Transport Infrastructure Investment and Sustainable Economic Growth in Côte d'Ivoire: A Cointegration and Causality Analysis

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Abstract

This study examines the temporal relationship between transport infrastructure investment and output in Côte d'Ivoire over the period 1970-2002. Using cointegration and causality tests within a multivariate framework, it is found that the public investment in transport infrastructure, private investment and economic output are cointegrated. The results of the Granger causality tests reveal that public investment in transport does not have a causal impact on economic growth; conversely economic growth has a causal impact on transport investment.

Keywords: Transport infrastructure, Economic growth, Cointegration, Causality

JEL Classification: C32, E62, H54

1. Introduction

The role of public infrastructure in the process of economic growth has received a wide attention since the contributions of Aschauer (1989) and the theoretical model of Barro (1990). These seminal works showed that public capital generates spillover effects for the private sector. This view has been questioned in subsequent studies. It has been argued that while public investment may be considered as a factor input that contribute to economic growth, the way it is financed may crowd out private investment (Mittnik & Neumann, 2001). The main criticism of government intervention is that it is not as effective as market forces in allocating resources. However, the rationale for public intervention is based on the public good argument that the private sector cannot provide public goods to the economy. The conventional wisdom is that pubic investment in infrastructure, in particular those in transport, plays a crucial role in facilitating economic growth and international competitiveness. The development practitioners tend to emphasize the importance of reliable and affordable infrastructure for reducing poverty and its contribution in the achievement of Millennium Development Goals. Good transport linkages reduce transport costs, road congestion and promote industrial development throughout the country. This implies that the better the infrastructure the more successful the economic development polices (Ashipala & Haimbodi, 2003). Poor infrastructure facilities, especially in transport, communications and information technologies, are regarded as one of the major impediments for investment and growth in many African countries (World Bank, 1994).

Although a number of empirical studies report evidence supporting the significant contribution of infrastructure to economic development, it is a puzzling and disputing question of whether transport is the cause of growth or vice versa. Following the endogenous growth models, transport infrastructure leads economic growth while the Wagner's law regards the increase in GDP as a main drive for public investment. Under some conditions, it is even possible to observe a negative or non-significant growth impact of public investment. Thus, it is expected that the relationship between infrastructure investment and output exhibits two-way causality. As the direction of causality is theoretically unclear, one should investigate this issue from empirical investigations. Understanding the interdependence between public investment in infrastructure and economic growth is relevant as it provides some guidance for policy actions. If the causality is from GDP to public investment then the latter cannot be used as a policy instrument. Contrary, if the causality runs from public investment to GDP then governments can use public investment to boost economic growth. Two strands of the empirical literature have examined the relationship between public investment in transport infrastructure and economic growth. The first adopts a production function approach and uses either cross-section or panel data techniques. The second strand examines the issue for a particular country using time series techniques. This paper contributes to this second strand of the literature. Indeed, studies using the production function approach do not take into account the issue of non-stationary time series, which can result in meaningless statistical inference in the estimated relations. Another criticism of this strand of studies is that they have not adequately accounted for the problem of simultaneity of growth and public capital formation. We argue that an appropriate way to overcome these shortcomings is to use time series techniques by applying unit root, cointegration and causality tests in a VAR framework, which allows all variables to enter as endogenous within a system of equations.

The objective of this study is to investigate the causal relationship between public investment in transport infrastructure and economic growth in Cote d'Ivoire. Previous empirical studies are ambiguous on the direction of causality between the two variables. Furthermore none of these studies has its focus on Cote d'Ivoire. This further motivates this study. The case of Cote d'Ivoire is also of a particular interest, since it experienced both political and economic upheaval through the 1999-2004 time periods. After two decades (1960-1980) of good economic performance, Cote d'Ivoire enters a long period of economic crisis. Domestic adjustment strategies pursued during the 1980s failed to boost economic activity and close all deficits. The devaluation of its currency on January 1994 accompanied by structural reforms led to an encouraging recovery. But the country will experience its first war on September 19, 2002 which divided the country in two. This war deeply affected the economic outlook and physical infrastructures. Today, the country is going towards stability. The government in place considers as a priority the rebuilding of the country economic prosperity. About 95% of the total paved road network needs to be rehabilitated and this will require more than 417 millions of Euros. Apart from filling the gap in the empirical literature, our analysis is an advance over most existing studies using Johansen (1988) cointegration test and the bounds testing approach of Pesaran et al. (2001), because we take into account the finite sample size when computing critical values.

The rest of the study is structured as follows. Section 2 reviews the literature on the relationship between public investment and economic growth. Section 3 is concerned with the econometric methodology, while Section 4 presents and discusses the findings of the study, consequently. Section 5 concludes with a summary and some policies recommendations.

2. Literature Review

The relationship between public infrastructure investments and development outcomes is one of the most popular topics for debate in economic literature (Note 1). In neoclassical growth models fiscal variables such as taxes and public spending can affect the long-run level of output but not the long-run output growth. The steady-state output growth is determined by exogenous factors such as population growth and technological progress, while fiscal policy can affect only the transition path of this steady-state. Hence fiscal policy differences among countries may only explain the observed differences in income levels but not in long-run growth rate. By contrast, the endogenous growth theory produced growth models in which public investment in human and physical capital can have long-term or permanent growth effects, and consequently there is much more scope in these models for at least some elements of government expenditure to play a role in the growth process (Barro, 1990; Kneller et al., 1999).

Public investment is seen as a driving force for private investment, which in turn drives economic growth. Many of the benefits of public investment services accrue to firms: infrastructure through services lowers production costs (transportation and communication services), expands market opportunities that positively affect competitiveness, stimulate private investment and lead to economic growth (Aschauer, 1989; Agénor & Moreno-Dodson, 2006; Fourie, 2006). Straub (2008) distinguishes additional channel through which infrastructure investment may cause growth effect: economies of scale and scope. The author argues that better transport infrastructure lowers the costs of transportation and leads to economies of scale and better management.

The theoretical literature on infrastructure and growth has been substantially influenced by the work of Barro (1990). He shows that the benefits of infrastructure investments may be offset by the negative impact of additional distortionary taxes to finance them. The negative effect of public spending on growth arises from the distortions to choice and the disincentive effects (Helms, 1995; Mendoza et al., 1997). Public sector activity competes with the private sector in the use of the scarce resources and drives theirs prices up. Especially, if public investments are financed by domestic borrowing, this leads to an increase in the market interest rates and makes capital more expensive. The increase in interest rates discourages private investments and spending. Since private investments contribute more to growth, an increase in the size of the public sector at the expense of the private sector also hinders economic growth. The crowding out effect reduces the ability of government to influence economic activity through fiscal measure.

Like many economic questions, the empirical research looking at the growth effects of public investment does not conclusively support the conventional belief. The evidence is mixed across countries, data and methodologies, with some finding a positive impact, while others find little or no significant growth effect of infrastructure. Empirical work by Aschauer (1989) on the United States has provided evidence of a strong and positive relationship between public investment in infrastructure and growth over the period 1949-1985. He asserts that the decrease in public investment may be crucial in explaining the US economy's relatively poor economic performance between 1970s and 1990s. This finding has been confirmed in some subsequent studies, but challenged in others. For example, the World Bank's World Development Report (1994) finds a large range of empirical results on the importance of infrastructure for economic growth, with estimates ranging from no effect, to rates of return in excess of 100% per annum. Using cross-country data, Easterly and Rebelo (1993) find a positive effect of investment in transport and communication on economic growth. Sanchez-Robles (1998) also finds a positive impact of road length and electricity generating capacity in explaining subsequent economic growth. Aschauer (2000) finds that the stock of public infrastructure capital is a significant determinant of aggregate total factor of productivity and that investments in public sector not only improve quality of life but also increase economic growth and returns for private investments. The findings of Demetriades and Mamuneas (2000) indicate that public infrastructure capital has significant positive long-run effects on both output supply and input demands in 12 OECD countries. Calderón and Servén (2004) find that indicators of telecommunication and energy infrastructure have positive and significant effect on growth. Boopen (2006) analyses the contribution of transport capital to growth for a sample of 38 Sub- Saharan African countries using both cross-sectional and panel data analysis. In both sample cases, the analysis concludes that transport capital has been a contributor to the economic progress of these countries. Results of Seethepalli et al. (2008) also prove that infrastructure is important for promoting growth in East Asia. Zou et al. (2008) analyse data from China and find that higher economic growth level comes to a greater extent from better transport infrastructure and that public investment on road construction in poor areas is crucial to growth and poverty alleviation. The results obtained by Montolio and Solé-Ollé (2009) support the idea that productive public investment in road infrastructure has positively affected relative provincial productivity performance in Spain. In contrast, Tatom (1991; 1993), Holtz-Eakin (1994), Holtz-Eakin and Schwartz (1995) and Garcia-Mila et al. (1996) suggest that there is little evidence of an effect from infrastructure to income growth in a panel of U.S. state level data, particularly when fixed effects are included.

It is interesting to note that even though the relationship between transport infrastructure and economic growth has attracted a lot of research effort and attention from economists, policy makers and politicians in the early 1990s (Gramlich, 1994), it remains essentially unclear whether the direction of causation is from transport infrastructure to economic growth or vice-versa or both. Kessides (1996) notes that one of the main shortcomings of research on the economic impact of transportation infrastructure is that it has so far not adequately accounted for simultaneity of effects-economic growth can lead to development of the transport system as well as result from it. Previous studies based on Cobb-Douglas production function could not confirm the direction of causation between the development of the transport sector and economic growth. In addition, most of these studies have typically relied on cross-sectional or panel data regressions. A general problem associated with such studies is that they implicitly impose or assume cross-sectional homogeneity on coefficients that in reality may vary across countries because of differences in geographical, institutional, social and economic structures. Hence, the overall results obtained from these regressions represent only an average relationship, which may or may not apply to individual countries in the sample (Bloch and Tang, 2003). Results obtained by Ashipala and Haimbodi (2003), Canning and Pedroni (2008) and Egart et al. (2009) lend support to this view.

The World Development Report noticed that as the economy develops, an increasing proportion of the country would need to open up by the construction of roads (World Bank, 1994). Work by Fernald (1999) provides evidence that increasing the roading stock induces faster productivity growth in those industries that use roading more intensively, implying that the causation is more likely to be from infrastructure investment to output growth, rather than the other way around. Based on a cross-regional study comparing infrastructure provision in

Spain and the US, De la Fuente (2000) also concludes that causality flows from infrastructure investment to economic growth. Other studies have used the VAR approach to solve the problem associated with the endogeneity of public investment in the production function approach. Majority seems to agree with the theoretical postulation that public investment has a positive effect on output. Among these are Queiroz and Gautam (1992) who find road infrastructure to be significant factor of economic growth and development. Sturm et al. (1999) find strong evidence of a positive impact of investments in transport infrastructures, such as roads, canals and railways, on the output level of the Dutch economy in the second half of the nineteenth century. Furthermore, they find that transport infrastructure positively Granger-causes GDP whereas GDP negatively Granger-causes transport infrastructure. Mittnik and Neumann (2001) also establish that public investment has positive influence on GDP. However, there is no significant causal link running from GDP to public investment. Their results provide evidence for a complementary relationship between public and private investment. Using time series data for the US economy and cointegration analysis, Lau and Sin (1997) reject the endogenous growth model for the US economy. Looney (1997) analyses the effects of several types of public infrastructure in Pakistan and finds that public infrastructures have not been instigating private sector expansion but have been rather a response to the needs of the sector. Mamatzakis (2002) finds a positive effect of public infrastructure (ports, railways, roads, electricity and communications) on output and private capital productivity of the Greek industrial sector. He also finds that the causal relationship is from public infrastructure to productivity. Canning and Pedroni (2008) investigate the consequence of various types of infrastructure provision in a panel of countries. They show that while infrastructure does tend to cause long-run economic growth, there is substantial variation across countries. Ashipala and Haimbodi (2003) look at the relationship between public investment and economic growth in South Africa, Botswana and Namibia using the VECM methodology. They find that the effect of public investment on growth is not significant however, it has the correct sign. On the other hand, private investment is shown to have a long run growth impact in South Africa and Namibia. However, they find evidence indicating a reverse causality from GDP growth to public investment. The causality is negative in the case of Botswana suggesting that as the economy grows investment in public goods declines, which contradicts both the Keynesian theory and Wagner's law. Nurudeen and Usman (2010) use cointegration and error correction methods to analyze the relationship between government expenditure and economic growth in Nigeria. Their results reveal that government total capital expenditure, total recurrent expenditures, and government expenditure on education have negative effect on economic growth. On the contrary, rising government expenditure on transport and communication results to an increase in economic growth. Finally, Pradhan (2010) explores the nexus between transport infrastructure (road and rail), energy consumption and economic growth in India over the period 1970-2007. He finds evidence of unidirectional causality from transport infrastructure to economic growth.

3. Data and Econometric Methodology

3.1 Data

We use annual data on real GDP, real government investment in transport and communication and real private investment from Cote d'Ivoire for the period 1970-2002. Data on public investment in transport infrastructure and private gross fixed capital formation are compiled from the National Institute of Statistic. Nominal data are transformed into real variables using GDP deflator. Data for real GDP and GDP deflator are obtained from World Development Indicators of the World Bank (WDI, 2007). Also, all the data series are transformed in natural logarithms so that their first differences approach the growth rates. From an economic point of view, this transformation also allows us to interpret coefficient estimates in terms of elasticity.

The empirical methodology involves three steps. We begin by performing an integration analysis using unit root tests. Seminal work by Granger and Newbold (1974) casts doubt on empirical evidence based on regression analysis using nonstationary variables. Thus, to avoid the problem of the spurious regression and the failure to account for the appropriate dynamic specification, we follow most existing empirical studies by using the standard Augmented Dickey-Fuller (hereafter ADF), Phillip-Perron (hereafter PP) and Elliott et al. (1996) (hereafter DF-GLS) unit root tests. The second step tests for cointegration among the variables under study. The third step examines the temporal causality between variables.

3.2 Testing for cointegration

Once the order of integration of each variable is determined and variables are found to be I(1), the concept of cointegration pioneered by Engle and Granger (1987) is used to examine the existence of cointegrating relationship among the variables. The concept of cointegration is intuitively appealing because it is supported by the notion of long-run equilibrium in economic theory. There exist several methods for testing for cointegration between two or more variables. In this study we conduct both the Johansen cointegration test and the ARDL bounds testing approach of Pesaran et al. (2001).

3.2.1 The Johansen Maximum Likelihood Approach

Johansen (1988) has proposed a maximum likelihood procedure that tests for the possibility of multiple cointegrating relationships among the variables. The procedure is a multivariate generalization of the Dickey-Fuller unit root test. Gonzalo (1994) showed that Johansen estimation technique performs well relative to several other techniques. In contrast to the Engle-Granger (1987) two-step method for cointegration testing, the Johansen procedure is invariant to the choice of the variable selected for normalization. The econometric procedure of the test is as follows. Let X_t be a (n x 1) vector of I(1) variables. These variables are linked in a level VAR system as follows:

$$X_t = \sum_{i=1}^{\ell} \pi_i X_{t-i} + \Phi D_t + \varepsilon_t, \qquad \varepsilon_t \sim \mathrm{NI}(0,\ \Omega) \tag{1}$$

where ℓ is the maximal lag length; Φ is a n ×*d* matrix of coefficients on D_t, a vector of *d* deterministic variables (such as a constant term and a trend); ε_t is a vector of *n* unobserved, sequentially independent, jointly normal errors with mean zero and constant covariance matrix Ω.

The VAR in Eq.(1) may be rewritten as a vector error correction model:

$$\Delta X_t = \pi X_{t-1} + \sum_{i=1}^{\ell-1} \Gamma_i \Delta X_{t-i} + \Phi D_t + \varepsilon_t, \qquad \varepsilon_t \sim \mathrm{NI}(0,\ \Omega) \tag{2}$$

where π and Γ_i are:

$$\pi = \left(\sum_{i=1}^{\ell} \pi_i\right) - I_n,$$

$$\Gamma_i = -\sum_{j=i+1}^{\ell} \pi_j, \qquad i = 1,\ldots,\ell-1,$$

I_n is the identity matrix of dimension n, and Δ is the first difference operator defined as $\Delta X_t = X_t - X_{t-1}$. For any specified number of cointegrating vectors *r* ($0 \le r \le n$), the matrix π is of (potentially reduced) rank *r* and may be rewritten as $\alpha\beta'$, where α and β are *n*×*r* matrices of full rank. By substitution, Eq.(2) becomes:

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{i=1}^{\ell-1} \Gamma_i \Delta X_{t-i} + \Phi D_t + \varepsilon_t, \qquad \varepsilon_t \sim \mathrm{NI}(0,\ \Omega) \tag{3}$$

where β is the matrix of cointegrating vectors, and α is the matrix of adjustment coefficients. The cointegrating vectors β have the property that $\beta' x_{t-1}$ is stationary. Johansen (1988) derives two maximum likelihood statistics for testing the rank of π and hence for testing the number of cointegrating vectors. The likelihood ratio test statistic for the null hypothesis that there are at most *r* cointegrating vectors is the trace test and is computed as $Q_r = -T \sum_{i=r+1}^{n} \ln(1-\lambda_i)$ for $r = 0,1,\ldots,n-1$, where T is the number of observations and λ_i is the i-th largest eigenvalue. The likelihood ratio test statistic for the null hypothesis of r cointegrating vectors against the alternative of r+1 cointegrating vectors is the maximum eigenvalue test and is given by $Q_{\max} = -T \ln(1-\lambda_{r+1})$. Critical values for those statistics are provided in Osterwald-Lenum (1992) and MacKinnon et al. (1999).

3.2.2 The ARDL Bounds Testing Approach

A recently developed bounds approach to cointegration test has been proposed by Pesaran et al. (2001) within the autoregressive distributed lag (ARDL) framework. The main advantage of this method is that it can be applied irrespective of whether the regressors are purely I(0), I(1) or mutually cointegrated. Hence, it rules out the uncertainties present when pre-testing the order of integration of the series. Another advantage is that the test is relatively more efficient in small sample data sizes in which the order of integration is not well known or may not be necessarily the same for all variables of interest. It has been shown that this technique generally provides unbiased estimates of the long run model and valid t-statistics even when some of the regressors are endogenous. In other words, the bounds test takes into account the possibility of reverse causality among variables. This is particularly important in our study as many studies present evidence supporting the endogeneity of public spending on infrastructure.

The bounds test for cointegration involves estimating by ordinary least square the following unrestricted error correction model considering each variable in turn as a dependent variable (y_t):

$$\Delta y_t = \gamma_0 + \sum_{i=1}^{p} \delta_{1i} \Delta GDP_{t-i} + \sum_{i=0}^{p} \pi_{1i} \Delta GIT_{t-i} + \sum_{i=0}^{p} \pi_{1i} \Delta PI_{t-i} + \phi_1 GDP_{t-1} + \phi_2 GIT_{t-1} + \phi_2 PI_{t-1} + \mu_t \quad (4)$$

It should be noted that Eq. (4) is estimated using each variable as dependent variable. Herein lies one of the main assets of the bounds technique, for it proffers exactly which is the dependent variable and which is the independent variable in a particular relationship. Eq. (4) can also be interpreted as an ARDL(p, q) model. In practice there is no reason why *p* and *q* need to be the same. Therefore we allow for the possibility of different lag lengths. Under the condition $\Delta GDP = \Delta GIT = \Delta PI = 0$, the reduced-form solution of Eq.(4) yields the long-run model for y_t. The long-run coefficients are computed as the coefficients on regressors divided by the coefficient on the dependent and then multiplied by a negative sign (Bardsen, 1989).

The bounds testing procedure for long-run relationship between the variables is through the exclusion of the lagged levels variables in Eq. (4). The null hypothesis is $H_0: \ \phi_1 = \phi_2 = \phi_3 = 0$ against the alternative hypothesis that $\phi_1 \neq 0, \phi_2 \neq 0, \phi_3 \neq 0$. This hypothesis is tested by the mean of the *F-s*tatistic. However, its asymptotic distribution is non-standard under the null hypothesis. It depends upon: (a) the non-stationarity properties of the variables, (b) the number of regressors, (c) the sample size, and (d) the inclusion of intercept and trend variable in the equation. Thus, the calculated F-statistic is compared with two asymptotic critical values tabulated by Pesaran et al. (2001). The lower bound critical value assumes that all the regressors are I(0), while the upper bound critical value assumes that they are I(1). If the computed F-statistic is greater than the upper critical value then the null of no cointegration is rejected and we conclude that the two variables share a long-run level relationship. Otherwise the variables are not cointegrated.

3.3 Granger-Causality test

Cointegration is only able to indicate whether or not a long-run relationship exists between the variables, it does not provide information on the direction of causal relationships. The use of Granger causality tests to trace the direction of causality between economic variables is common in the empirical literature. The statistical procedure for testing non-causality is performed within a VAR model. However, when cointegration exists among the variables, the temporal relationship between the variables should be modelled within a dynamic error correction representation in which an error correction term is incorporated into the model (Engle & Granger, 1987). Accordingly, the Granger causality tests will be based on the following regressions:

$$\Delta GDP_t = \alpha_1 + \sum_{j=1}^{p} \beta_{1j} \Delta GDP_{t-i} + \sum_{j=1}^{p} \gamma_{1j} \Delta GIT_{t-j} + \sum_{j=1}^{p} \theta_{1j} \Delta PI_{t-j} + \lambda_1 e_{t-1} + \mu_{1t} \quad (5)$$

$$\Delta GIT_t = \alpha_2 + \sum_{j=1}^{p} \beta_{2j} \Delta GDP_{t-j} + \sum_{j=1}^{p} \gamma_{2j} \Delta GIT_{t-j} + \sum_{j=1}^{p} \theta_{2j} \Delta PI_{t-j} + \lambda_2 e_{t-1} + \mu_{2t} \quad (6)$$

$$\Delta PI_t = \alpha_2 + \sum_{j=1}^{p} \beta_{3j} \Delta GDP_{t-j} + \sum_{j=1}^{p} \gamma_{3j} \Delta GIT_{t-j} + \sum_{j=1}^{p} \theta_{3j} \Delta PI_{t-j} + \lambda_3 e_{t-1} + \mu_{3t} \quad (7)$$

where e_{t-1} stands for the lagged error correction term derived from the long-run relationship. In the absence of a cointegration, this term is not included and Equations (5)-(7) reduce to a VAR model in first differences. An error correction model enables one to distinguish between long-run and short-run Granger causality, and identify two different sources of causality. The long-run causality is performed by testing the significance of the coefficient on e_{t-1} while the short-run causality examines the significance of the lagged dynamic terms. For

Eq.(5), GIT_t does not cause GDP_t in the short-run if $\gamma_{11} = \gamma_{12} = ... = \gamma_{1p} = 0$. Similarly, for Eq.(6), GDP_t does not cause GIT_t if none of β_{2j} is statistically different from zero. There is a bi-directional causality when γ_{1j} and β_{2j} in both regressions are statistically significantly different from zero.

4. Empirical Results and Discussion

The Table 1 presents the results of the unit root tests. The results indicate that the series are non-stationary in their levels but become stationary after taking the first difference. Having established that the variables are I(1), we further test for cointegration between them. We start the cointegration analysis by using the system-based tests of Johansen (1988). The results reported in Table 2 show that both trace and maximum eigenvalue tests unanimously reject the null of non-cointegration. This indicates that there is a long run relationship between government investment in transport infrastructure, private investment and GDP over the sample period. As a cross check, we also apply the ARDL bounds testing approach to cointegration proposed by Pesaran et al. (2001). Results reported in Table 3 confirm that the null hypothesis of no cointegration can be rejected at the 5% significance level only when GIT serves as the dependent variable.

Owing to the fact a long-run relationship exists between the series, we proceed now to provide estimates of the long-run coefficients. We estimate the coefficients using four different techniques, namely the ordinary least squares approach from Engle and Granger's two-step method, the Dynamic Ordinary Least Squares (DOLS) estimator suggested by Stock and Watson (1993), the VECM approach of Johansen and the ARDL model of Pesaran et al. (2001). The results on the long-run coefficients are reported in Table 4. As can be seen, all variables enter the long-run equation significantly at the 5% level with positive signs. This shows that an increase in GDP and private investment has a positive effect on government investment in transport infrastructure, associating the level of public spending on infrastructure to the degree of economic development. Although cointegration suggests the presence of causality, it does not provide information on the direction of this causality.

The results of the Granger causality tests reported in Table 5 indicate that the error correction coefficient has the expected negative sign and is highly significant in the equation concerning public investment in transport infrastructure (GIT). This reinforces the finding of a long-run relationship among the variables. The expansion in public investment in infrastructure is determined by economic growth and private investment. Evidence also reveals that public investment does not cause GDP and private investment both in the short and long-run. The reverse causality is, however, found from economic growth to transport infrastructure. Thus, it is the economic growth that determines the level of public investment in transport infrastructure but not the reverse. This could be as a result of increased demand for transport when economy is growing. When output and taxes are at low levels, the government is less willing to finance transport infrastructure projects, while when the economy is growing and a higher level of taxes are collected, public investments in infrastructure are also increased. Overall, transport has not been an effective infrastructure for economic growth in the Ivorian economy during the period 1970-2002. This result is not consistent with the Barro (1990) endogenous growth model. However, it accords with the well-known Wagner's law in the public spending and economic growth literature.

These results can be discussed by analyzing the quantity and quality of the road infrastructure in the country. In 2001, the total road network of Cote d'Ivoire covers about 82000 km including 6500 km of paved roads. Although it is relatively developed compared with other Sub-Saharan African countries (Note 2), its quality needs to be improved. Less than 10% of the national road network is paved and the network is ageing and does not offer an adequate access to all seasons. The normalized road index of Cote d'Ivoire is only 86%, i.e. 14% less than the norm for countries with similar characteristics (Note 3). Today, the national road network has a desperate need of maintenance. For instance, in 2005, 63% of the total paved road network is aged over 15 years. This poor quality impedes the competitiveness of the economy and its economic growth. A study recently conducted in 24 African countries "Africa's Infrastructure: A Time for Transformation" (Note 4) shows that the poor state of infrastructure in Sub-Saharan Africa -its electricity, water, roads, and information and communications technology- cuts national economic growth by 2 percentage points every year and reduces business productivity by as much as 40%.

5. Conclusion and policy implications

The aim of this paper was to shed light on the effect of public investment in transport infrastructure on economic growth in Cote d'Ivoire using annual data over the period 1970 to 2002. Using cointegration and causality tests, we found that there exists a unidirectional causality running from GDP to public investment both in the short and long-run. We did not find evidence of a causal relationship in the reverse direction. Thus, our empirical result for Cote d'Ivoire does not support the endogenous growth theory, but is in line with the Wagner's law.

The non-significant growth effect of public investment in transport infrastructure is explained by not only the short supply but the relatively poor quality of the total road network. The major policy recommendation that we draw from this study is that to satisfy the increasing infrastructure needs in Cote d'Ivoire, a sustainable strategy is to promote private investment in transport infrastructures particularly in roads. The presence of good transport infrastructure may raise the image and perception of the country, thereby attracting additional private investment. Government should play a role of facilitator and regulator of services provided by private sector. The private sector's participation in development and management of infrastructure and the provision of public services is indeed the only way to meet the growing infrastructure needs in Côte d'Ivoire. The objective behind this policy is to exploit the benefits of private participation, as this would improve managerial efficiency as well as efficiency in the provision of services (World Bank, 1996; Pargal, 2003). Private participation in infrastructure besides accelerated investments in infrastructure freed governments from heavy administrative and fiscal burdens.

Private participation can take the form of green-field projects, complete or partial privatization, management and lease contracts or concessions. Asian countries like China, India, Indonesia, Malaysia, Philippines and Thailand have long recognized the need to improve the quality and quantity of their physical infrastructure (telecommunication, transport, energy and water and sewage sectors); realizing the fact infrastructure plays a crucial role in facilitating economic growth and international competitiveness. Given financial constraints, they have changed their policies to create an environment conductive to sustainable private sector involvement in their infrastructure sectors. As a consequence, private participation in the transport sector has increased tremendously in these countries (Bellier & Zhou, 2003; Kintanar et al., 2003; Nikomborirak, 2004; Malik, 2009). The encouraging results obtained by these countries can offer a promising route for most African countries where the poor quality of public infrastructure impedes their economic and social development.

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Notes

Note 1. For a review of the literature see Kessides (1996) Gramlich (1994) and Munnell (1992).

Note 2. Cote d'Ivoire has more than 40% of the length of roads in the WAEMU zone (West African Economic and Monetary Union). This zone includes Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo.

Note 3. The normalized road index is the total length of roads in a country compared with the expected length of roads, where the expectation is conditioned on various indicators such as topography, demography, socio-economic characteristics, natural resources, and other economic indicators. An index of 100 indicates an adequate road network (normal).

Note 4. See Africa's Infrastructure: A Time for Transformation, 2009. Available at www.infrastructureafrica.org.

Table 1. Tests for Unit Root Tests

Series	Level			First-difference		
	ADF	PP	DF-GLS	ADF	PP	DF-GLS
Model I: drift and no trend						
GDP	-2.874**	-2.518	-0.351	-3.568*	-3.528*	-3.149*
GIT	-1.802	-1.803	-1.813**	-5.111*	-5.037*	-4.539*
PI	-1.479	-1.754	-1.453	-4.592*	-4.586*	-4.616*
Model II: drift and trend						
GDP	-2.430	-2.463	-1.707	-3.666*	-3.643*	-3.676*
GIT	-2.221	-2.239	-2.132	-4.909*	-4.813*	-4.897*
PI	-1.559	-1.841	-1.531	-4.513*	-4.507*	-4.646*

Notes: ** (*) denotes rejection of the null hypothesis at the 10% (5%) level.

Table 2. Results of the Johansen Tests for Cointegration

Null	Alternative	Statistic	95% critical value	Adjusted 5% critical value
Maximum Eigenvalue Test				
$r = 0$	$r = 1$	53.797*	25.823	37.443
$r \le 1$	$r = 2$	14.090	19.387	28.111
$r \le 2$	$r = 3$	9.277	12.517	18.151
Trace test				
$r = 0$	$r \ge 1$	77.166*	42.915	62.227
$r \le 1$	$r \ge 2$	23.368	25.872	37.514
$r \le 2$	$r = 3$	9.277	12.517	18.151

Notes: The *r* indicates the number of cointegrating vectors. Criterion (AIC) was used to select the number of lags required in the cointegrating test. The AIC suggested k=3. Critical values are taken from Osterwald-Lenum (1992). * denotes rejection of the null hypothesis at the 5% level. Adjusted critical values are obtained using the small sample correction factor suggested by Cheung and Lai (1993). Their finite sample correction multiplies the Johansen test critical values by the scale factor of T/(T-pk), where *T* is the sample size, *p* is the number of variables, and *k* is the lag length for the VEC model.

Table 3. Bounds Test Results

Dependent variable	F-statistic	5% exact critical value	
		I(0)	I(1)
GDP	4.461	4.567	5.448
GIT	18.909*	4.567	5.448
PI	1.632	4.306	5.464

Notes: Critical values for F-statistics are calculated using stochastic simulations specific to the sample size based on 40 000 replications (see Pesaran et al. (2001) for more details). * denotes the rejection of the null hypothesis at the 5% significance level.

Table 4. Long-Run estimates

Method	GDP_t	PI_t
OLS	2.834*	0.470*
	(4.639)	(2.779)
DOLS	2.687*	0.583*
	(4.269)	(3.488)
Johansen	3.336*	0.446*
	(19.556)	(9.913)
ARDL	3.280*	0.493*
	(10.291)	(6.276)

Notes: Figures in parenthesis are t-statistics. * denotes statistical significance at the 5 % level.

Table 5. Results of Granger Causality Tests

Hypothesis	Short-run causality		Long-run causality	
	F-test	*p-value*	Dependent variable	ECT (t-stat.)
ΔGIT→ΔGDP	0.864	0.833	GIT	-3.936*
ΔGIT→ΔPI	3.586	0.309	GDP	1.002
ΔGDP→ΔGIT	8.037*	0.045	PI	-1.224
ΔPI→ΔGIT	2.697	0.440		

Note: The lagged ECT is derived by normalizing the cointegrating vector on government investment in transport infrastructure (GIT). In the short-run dynamics the values in the parentheses are the probabilities indicating the level of significance to reject the Ho that there is no Granger causal relationship between the two variables. The coefficients of the lagged ECTs are tested using the t-statistics testing the null hypothesis that the estimated coefficient is equal to zero. * indicates significance at the 5 % level.