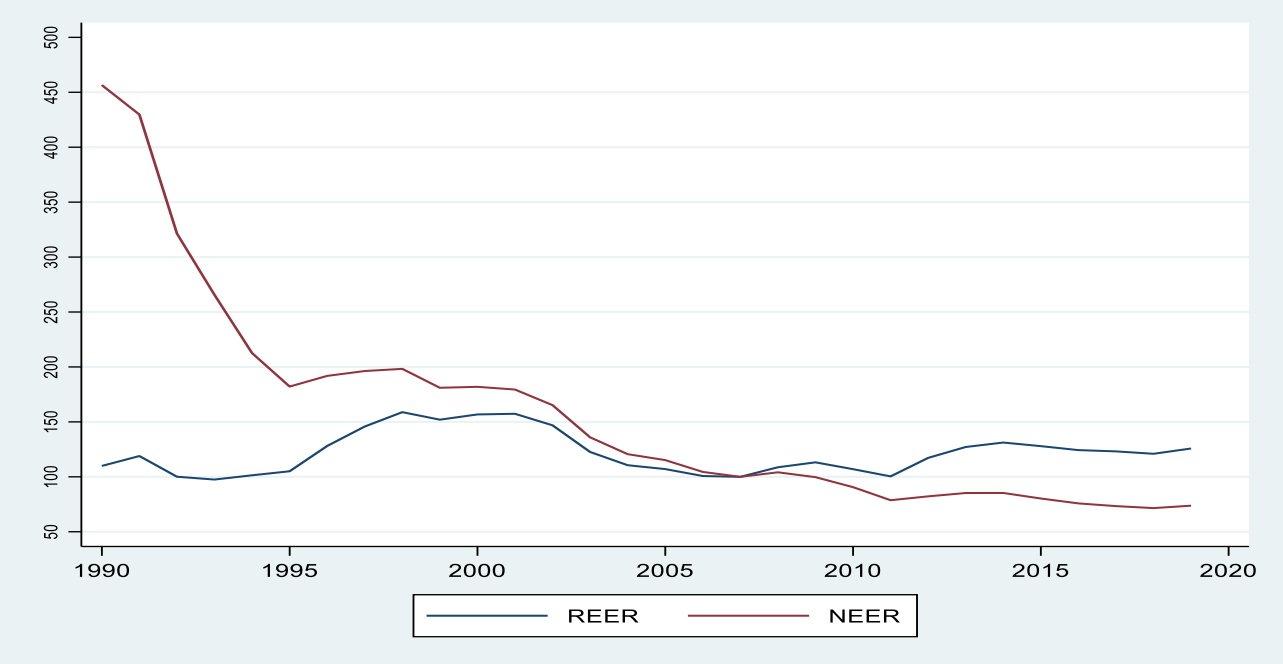
Source: Author's Own Compilation Based on Various Data Sources

Figure 6: Commercial bank credit to private sector (percent of GDP and growth rate)



Source: Author's Own Compilation Based on Various Data Sources

Figure 7: Real and Nominal Effective exchange rate



Source: Author's Own Compilation Based on Various Data Sources
Notes: REER and NEER denotes real effective exchange rate and Nominal effective exchange rate

4. EMPIRICAL STRATEGY AND DATA

4.1 Empirical Specification and Estimation

To investigate and examine the private investment and physical capital formation effect of public infrastructure (spending and capital) in Tanzania, this study uses a times series data of about 30 years (1990 – 2020), allowing for comparative analysis of the recent past and current period. As such, such economic time series are commonly characterized by strong 'trend type' behaviour, time 'trend type' (dynamic component/adjustments) behaviour and the 'long-run' against the 'short-run' behaviour.

As the result, using dynamic model is essential to study the private investment and physical capital formation effect of public infrastructure (spending and capital), beyond the need to account for gestation lags. This is because the relationship between public infrastructure (investment and capital) and private capital (investment and physical capital formation) may be one of substitution in the short run, and one of complementarity in the long run, depending on how productive public infrastructure is. Hence, it is important to control for indirect effects that operate through changes in output, the real exchange rate, and possibly interest rates or credit. Also, there could be a feedback effect through public investment in infrastructure itself; to the extent that the rise in private investment stimulates output and leads to higher tax revenue, public investment in infrastructure may increase further, because of the additional resources at the disposal of the public sector. These dynamic and feedback effects are key reasons for choosing a dynamic VAR framework in our empirical analysis.

VAR-based analysis features a number of advantages. First, in contrast to the production function and cost function approaches, VAR models do not impose causal relationships between variables a priori; rather they allow for testing of the existence of causal relationships in either direction (can do that without estimating robust structural model). For example, next to finding that public infrastructure positively affects private capital formation and income growth, it could be envisaged that with income the demand for adequate infrastructure rises. Second, VAR models allow for indirect links between all the variables in the model, hence, the long-run output effect of a change in public capital in infrastructure results from the interaction of all the considered variables (allowing for feedback effects). Third, VARs do not a priori restrict the number of long-run relationships in the model, instead they can be consistently tested in the data (Kamps, 2005).[4]

[4] On the downside, the VAR approach faces shock identification issues and often lacks a clear structural interpretation of the estimated relationships in the model. Furthermore, the so-called issue of 'curse of dimension' often limits the number of endogenous variables that can be included in the model.

There have been thus, a number of studies that have employed VAR approach in an effort of establishing the effects of public infrastructure (both flow and stock) on private investment/physical capital formation, private capital stock and real GDP growth. One of the most cited papers in the literature employing the VAR approach is Kamps (2005). He estimates country-specific VAR models for 22 OECD countries using his constructed database on public capital stocks (Kamps, 2006). The VAR model-based simulations reveal that an increase in public capital seems to contribute to economic growth, but less so than often reported in studies utilizing the production-function approach. This finding points to the importance of feedback effects from output to public capital for which partial equilibrium analysis fail to account. Furthermore, public and private capital stocks are found to be long-run complements in the majority of countries. Jong-A-Pin and De Haan (2008) extend the analysis by Kamps (2005), only partially confirming his findings. Another study by Broyer and Gareis (2013) that uses data for 1995–2011 finds very strong positive effects of infrastructure expenditures in the four largest euro area countries. Based on data for 17 advanced OECD economies over 1985–2013, IMF (2014) directly estimates the relationship between public investments and output growth in a panel setting and finds strong positive output effects of public investment.[5][6] We extend on these studies by first make a distinction between the flow of public investment in infrastructure and the stock of public capital in infrastructure; account for potential crowding-out effects; and account for indirect effects of public investment in infrastructure on private investment, physical capital formation and growth.

As shown, the channels through which public infrastructure affects private investment and physical capital formation involve both 'flow' effects (which operate through aggregate demand, relative prices, and the financial sector) and 'stock' effects (which operate both through the demand and the supply sides). We thus estimate VAR model for data with a time series (1990 – 2022). Given that most economic time series have a strong 'trend type' behaviour as well as 'time trend' behaviour, we need first to establish the level of integration by testing for non-stationarity and thereafter de-trend the data (by differencing) to remove the stochastic trend from I(1) variables, rendering them stationary I(0).While this removes the problem of trends it also throw away the valuable information about the 'long-run' behaviour (about which economic theory is informative) against the 'short-run' behaviour (about which economic theory has little to say). Hence, our estimation approach allows to describe both the short-run and long-run behaviour yet avoid 'spurious regression', that is so common with I(1) data.

[5] Interestingly, these effects appear to be particularly strong during periods of low growth and for debt-financed shocks but are not significantly different from zero if carried out during periods of high growth or for budget-neutral investment shocks.

[6] Others VAR studies on the impact of public investment on private capital formation and growth include: Mittnik and Neumann (2001); Ghali (1998); Ligthart (2000); Belloc and Vertova (2004); Voss (2002); Belloc and Vertova (2004)

As a rule, it is common practice in the time series analysis first to introduce the dynamic element in the specification (what happened today reacts to what happens in the previous periods as well as the current period). We incorporate dynamic component using the Autoregressive Distributed Lag (ARDL) model. Assuming that the variables are I(1), the data generating process is approximated by

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + \varepsilon_t \quad (1)$$

where $\varepsilon_t \neg N(0, \sigma^2)$. To test for the lag length, we use either the Akaike Information Criterion (AIC) or the Swartz Bayesian Criterion (SBC). The statistic or long run equilibrium is then given by

$$y = \alpha + \beta x \quad (2)$$

where ($\alpha = \alpha_0 (1 - \alpha_1)^{-1}$ and ($\beta = \beta_0 (1 - \beta_1)^{-1}$ are the long run relationship between y_t and x_t. Equation (1) is not in a convenient form for estimation or interpretation unless we knew that y_t and x_t are cointegrated. Even if were cointegrated, the ARDL model is not particularly meaningful from an economic viewpoint (unless we are only interested on forecasting). Thus, it is more useful to express the relationship either as 'long run' model such equation (2) or as a 'short run' model such as equation (3) below, which describes how y_t adjust through time to restore to the equilibrium. If the variables cointegrate, then the short run takes a special form called the *error correction model* (ECM). Substituting y_t by $y_{t-1} + \Delta y_t$ and x_t by $x_{t-1} + \Delta x_t$ in (1) and grouping like terms in the ARDL model in its error correction representation:

$$\Delta y_t = \beta_0 \Delta x_t - (1 - \alpha_1)[y_{t-1} - \alpha - \beta x_{t-1}] + \varepsilon_t \quad (3)$$

which says that the current change in y_t is thus proportional to the current change in x_t and a correction to take account of the extent to which y_{t-1} deviate from its equilibrium value corresponding to x_{t-1} (as given by [$y_{t-1} - \alpha - \beta x_{t-1}]$ and $(1 - \alpha)$ ensures that the disequilibria will be corrected.

Specification (1) – (3) which are part of VAR system can as well be presented in matrix form, such that ECM now becomes Vector of ECM (VECM). To begin with, VAR model in its general form, ignoring deterministic elements, can be written as follows:

$$y_t = A(L) y_t + + \varepsilon_t \quad (1b)$$

where y_t is a vector of endogenous variables and A(L) is a matrix of a polynomial order p (number of lags)? $\mathcal{E}_t$ is a vector of reduced form i.i.d. residuals, with E($\mathcal{E}_t$) = 0, E($\mathcal{E}_t$ $\mathcal{E}_t$ ') = Ω and E($\mathcal{E}_t$ $\mathcal{E}_t$ ') = 0 for s ≠ t, with Ω a (k × k) symmetric positive definite matrix, k denoting the number of endogenous variables in vector zt. To gauge the long-run effects of public capital in infrastructure, it is sufficient to estimate an unrestricted VAR in levels. The OLS estimator for the autoregressive coefficients in such a model is consistent and asymptotically normally distributed, even in case where some variables are integrated or cointegrated. Therefore, a VAR in levels can be used to investigate the properties of the data and construct a valid empirical model. However, the consistency of estimates for the autoregressive coefficients does not carry over to the impulse response functions (IRFs) obtained from unrestricted VARs in levels. IRFs are inconsistent at long horizons if non-stationary variables are included (Phillips, 1998). To this end, a VAR model of order *p* can always be written in the form of a VECM:

$$\Delta y_t = \Gamma(L)\Delta y_t + \Pi y_{t-1} + \varepsilon_t \quad \text{(3b)}$$

where Γ(L) ≡ $\sum pi=j+1$ Ai (for j = 1,2, …, $p-$ 1) and Π ≡ −I + $\sum pi=1 Ai$ are matrices of coefficients. If matrix Π has a rank of 0 < r < k, r linearly independent cointegrating vectors exist. In this case, a VECM is estimated. If the rank of Π = 0, the nonstationary variables (in levels) are not cointegrated and a VAR in first differences is considered. If the rank of Π = k, all series are stationary in levels (i.e., I(0)) and a VAR in levels is considered.

4.2 Data and Descriptive Statistics

The study uses data from various sources, both local and international sources, as shown in Table 1. Due to the absence of well compiled infrastructure spending data in Tanzania, the infrastructure data is compiled from various Ministry of Finance and Planning (MoFP)-budget books from 1990 to 2020, to build an estimate. Our definition of infrastructure investment follows the same approach as those of Agenor, *et al.,* (2005). Specifically, the capital infrastructure is calculated by adding capital (development) expenditure on various categories including those by ministry responsible for construction, transportation, and communication, ministry of water and ministry of mineral and energy. As Agenor, *et al.,* (2005) argues, some of the components may be related to maintenance operations rather than the actual increased investment, thus the calculated sum of all capital expenditure does not necessary reflect the actual investment in infrastructure. However, the capital expenditure on the selected category account to about 40 percent of total capital expenditure, on average. The infrastructure capital is derived from the infrastructure investment (flow) data by using the perpetual inventory method (PIM) – using stockcapit stata program, assuming a constant depreciation rate of 5 percent. The

infrastructure investment and stock were then converted to real values by deflating with capital formation deflator.

The private capital formation(flow) and stock are obtained from IMF investment and capital stock dataset, 1960-2019[7]. The other data such as real GDP growth rate, real interest rate and commercial bank credit to private sectors are sourced from World Development Indicators (WDI).

Table 1: Data Sources and Description

#	Variables	Description	Sources
1.	Infrastructure investment	Capital outlay (development) spending by the ministry of construction, transport, communication, water, and energy	MoFP, Budget Books
2.	Infrastructure capital stock	Derived infrastructure capital stock computed from infrastructure investment (flow data) using perpetual inventory method and assuming a constant depreciation rate of 5 percent	Derived from infrastructure investment (flow)
3.	Private capital investment	Private fixed capital formation (in Biln. TZS)	IMF
4.	Private capital stock	Private fixed capital stock (in Biln. TZS)	IMF
5.	Commercial bank credit to GDP	Ratio of commercial bank credit to private sector over real GDP	WDI
6.	real interest rates	Real interest rate (nominal interest rate minus inflation rate) as borrowing cost by the private sector	WDI
7.	GDP growth	Percentage growth in the real Gross Domestic product (GDP) growth	WDI
8.	Real effective exchange rate	changes in the real exchange rate account for both the relative price effect of an increase in domestic absorption, and indirect effects on the user cost of capital and the price of imported inputs	IMF

***Sources**:* Author's Own Compilation

[7]Publicly accessible at https://data.imf.org/?sk=1CE8A55F-CFA7-4BC0-BCE2-256EE65AC0E4

Tables 2 provides a summary statistic for the variables used in this study. As shown, total government expenditure is three times larger than capital (development) expenditure, or in other words capital expenditure account to about 31 percent of total government expenditure. Of the capital expenditure, infrastructure expenditure account to about 41 percent.; while of the infrastructure spending on construction, transport, and communication (especially roads and bridges construction) account to about than 63 percent of total infrastructure spending. As is argued in the literature, we expect such spending on infrastructure not only to affect the public capital stock on infrastructure so is private capital formation and private capital stock, all of which are critical for economic growth.

At 17.8 percent as share of GDP, private fixed capital formation is 2.4 times more than public capital formation that is at 7.4 percent of GDP. The same is the case when looking at the private capita stock that is at 183.6 percent of GDP is 2 times more than public capital stock that is at 87.2 percent of GDP. Infrastructure investment as share of GDP is on average at about 1.5 percent, while infrastructure capital stock is at 5 percent of GDP. Domestic and bank credit to private sector as a share of GDP are at 9.5 percent and 9.3 percent respectively.

Table 2: Summary Statistics

	Mean	SD	Min	Max
Panel A: GDP, Government, and Development Expenditure				
Real GDP (Biln. TZS)	57464.1	29484.6	24390.1	122868.3
Total government spending (Biln. TZS)	8483.6	5926.5	2287.2	22314.4
Capital/Development expenditure (Biln. TZS)	2597.8	2419.7	137.7	10467.2
Dev. Expenditure by ministerial:				
Construction, Trans., and communication	676.1	903.4	30.6	3202.9
Ministry of water	134.9	104.6	9.8	367.6
Ministry of Energy	260.7	343.0	4.3	1517.3
Dev. Expenditure by votes:				
Roads and bridges	430.1	511.1	9.1	1833.8
Rural and urban water supply	86.0	76.8	3.4	275.8
Rural and urban energy supply	129.0	143.3	3.0	378.2
Panel B: Investment and capital stock				
Private fixed capital formation				
Amount in Biln. TZS	11637.0	9683.8	3347.9	38325.2
percent GDP	17.8	5.6	10.5	31.2
Private capital stock				
Amount in Biln. TZS	101874.6	50550.9	55271.5	236787.1
percent GDP	183.6	25.5	151.8	226.6
Public fixed capital formation				
Amount in Biln. TZS	4977.7	4194.1	1134.1	16191.4

percent GDP	7.4	2.7	3.9	13.2
Public capital stock				
Amount in Biln. TZS	50137.0	27498.2	24174.3	119636.6
percent GDP	87.2	7.06	76.2	99.1
Infrastructure investment				
Amount in Biln. TZS	1145.8	1273.1	66.5	432.0
percent GDP	1.5	1.0	0.2	3.7
Infrastructure capital stock*				
Amount in Biln. TZS	4078.1	4558.6	535.0	17193.5
percent GDP	5.1	3.5	1.7	14.0
Panel C: Credit, interest, and exchange rate				
Domestic credit to private sector (percent GDP)	9.5	4.0	2.9	14.6
Banks credit to private sector (percent GDP)	9.3	4.0	2.9	14.5
Real interest rate	6.4	7.7	-26.5	14.7
Real effective exchange rate	121.6	18.9	97.5	158.9

Sources: Author's Own Compilation

Notes: Except for percent variables, all figures in Table are in billions of Tanzanian Shillings TZS) unless specified otherwise.

4.3 Unit Root Test, Trend and Lag Level Selection

Unit Root Test

The VAR model requires that all variables (endogenous and exogenous) are free from unit root problem (stationary variable). The unit root tests are performed using the Augmented Dickey-Fuller (ADF) test and Philips-Perron (PP) test. Both tests are widely employed in empirical literature in estimating the VAR and cointegration analysis to assess the degree of integration of the variables. The unit root tests (both ADF and PP) results are reported in Table 3 and only the p-value are shown. As reported in the Table 3, on all variables (except for private capital stock and real GDP growth) the p-values based on Dickey-Fuller and Phillips-Perron tests (Columns 1 and 2) are less than 5 percent ($p>0.05$), suggesting that these variables are all stationary and therefore are integrated of order 0. After differencing the other two variables, the private capital stock and real GDP growth, which were not stationary at level, the p-values of the variables now turn to be significant ($p<0.05$), indicating that these variables become stationary and there are integrated of order 1.

Table 3: Unit Root Test using ADF and PP tests.

Variables	I(0)		I(1)	
	ADF	PP	ADF	PP
	(1)	(2)	(3)	(4)
Infrastructure investment (growth)	0.0000	0.0000		
Infrastructure capital stock (growth)	0.0071	0.0076		
Private fixed capital investment (growth)	0.0003	0.0001		
Private capital stock (growth)	0.9124	0.9027	0.0000	0.0000
Real GDP growth	0.2072	0.1307	0.0000	0.0000
Real effective exchange rate (change)	0.0065	0.0056		
Real interest rate (change)	0.0001	0.0001		

Sources: Author's Own Compilation

Notes: ADF and PP denotes Augmented Dickey–Fuller and Phillips–Perron test, respectively.

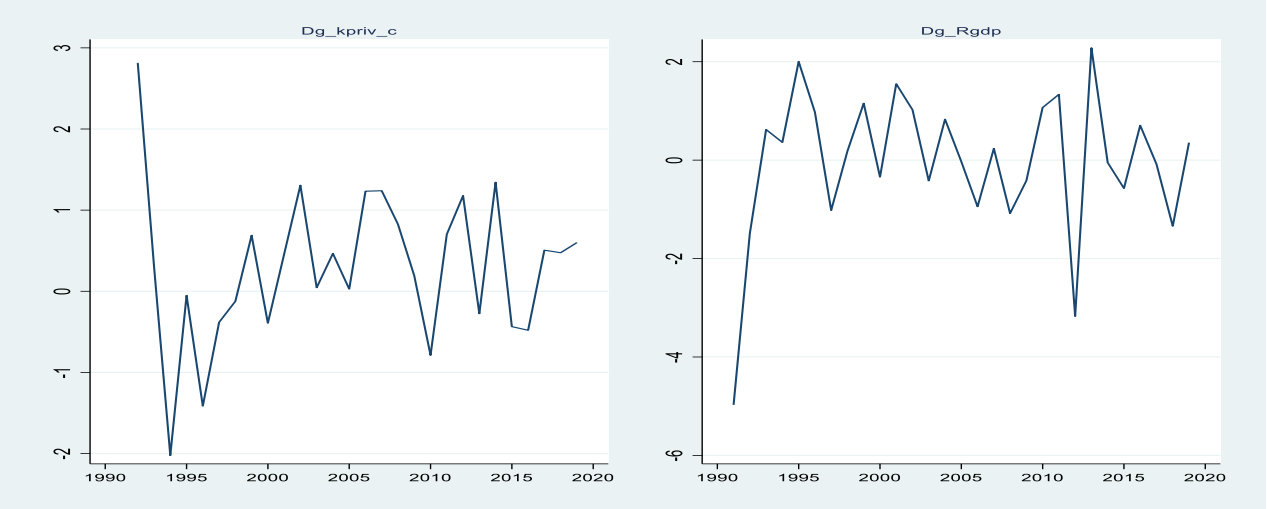
Figure 1: Trends in Variables (1(0))

Sources: Author's Own Compilation

Similarly, Figure 1 shows that the two variables are either trending up-ward and therefore are not stationary. The unit root test results for differenced non-stationary variables at order 0 are shown in Columns 3 and 4, showing that these variables are integrated of order 1. Both the ADF and PP's tests show that p-values are now less than 5 percent, indicating that these variables are integrated of order 1, and Figure 2 indicates that they

are now stationarity after taking the first difference. This study therefore uses the variables that are integrated of order 1 after first difference, and those that were at level stationary, that is integrated of order 0.

Figure 2: Trends in Variables (1(1))



Sources: Author's Own Compilation

Optimal Lag Selection

After performing the unit root test, the optimal lag to be employed in a VAR model are explored[8]. The optimal lag level selection is based on Akaike's Information Criterion (AIC), Schwarz's Bayesian Information Criterion (SBIC), and the Hannan and Quinn Information Criterion (HQIC), where lag – order selection statistics as reported in Table 4. As shown, all selection criteria suggest lag 4 as optimal lag for the VAR model. Hence, all the subsequent VAR analysis in this paper are based on this optimal lag level selection.

Table 4: Optimal Lag Selection

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-337.409				2.30E+07	31.1281	31.1865	31.3761
1	-318.43	37.958	25	0.047	4.20E+07	31.6755	32.026	33.1633
2	-300.917	35.027	25	0.088	1.30E+08	32.3561	32.9986	35.0837
3	-203.367	195.1	25	0	749840	25.7606	26.6952	29.728
4	1428.65	3264*	25	0	4.0e-55*	-120.331*	-119.105*	-115.124*

Sources: Author's Own Compilation

Notes: Endogenous variables include private investment, infrastructure expenditure, differenced GDP per capital growth, differenced lending interest rate and differenced exchange rate.

[8] The optimum lag length selection is performed using the command "*varsoc*" in STATA

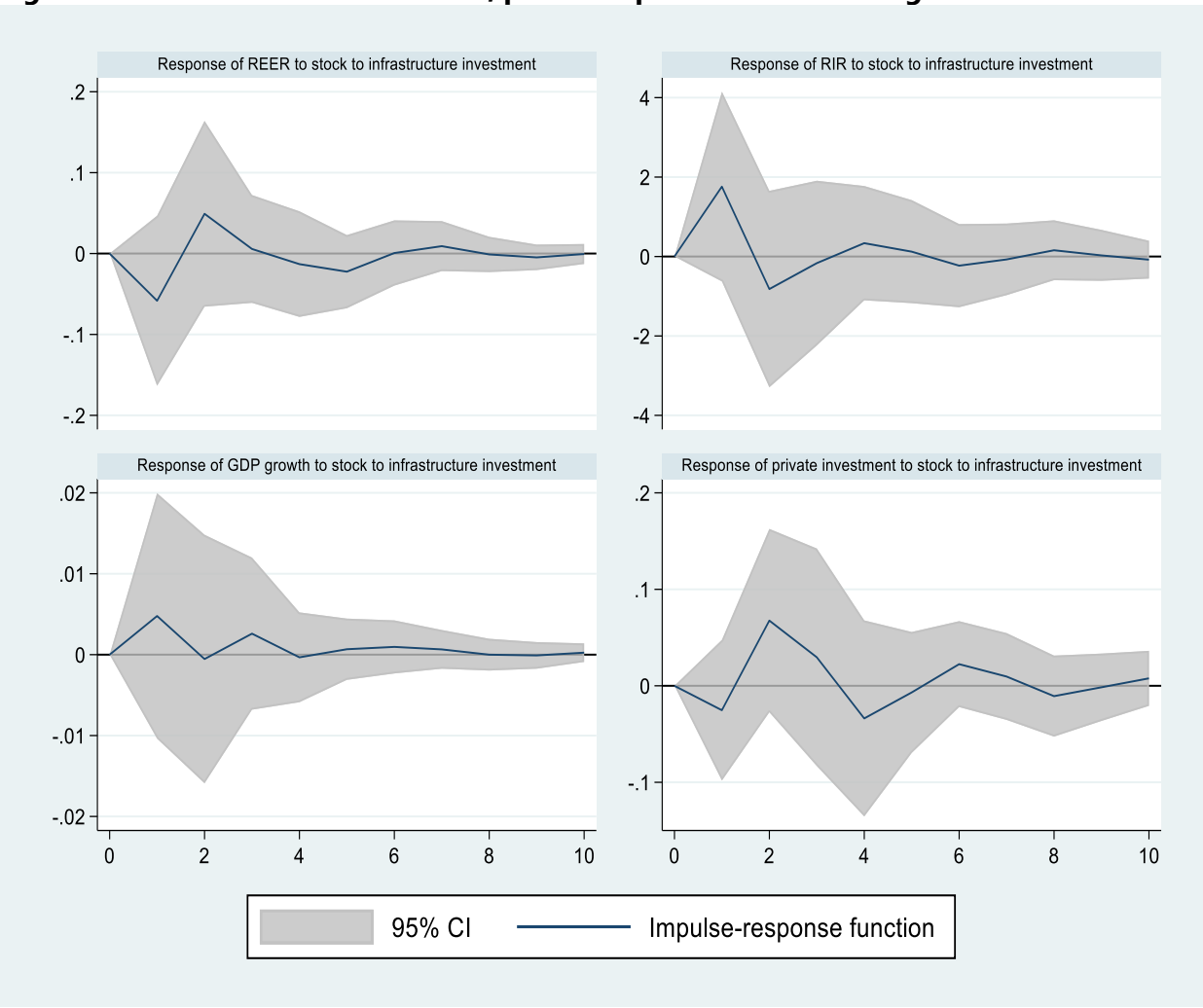
5. RESULTS AND DISCUSSION

5.1 Shock to Public Infrastructure Investment

We examine and discuss the response of private capital investment (flow), private capital stock (stock) and real GDP growth from innovation on infrastructure investment (flow) using the VAR estimation in this section. As noted earlier, the VAR model includes growth in real private investment, growth rate in real infrastructure spending, real GDP per capita growth, the rate of change of real interest rate and real effective exchange rate. The variables are ordered as follows, the rate of change of real effective exchange rate, the real interest rate, real infrastructure investment or stock, real private investment or capital stock and real GDP growth. The ordering assumes that infrastructure investment influences private capital formation and stock as well as real GDP growth but is not contemporaneously influenced by other variables. Similarly, for real effective exchange rate and interest rate. For all variables integrated of order 1, the differenced variables are included in the analysis. The exogenous time trend is also included in the VAR analysis. The first analysis focuses on the effects of public expenditure on infrastructure on private capital investment and economic growth.

Figure 3A presents the response of variables to innovation on infrastructure investment on real interest rate, real effective exchange rate, real GDP growth and private capital formation. The solid line of the Figure presents the response, and the coloured areas indicate 95 percent confidence interval with both upper and lower confidence bands. Overall, the result on the effect of infrastructure expenditure on private capital formation and economic growth (the variables of our main interest) as evidenced by the positive long-run impact of one standard deviation shock (impulse response function) seem to be positive and productive but only short-term and medium-term effect. Over the long run, the effects perished (approaches zero).

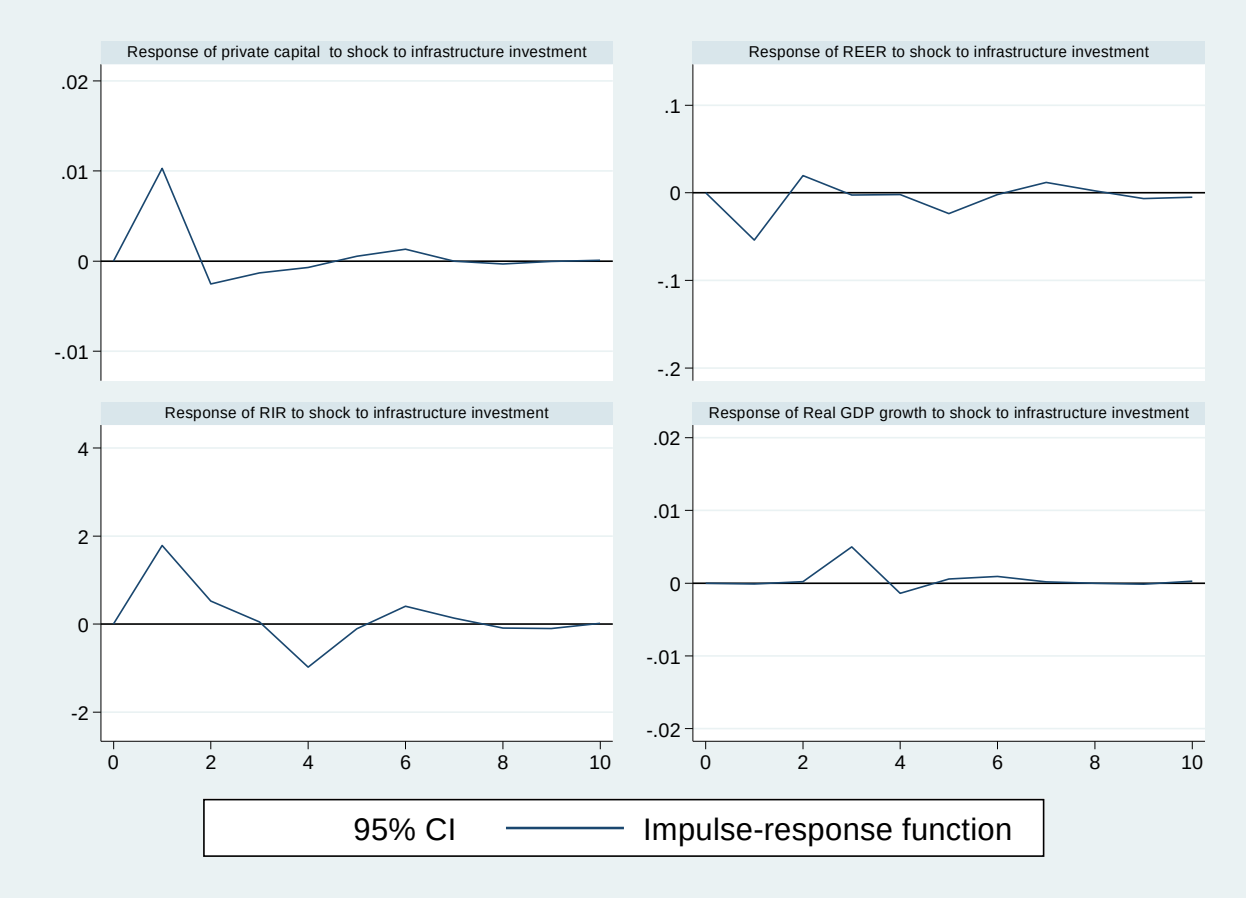
Figure 3A: Infrastructure investment, private capital formation and growth



Sources: Author's Own Compilation

As reported in the impulse response function (i.e. in Figure 3A), the result show that increasing public infrastructure investment negatively affect private capital investment in first period (the domination of crowding-out effect) and turn positive in third period (the domination of crowding-in effect). The result indicates that, the increased spending on infrastructure negatively and significantly affect the private capital investment in the short run probably due to the crowding-out effects. However, the effects turn to be positive in the medium term as crowding-in effects outweigh the crowding-out effects. However, these effects die in the long run as response function approaches zero. This is in consistence with the argument that, the overall response of private investment from public investment on capital formation (infrastructure investment) is determined by the relative strength of two opposing forces: the crowding out and crowding in effects.

Figure 3B: Infrastructure investment, private capital stock and growth



Sources: Author's Own Compilation

Unlike Figure 3A which shows the response of private capital investment(flow) due to infrastructure investment, Figure 3B in other hand shows the response of private capital (stock) and real GDP growth due to shocks to infrastructure investment. Of main interest in this section, is the response of private capital stock due to increased infrastructure investment by 1 standard deviation. As depicted in the impulse response functions, the plot show that increased public infrastructure investment raises private capital stock, even though, the effects are lower in magnitude and short-lived. The results are consistent with the argument that increased investment in infrastructure raised demand for private capital investment (as explained above) and thus on private capital stock. Consistently, the effect on real GDP is positive but the effects occur with some lags.

The main conclusion from this analysis is that, in the short run the crowding-out effects seems to be stronger than the crowding in effects as investment on infrastructure takes time to be productive. With respect to real GDP growth, the impulse response function show that the effects of shock to infrastructure investment on growth in real GDP per capita growth is positive but the effects do not persist overtime.

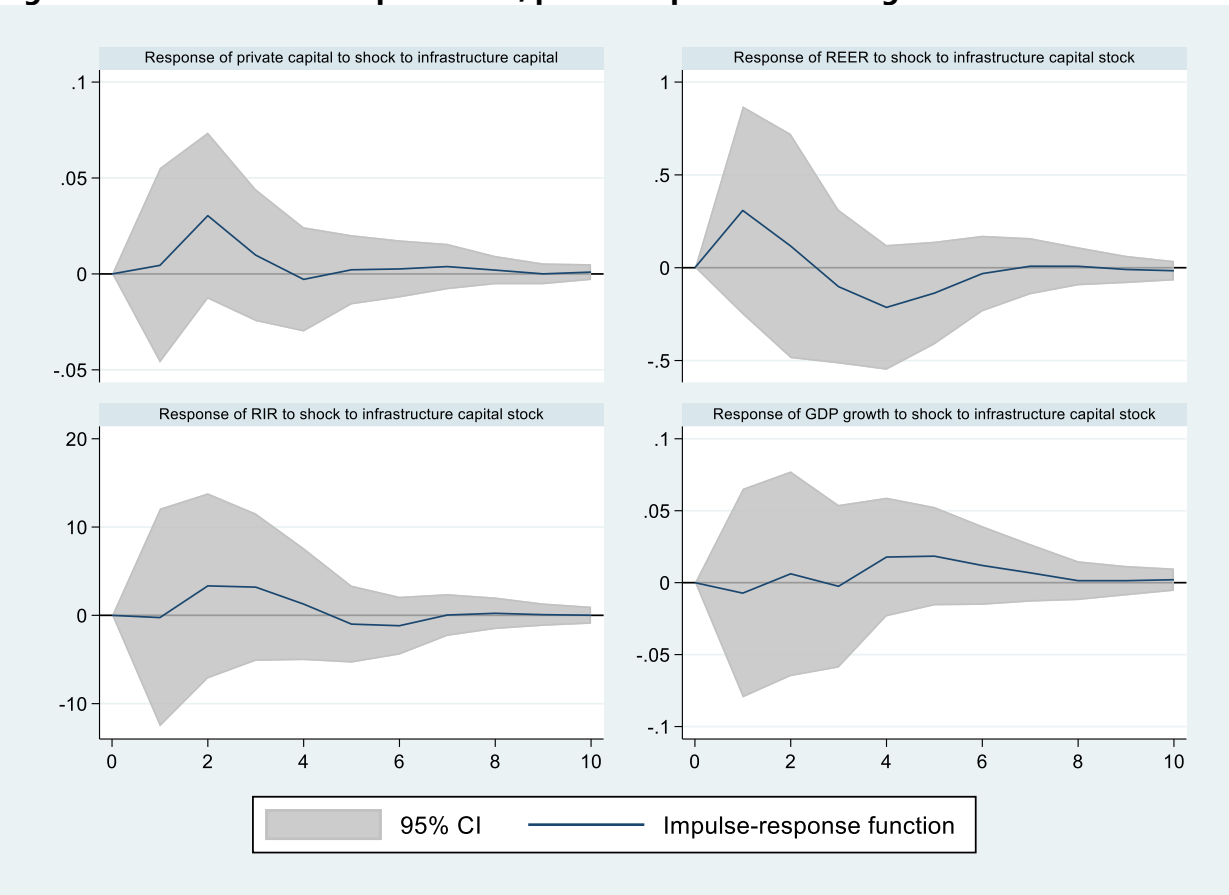
Regarding the response of other variables such as real interest rate and real effective exchange rate included in the analysis, the increased infrastructure spending by 1 standard deviation is found to increase the real interest rate but reduce real effective exchange rate (depreciation). Similarly, to the previous results, the impulse response function on shocks to public infrastructure spending (bottom-right) show that increased public spending on infrastructure has an immediate effect by reducing the private sector investment but letter the effects collapse to zero.

5.2 Shock to Public Infrastructure Capital Stock

In this section we examine and discuss the response of private investment (flow), private capital (stock) and real GDP growth from innovation on infrastructure capital stock. As in Section 5.1, the variables in the estimation of VAR model are ordered as follows, the rate of change of real effective exchange rate, the real interest rate, real infrastructure capital stock, real private capital stock and real GDP growth. This ordering reflects the assumption that infrastructure capital (stock) influences private capital stock and both the two affects the real GDP growth but is not contemporaneously influenced by other variables. The impulse response function over 10-year horizon due to shocks in infrastructure capital stock on other variables are shown in Figures 4A and 4B. The response function displays the response of private capita stock, real effective exchange rate, real interest rate and real GDP growth to a one-standard deviation innovation in the growth of public infrastructure capital stock.

First, looking at the impact of shocks on infrastructure capital stocks on private capital stocks (left-up plot) show that increased public infrastructure capital stock have positive effects on private capital stocks for the first four years with higher effects during the second year. However, the impact of increased infrastructure capital stock on private capital stocks perishes in the long run as the response function converges to zero after period 4, and the positive effects seem to occur with lags (as shown by response function). The result is consistent with crowding-in effects of public infrastructure capital stock on private capital stock suggesting complementarity rather than substitution. As discussed earlier, increased public infrastructure capital has impact on marginal productivity on private capital and labour; raising rate of return, lower cost of production and thus increase in demand for physical capital by the private sector (Aschauer, 1989; Barro, 990). The study find support for this channel by presenting the aggregate effects of increasing infrastructure capital on private capital stock.

Figure 4A: infrastructure capital stock, private capital stock and growth

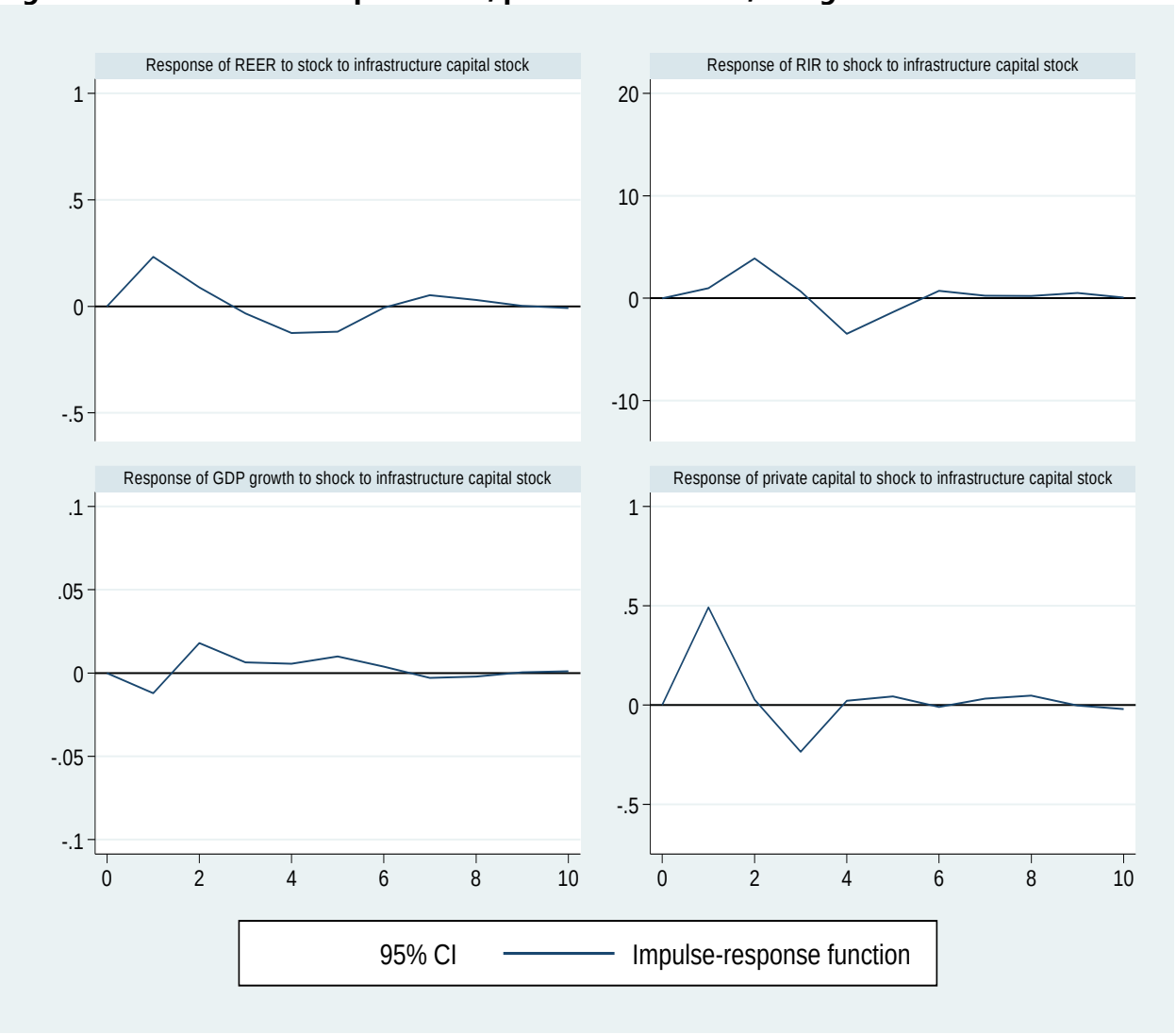


Sources: Author's Own Compilation

The response of growth rate of output (real GDP growth) due to innovation on public capital stock shows similar findings. Specially, the results show significant positive effects on real GDP growth due to increased infrastructure capital stock by 1 standard deviation during the first eight period (years). Also, the effects seem to turn positive after third period (year). The lagged effects on real GDP growth partly might be due to lagged response on private capital stock due to increased infrastructure capital stock. Consistent with the results above, the finding show that public infrastructure capital stock stimulates growth through private capital formation, such that increase in capital stock has a positive but decreasing effect.

Though smaller in magnitude and short-lived, the infrastructure capital shock appears to lead to real exchange appreciation, but the effects are balanced by the subsequent depreciation of exchange rate. This is particularly true as most of infrastructure in developing countries are financed by either foreign grants or loan from foreign institution affecting the supply of foreign reserves in the short run. Also, increased public capital stock appear to increase domestic real interest rate, though small in magnitude and short-lived effect.

Figure 4B: Infrastructure capital stock, private investment, and growth



Sources: Author's Own Compilation

Figure 4B report the response of REER, RIR, GDP growth and private capital investment to shocks to public infrastructure capital stock. Consistent with results above, the private capital investment (flow) appears to respond positively to increase in infrastructure capital stock. Overall, the study findings on the response of private capital (both flow and stock) and real GDP growth to infrastructure capital stock indicate that there are positive and statistically significant though relatively small in absolute magnitude and short-lived effects of public infrastructure capital stock.

6. SUMMARY AND POLICY IMPLICATIONS

The paper investigates the impact of public spending (flow) and public capital (stock) on infrastructure into private capital formation (investment), private capital stock and economic growth in Tanzania, using time series data (1990 – 2020) and applying VAR model. Tanzania presents a unique case to study this problem given its somewhat ad hoc policy changes and practices over a long period. During the first three five years' development plans (1964 – 1980), planned allocation of resources earmarked to economic infrastructure account to about 2/3 of the total development expenditure (i.e. about 41 percent in actual terms), 18 percent of the total government expenditure. Its contribution to Gross Domestic Product (GDP) averaged 8 percent and averaged 55 percent annually of public sector's fixed capital formation, during the same period.

Over a long time, from mid-1960s to 1980, and more recently from 1990s, following the economic reforms of mid 1980s and early 1990s, capital (development) expenditure and total expenditure as share of GDP has been increasing steadily from 2 percent as share of development expenditure and 18 percent as share of total expenditure in early 1990s to 9 percent and 47 percent in 2018. At the same time, infrastructure expenditure, as share of capital and total expenditure, and as share of GDP has also been increasing over time. As share of capital expenditure rise from 26 percent in early 1990s to70 percent in 2016 before modestly dropped to 62 percent in 2019 (significant increase was observed between 2014 to 2019). As the share of total expenditure has been at about 31 percent in early 1990s up until 2007, then collapse to 16.2 percent in 2016 before increasing to 25 in 2019.

Descriptive statistics shows that, on average, total government expenditure is three times larger than capital (development) expenditure, or in other words capital expenditure account to about 31 percent of total government expenditure. Of the capital expenditure, infrastructure expenditure account to about 41 percent.; while of the infrastructure spending on construction, transport, and communication (especially roads and bridges construction) account to about than 63 percent of total infrastructure spending. At 17.8 percent as share of GDP, private fixed capital formation is 2.4 times more than public capital formation that is at 7.4 percent of GDP. The same is the case when looking at the private capita stock that is at 183.6 percent of GDP is 2 times more than public capital stock that is at 87.2 percent of GDP. Infrastructure investment as share of GDP is on average at about 1.5 percent, while infrastructure capital stock is at 5 percent of GDP.

The findings show that increasing public infrastructure investment negatively affect private capital formation in short run due to dominance of the crowding-out effect but turn positive in medium term due to the dominance of crowding-in effect. Increased public infrastructure investment also raises private capital stock, even though, the effects are lower in magnitude and short-lived. The impact of increased public infrastructure

capital stocks on private capital stocks is positive effects, both private investment and private capital stock positively affect real GDP growth, implying crowding-in effects of public infrastructure capital stock, and the complementarity rather than substitution between the two. In addition, the finding show that public infrastructure capital stock stimulates growth through private capital formation, such that increase in capital stock has a positive but decreasing effect. The lower in magnitude and short-lived effects for most findings are reflective of the unfavourable environment for private investment in Tanzania. Hence, reducing unproductive public capital expenditure and improving the quality need to be accompanied by reforms aimed at limiting the investment to infrastructure capital that crowd-out the private sector.

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Appendix A1: Selected Empirical Evidence on Crowding-in Effect

Study	***Period and country***	***Model***	***Variables Selected***	***Results***
Shankar. S and Trivedi, P(2021),	1981 -2019 India	ARDL		Our results suggest investment complementarity between the public and private sector at an aggregate and sectoral level over the period 1981-2019. Barring short-run crowding-out in construction and financial services at industry level, public investment stimulates private counterparts, both in the long and short-run. The long-run crowding-out bearing of fiscal imbalance is quantitatively higher when the public sector invests in mining and manufacturing and insignificant with infrastructure
Nguyen, C. T. & Trinh, L. T. (2017)	1990 – 2016 Vietnam	ARDL	GDP growth, public investment, private investment, FDI, state-owned enterprises investment, labour, real interest rate, real exchange rates,	The estimated influence of public investment on private investment also shows a similar inverted-U shape in which public investment have crowding-in private investment short-term but crowding-out in the long run.
Albala-Bertrand and Mamatzakis (2004)				
Torvik (2002)				
S. Boopen and A. J. Khadaroo (2001)	1950 – 2000 Mauritius	Vector Autoregressive framework, ECM	private investment, capital stock, the level of real output, ending rate on banking sector's advances to the private sector, real rate of interest, real interest rates, bank credit to the private sector	Results from the analysis shows that transport capital is complementary to private investment and thus consistent with the crowding in hypothesis in both short and long run. Similar result is obtained for non-transport infrastructure. The results also confirm generally confirms a causality effect from transport capital to private capital but could not establish any causal effects from private capital to transport capital suggesting the latter exogenous nature.

Otto and Voss, (2002)				
Sankar (1997)	1960-1994 India	Accelerator model	Public infrastructure investment, public non-infrastructure investment, ratio of public infrastructure to non-infrastructure investment, bank rate.	Infrastructure investment crowds in private corporate investment.
Miguel D Ramirez (1994)	1950-1990 Mexico	Flexible accelerator model	Public investment, flow of credit, exchange rate	Public investment crowds in private investment
Greene and Villanueva (1991)	1975-1987 23 developing countries	Neoclassical model	GDP, public gross capital formation, debt ratio etc.	Gross public capital formation crowds in private investment.
Krishnamurty (1985)	1975-1990 India	Sectoral model	Public infrastructure investment	Infrastructure investment crowds in private investment in almost all sectors.

Appendix A2: Selected Empirical Evidence on Crowding Out Effect

Study	***Period and country***	***Model***	***Variables Selected***	***Results***
Enock Mwakalila (2020)	2004 – 2018 Tanzania	ARDL	government expenditure, credit to the private sector, lending rates, government expenditure, domestic borrowing, and inflation rate	The result shows that government expenditure and domestic borrowing crowd out credit to the private sector by increasing the lending rate in the long run
Chakraborty, L (2008)	1970/71 – 2002/03 India	Asymmetric ARDL	public infrastructure, private cooperate investment, rate of interest, rate of inflation, the availability of credit to	no real crowding out between public (in particular, infrastructure) and private investment; rather complementarity is observed between the two

			private sector, gross domestic product, gross fiscal deficit, exchange rate and money supply	the dynamics of financial crowding out is captured through the dual transmission mechanism via real rate of interest; reinforcing no financial crowding out in India.
Wang, B. (2005)	1961 – 2000 Canada	Cointegration, ECM	Transportation and communication (air, road, rail, water, telecommunications, other transportation and communications)	empirical results show that government expenditure on education and health has positive effects whereas government expenditures on capital and infrastructure have negative effects on private investment.
Agenor, *et al.,* (2005)	Egypt, Jordan and Tunisia	VAR	public infrastructure, private investment, changes in output, private sector credit, and the real exchange rate.	the impulse response analysis suggests that public infrastructure has both "flow" and "stock" effects on private investment in Egypt, but only a "stock" effect in Jordan and Tunisia. But these effects are small and short-lived, reflecting the unfavourable environment for private investment in our sample of countries.
Albala-Bertrand and Mamatzakis (2004)	Chile			
Ahmed Badawi (2003)	1970 – 1998 Sudan	Vector Autoregressive	real output, real private investment, real public sector investment, real banking sector's credit to private sector, real lending rate on banking sector's advances to the private sector	public sector investment appears to have deleteriously impacted private sector physical capital expansion, implying that the impact of crowding-out categories of public sector investment has been large enough to offset any crowding-in effects. Such crowding out effect has weakened favourable positive effect that public sector's investment has exerted on growth by jeopardizing private sector capital undertakings.
Torvik (2002)				
Reinikka and Svensson (2002)				

Otto and Voss, (2002)				
Alberto, Alesina (2002)	OECD countries	Tobin's Q Model	Fiscal spending (wage), Ratio of primary spending to GDP, Private Investment	Crowding out negative effect of fiscal spending – and in particular wage component – on private investment
Kulkarni and Balders (1998)				
Ostrosky (1997)	1950-1975 US	OSLM	Capacity utilization rate, average profit rate, net change in the government debt etc.	Investment is affected by the net change in the debt, and hence crowding out.
Sankar (1997)	1960-1994 India	Accelerator model	Public infrastructure investment, public non-infrastructure investment, ratio of public infrastructure to non-infrastructure investment, bank rate.	Infrastructure investment crowds in private corporate investment.
Lee *et al.,* (1996)				
Karen Parker (1995)	1974 –1994 India	Accelerator model	Interest rate, public investment, credit rate, real effective exchange rate, WPI inflation, index of industrial production, GDP	Public investment crowds out private investment. Public infrastructure crowds in private investment.
K. L. Gupta (1992)	1960-1985 10 Asian Countries	RET	Transitory and permanent income, taxes, transitory and permanent government expenditure.	RET is rejected for Sri Lanka, India, Indonesia and Philippines among 10 Asian countries. Evidence of crowding out in all Asian countries except India.
Mohanty (1995)	1960-1990 India	RET (Ricardian Equivalence Theorem)	Real disposable Income, capital stock, public debt, government expenditure, interest payments.	Direct crowding out impact of government expenditure on private consumption. Government consumption and transfer payments have positive while public investment and interest payments have negative impact on private consumption.

Ramirez (1994)				
Erenburg (1993)				
Karen Parker (1995) K. L. Gupta (1992)	1974 –1994 India 1960-1985 10 Asian Countries	Accelerator model RET	Interest rate, public investment, credit rate, real effective exchange rate, WPI inflation, index of industrial production, GDP Transitory and permanent income, taxes, transitory and permanent government expenditure.	Public investment crowds out private investment. Public infrastructure crowds in private investment. RET is rejected for Sri Lanka, India, Indonesia and Philippines among 10 Asian countries. Evidence of crowding out in all Asian countries except India.
Nemat Shafik (1992)	1970-1988 Egypt	Neoclassical model	Rate of interest, markup (WPI/Wage), private credit, public infrastructure, GDP.	Public investment crowds out private investment. Rate of interest determines private investment.
Achauer (1989)				
B K Pradhan, D K Ratha and Atul Sarma (1988)	1960-1990 India	Computable general equilibrium (CGE) model	Interest rate, modes of financing public investment, money creation, market borrowing, taxation and mark up.	The extent of crowding out varies with the different modes of financing the public investment.
Feldstein (1986)	1950-1982 Australia	Inter-temporal CGE model	Government deficit, government expenditure etc.,	Increase in debt financed proportion of government deficit crowds out private investment.
Blejer and Khan (1984)	1971-1979 24 developing countries	Flexible accelerator model	Output, real bank credit, real public investment	It is not the level, but the change in public investment that crowd out private investment.
Tun Wai and Chong (1982)	1965-1975 five countries of same development pattern	Flexible Accelerator Model	Public Investment, Quantity of Credit, Private Sector Output	Public Investment crowds out Private Investment. Quantity of Credit is also a significant factor.

Sunderrajan and Takur (1990)	1960-1978 India and Korea	Neoclassical (Jorgenson)l	Public investment, capital stock, rate of interest.	Evidence of crowding out in India. Complementary relationship between public and private investment in Korea.
Ostrosky (1979)	1950-1975 US	OSLM	Capacity utilization rate, average profit rate, net change in the government debt etc.	Investment is affected by the net change in the debt, and hence crowding out.
Cebula (1978)	1949-1976 US and Canada	ISLM	Capacity utilization, lagged domestic investment, budget deficit	Budget deficit crowd out private investment in Canada and US.
Buiter (1977)				

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