Telecommunication Infrastructure and Economic Development,

Simultaneous Approach: Case of Developing Countries

Hend Belaîd
ERMES, Research Team on Markets, Employment and Simulation
Paris II University, Panthéon-Assas
hend_belaid@yahoo.com
Tel: +33614987939; Fax:+33169269345

Abstract. This paper discusses the role played by telecommunication infrastructure in economic and social growth process of developing countries. It focuses on the fact that these countries give more priority to investment in telecommunications, than in other kinds of basic infrastructure, to increase the economic gap. We use evidence of 37 developing countries over a 15-year period to examine the probability of a mutual impact between an economic growth and a development in the telecommunication sector. We use jointly a micro model for telecommunication investment with a macro production function to test the reverse causality. We find only one significant and positive causal link because of the missing of a minimum level of development, able to lead to a significant growth in the telecommunication sector.

JEL Classification: C33, O57, O47, R11,

Keywords: Economic Growth, Infrastructure, Telecommunications, Developing Countries,…

.

.

1. Introduction

The traditional debate about the sources of the economic growth and the sources of the increasing disparities between rich and poor countries has known news prospects, thanks to the contribution of *the Endogenous Growth Theory.* Actually, considering the works of D.Ashauer (1989)[1], R.Barro and X.Salal-I-Martin (1992c)[2] and Delong.J.B and L. H.Summers (1991)[3], we denote a new interest in the role that public capital could play on a long-run growth, as a complement to the private sector. The Barro (1990) model grants a basic role to the accumulation of public capital infrastructure on the economic growth. However many critics were addressed to these works by empirical literature. We mention mainly that, the endogeneity of infrastructure capital stock was ignored and the rate of return on capital was over-estimated. Therefore, our objective in this paper is to estimate a simultaneous model for telecommunication investment and economic growth by specifying a micro-model for supply and demand.

We are particularly interested in telecommunication infrastructure because of the important spillovers and network externalities, which this kind of investment has created. In addition to this report, recent investigations have argued for the significant contribution of telecommunications to improve the firm productivity, to fall transaction costs and to encourage foreign direct investments.

According to Lars-Hendricks Roeller and Leonard Waverman[4](2001), network externalities could lead to conclude that the impact of telecommunication infrastructure on growth might not be linear. A suspected positive effect is still depending on the achievement of critical mass in a given country's telecommunication infrastructure.

The aim of this article is first, to analyse how the telecommunication infrastructure impacts the economic growth, and whether the initial level of development favours the proliferation of the sector, using evidence of 37 developing countries. We shall, to conclude, to determine the critical mass referred to above.

This paper is organized in five sections. Section 1 summarizes the most important related studies. Section 2 discusses data and the main results of Granger causality tests (per country) and section 3 sets out the basic econometric model. All related results and analysis are presented in section 4, allowing a comparison with previous section 2 assertions. Finally, in section 5, we conclude and discuss some interesting extensions to the model.

2.Previous Related studies

It would be necessary, before examining the specific impact of telecommunications infrastructure on economic growth, to appreciate the role of the public infrastructure, as public capital accumulation on economic performance. The famous relationship between the decline of public infrastructure investment and the decline of growth was referred to by the doctrine as "the assumption of Aschaur ". The basic work of Aschauer (1989) consisted in estimating a time series Cobb-Douglass production function that had integrated, public capital stocks. He attempted to demonstrate a positive relationship between infrastructure capital and productivity of private sector. This work has, however, often been criticized because of the econometric techniques, leading to over-estimate a return rate of public capital.

After this work, many economists were interested in such a debate and expected an important role for the infrastructure investment in the economic growth. The implication of policymakers seemed to be evident: public investment should grow to give a boost to the economy. Indeed, international institutions such as the World Bank and IMF support such policies.

Furthermore, we quote a basic work realized by Alicia Munnel (1990b)[5]. She used a United States annual data to estimate production function (Cobb-Douglass), including public sector capital. She found three interesting contributions of the public infrastructure capital, respectively in private sector productivity, in employment and in private investment and firm decision localization. The neglect of fixed states effects and the use of one simple regression, were the main critics developed against this work.

Later, investigations using the same database, conducted by, for instance, Hulten and Schwab (1993) and Douglas Holtz-Eakin (1994), were based on more rigorous econometric methods. They used disaggregated data and controlled for individual fixed effects. In one hand, they found, a non-significant (null) impact of public capital on private sector productivity and growth performance. On the other hand, Hulten and Schwab (1993) demonstrated that public infrastructure had an influence on inter-regional labour and capital movements that could be the main engine differential regional manufacturing growth over the period 1970-86.

A more recent study realised by Remy Herrera (2001)[6] dealt with the problem of endogeneity of the capital stock and simultaneity bias, using a panel of 28 developing countries. Indeed, he disaggregated the total physical capital stock on public and private one. He then considered a simultaneous equations model. The system included respectively, GDP (Cobb-Douglas Production function), demand for public capital and demand for private capital equations. Key variables were introduced dealing with the characteristics of developing countries: the human capital, the public and private indebtness ratio, the degree of openness of the economy and the index of total factor productivity in the USA (to capture common influence).

The main results found by Herrera suggested that the public capital accumulation had a positive effect on a long-term growth but seemed to alleviate those found by previous investigations (Aschauer and Munnel). In addition, the second and third equations show that public debt had burden the private sector and had no effect on public capital formation. In fact, what Herrera wanted to emphasize is that in 1980, most of the sample countries had an excessive public capital stock according to the optimal level for growth.

As for Jon R.Neil (1996), he tried to determine an optimal ratio of investment in infrastructure, which maximizes the level of the consumption per capita. His model, tried to explain consumption per capita by labor, private capital and national infrastructure expenditure under the assumption that this variable is dependent on the tax rate. Among the results obtained by the application of this model to the American statistics, we retain basically, the positive impact of the rate of public investment on the taxable production per capita. The tax policy is thus rigorous, and the tax rate of public services is such, that the rate of the investment is strongly increasing.

Therefore, in order to appreciate a real return from public infrastructure, we have to use specific econometric methods of estimation and measurements of public capital stock.

If we focus on specific telecommunications infrastructure, there are far fewer studies that concentrated on the role of this kind of infrastructure in the economic performance. The main ones concentrate on a contribution of telecommunications in reducing transaction costs (S.W.Norton (1992)) and regional disparities in the same country (Ranald Richards and Andrew Gillespie (1996)) and in increasing TFP (total factor productivity) of the private sector. As for Rodney Maddok (1996), he focused on the role of telecommunications in the fast diffusion of new technologies. According to him, diffusion technology could be introduced by the creation of an integrated and more efficient market and the improvement of the internal management procedures of the firms. This would allow developing countries to remedy the problem of the asymmetric information and to catch up with the developed economies.

All these empirical studies used a single equation model and provided some evidence that telecommunication investment has positive effects on growth. However, if we take account of the JIPP[7] curve, it would be interesting to examine the reverse causality. We quote investigations of both Amitava Dutta (2001) and G.Madden, S.J Savage (1998), in which Granger test was used. Their significant results only covered the impact of the telephone penetration rate and the telecommunication investment on economic growth. The reverse causality was very weak for each of the two considered samples: developing countries and transitional economies in Central and Eastern Europe.

We were especially interested in the empirical study, achieved by Lars-Hendrik Roeller and Leonard Waverman (2001)[8]. They used evidence of 21 OECD countries over a 20-year period to estimate a micro-model for telecommunication investment with a macro production function. They found a significant positive causal link between telecommunications and economic growth, under the condition that a critical mass of telecommunications infrastructure is present.

Referring to this work, we attempt to examine the same relation for a sample of developing countries, introducing some modifications.

3.Data and main results of Granger test

*Data:

Weak infrastructure is a major impediment to trade, competitiveness and sustainable development in most LDCs (Less Developed Countries), particularly in land-locked developing states. During the last few years, we had noticed an upturn in the telecommunication sector development in LDCs, arising from the sector reforms and the introduction of new technologies. According to Tab1, we note an important disparity in both main fixed lines and mobiles teledensity between low, middle and high-income countries. The telecommunication supply is largely under the effective and potential demand (waiting list, Tab1).

Tab1: ***Access to telecommunications on 2000***

Regions	Mobile phone (1000h)	Radios (1000 h)	Principals fixed main lines (1000 h)	Waiting time for fixed line (year)
Low income	6	157,3	17,6	5,9
Middle income	90	359,4	153,2	1,1
High income	615,3	1288,5	557,2	0
East /pacific Asia	179,5	302,3	200,6	1,2
South Asian	7,5	112,7	27,8	1,6
Sub-saharian Africa	27,7	201,5	24,4	6
Central Europe/Asia	329,5	446	24,4	2
Latin America	88,7	418,6	323,5	0,5
World	156,7	420,1	241,9	1,4

Source : UIT (octobre 2001)

Using IUT (International Union of Telecommunication) and WDI (Word Development Indicators) databases we built our complete panel data. We gathered only 37 developing countries, over 15 years, divided by region as the table below shows.

Tab2.*Geographical sharing of a sample*

Region	Countries number	%
Latin-America	12	27,02
North Africa	3	8,18
South Asian	5	13,51
South and Central Africa	9	24,32
Middle East	5	13,51
Asia (other)	3	8,18
Total	37	100

The sample is essentially composed of Latin-America countries, South and Central Africa ones. Consequently, presence of unequal level development countries makes the sample very heterogeneous (see Tab 3). Then, the use of a panel of technical estimations will provide us with an appreciation of some long-run relationship.

Tab3 argues for the heterogeneity of the sample. Economic variables present the most important divergences. However, telecommunication sector variables are globally less divergent, especially for annual telecommunication investment (TTI) and the Penetration rate for main lines (PEN). Indeed, in the 1990s, most of the LDCs (less developed countries) had undertaken structural adjustment plans and opted for progressive privatization and liberalization of the public sector.

Tab3. ***Level variables (SAS)***

	Description	**Min**	**Max**	**Mean**	**Str-devlp**
K	*Non-residential capital stock net of telecommunications capital in billion*	8,73E-07	0,052824749	0,00176848	0,004659264
PEN	*Penetration rate, main lines per capita*	0,0012	0,444	0,066289369	0,074179643
TLF	Total labor force (millions)	0,402336	750,903424	32,95956435	110,5635201
GDPPOPT	*GDP per capita billion of $,*	8,47E-11	1,21E-08	2,40E-09	2,07E-09
TELP	Price of telephone service	114,6154327	2825,55	717,6338727	434,5670565
GD	Government surplus (deficit) in billion	-0,101298798	0,011945259	-0,0030848	0,010495622
WL	Waiting list for main lines per capita	0,002603611	209,1951173	14,01217247	25,73553252
TTI	Investment in Telecom infrastructure in billion	7,87E-07	0,019100121	0,00068637	0,001786358
GDP	GDP in billion (constant)	0,002258565	0,963746005	0,095215607	0,156069278
GDPT	GDP per worker	0,000191681	0,023946311	0,006093252	0,005155078
GA	Geographic area in 1000 km²	1,429108687	472,0733427	64,251001	78,65332977

On the other hand, if we analyse frequencies of main lines penetration rate, we can notice that 93% of our sample do not exceed 19, 8 % main lines per 1000 capita. Only 1.2% benefit from the universal service, fixed around 40% main lines per 100 capita.

Finally, we notice that the price of telephone services records a heavy disparity within the countries considered in our sample. We can explain this phenomenon, by the explosion of the mobile market; such as this is the case in Egypt, Morocco and South Africa that had generated a mobile/fixed lines substitution.

**Granger test:

Respecting the study accomplished by Amitava Dutta, as a starting point, we tried, before carrying out the estimation of our model, to have an idea on the possible interactions between certain key variables. To facilitate our work, we chose the Granger test, already programmed on SAS software. We tested double causality between the LGDP (Log(GDP), Gross Domestic Product) with, tow variables representing telecommunication infrastructure size (TTI: telecommunication investment and PEN: Penetration rate) and telecommunications capital stock in each country (constructed with PIM method, considering 10% as depreciation rate) . We initially verified, whether variable from first group influences variable from second one. Then, we tested the opposite relationship, as it is described here after.

Test 1: Group 1 Variables: LGDP
Group 2 Variables: LPEN

The GDP seems to not significantly impact the penetration rate of main lines (35%) except in North Africa region, where 66.66% of the countries supports the thesis of such causality.

Region	Number of countries	LGDP cause LPEN	%
Latin America	12	5	41.6
North of Africa	3	2	66.6
South East Asian	5	2	40
South/ Central Africa	9	2	22.22
Middle East	5	2	40
Asia (others)	3	0	0
Total countries	37	13	35

Test 2: Group 1 Variables: LPEN
Group 2 Variables: LGDP

62% of the sample supports a significant impact (under a 10% error risk) of the telephone penetration rate on the economic growth. Thus, a double causality would exist between the two variables.

Region	Number of countries	LPEN cause LGDP	%
Latin America	12	7	58.3
North of Africa	3	3	100
South East Asian	5	3	60
South/ Central Africa	9	4	44.44
Middle East	5	3	60
Asia (others)	3	3	100
Total countries	37	23	62

Test 3: Group 1 Variable: LGDP
Group 2 Variable: LTTI

Region	Number of countries	LGDP cause LTTI	%
Latin America	12	3	25
North of Africa	3	0	0
South East Asian	5	2	40
South/ Central Africa	9	3	33.33
Middle East	5	2	40
Asia (others)	3	0	0
Total countries	37	10	27

The causality relationship put forward by the third test is the weakest of all tested relations. Actually, only 27% of the sample supports a possible impact of GDP on the bulk of telecommunication investment. This relationship is more explicit in the region of South-East Asia and the Middle East.

Test 4: Group 1 Variable: LTTI
Group 2 Variable: LGDP

Almost, half of the sample seems to attest this causality link, especially countries from South-East Asia, Latin America and North Africa. This result can be explained by the fact that, the penetration telephone rate approaches in these regions universal service, either the critical mass as confirmed by Roller and Waverman (2001). The thesis of the double causality remains quite obvious and we would privilege the relation described in test 4.

Region	Number of countries	LTTI causes LGDP	%
Latin America	12	8	66.66
North of Africa	3	2	66.66
South East Asian	5	4	80
South/ Central Africa	9	1	11.11
Middle East	5	2	40
Asia (others)	3	0	0
Total countries	37	17	45.94

Test 5: Group 1 Variable: LGDP
Group 2 Variable: LKT

It cannot be sustained, on the basis of this test that the causal relationship is eminent, since only 37.87% of the considered countries shows that the increase in the GDP leads to a more significant accumulation of the capital stock of telecommunications infrastructures.

Region	Number of countries	LGDP cause LKT	%
Latin America	12	4	33.33
North of Africa	3	2	66.66
South East Asian	5	1	20
South/ Central Africa	9	3	33.33
Middle East	5	3	60
Asia (others)	3	1	33.33
Total countries	37	14	37.87

Test 6: Group 1 Variable: LKT
Group 2 Variable: LGDP

The significance of the above causality link seems to be unanimous for the major part of the sample. Thus, the accumulation of the capital stock impacts economic growth, as mentioned in the traditional and endogenous growth theories. For more than the half of our data set countries, a positive role seems to be played by telecommunications networks to enhance economic and social development, as predicted by theoretical investigations.

Region	Number of countries	LKT cause LGDP	%
Latin America	12	7	58.33
North Of Africa	3	2	66.66
South East Asian	5	3	80
South/Central Africa	9	5	55.55
Middle East	5	3	60
Asia (others)	3	2	66.66
Total countries	37	22	59.45

Following the Granger test, all results do not seem to be sharp enough for a thesis of simultaneous causality between infrastructure of telecommunication and economic growth. Causality link, telecommunication/growth would be apparently more obvious.

The following econometric study shall allow us to confirm or refute this thesis.

4.The Econometric Model

We shall rely upon the model described by Lars-Hendricks and Leonard Waverman (2001). Indeed, to account for the interaction between the economic growth and the telecommunication sector, it was imperative to endogenise variables related to the telecommunication investment.

We defined a supply and demand functions and a production macro-model for telecommunication. By considering externalities of the telecommunication network we implicitly suppose that the impact of this kind of infrastructure on the growth is not linear. Therefore, we shall use the generalized method of moments (GMM) on panel data (using SAS) to estimate a four-equations model:

$$\begin{cases} \log (GDP_{it}) = a_0 + a_1 \log (K_{it}) + a_2 \log (TLF_{it}) + a_3 \log (PEN_{it}) + a_4 t + \varepsilon_{1it} \\ \log (PEN_{it} + WL_{it}) = b_0 + b_1 \log (GDP_{it}/POP_{it}) + b_2 \log (TELP_{it}) + \varepsilon_{2it} \\ \log (TTI_{it}) = c_0 + c_1 GD_{it} + c_2 \log (WL_{it}) + c_3 \log (TELP_{it}) + \varepsilon_{3it} \\ \log (PEN_{it}/PEN_{i\,t-1}) = d_0 + d_1 \log(TTI_{it}) + \varepsilon_{4it} \end{cases}$$

Contrary to Lars-Hendricks and Leonard Waverman, we considered variables on first difference, as the method of estimation stipulates (by Arellano and Bonds), in order to eliminate the specific effect and avoid the problem of correlation between explanatory variables (of which the tendency seems to follow a non-deterministic stochastic process) and the unobservable specific effects of countries, that could exist if we use GMM level estimation.

Equation 1: Aggregate production function: it allows estimating one-way causal relationship flowing from telecommunication infrastructure (PEN) to the economic output. In fact, several economists like Savage and Madden, and D.Canning considered that the penetration telephone rate is the best proxy for capital telecommunications infrastructure.

To construct the non-residential capital stock net of telecommunications variable (K), we used the PIM (Perpetual Inventory Method) with 4% as annual depreciation rate. Is also included, a total labour force (TLF) as a proxy of human capital and a penetration telephone rate, PEN (per capita).

Equation 2: Demand function**:** it explains the effective and potential demand of main fixed lines by the price of the telephone service connection and by the GDP per capita.

Equation 3: Supply function*:* the price of telephone service is a key variable of this equation because it allows us to appreciate the level of demand elasticity. For a large number of countries (poor countries), telephone remains a luxury good but for others, attempting universal service, it represents an ordinary one. Regarding waiting lists, developing countries seem to represent an important potential market, for which supply should be anticipated and provided by Telecom Operators. The variable of the budget deficit reflects the role of public policies and the efficiency of public firms (telecommunication, transport…)

Equation 4: Telecommunications infrastructures production function:

It reveals the impact of the annual telecommunication investment on the differential of telecommunication infrastructure capital stock. It finally describes a process of the telecommunication capital accumulation.

5.Interpretation of Main Results

$$\textbf{Equation 1: } DLGDP_{it} = \underset{(7.23)}{0.51*DLK_{it}} + \underset{(49.59)}{0.95*DLTLF_{it}} + \underset{(2.24)}{0.50*DLPEN_{it}} - \underset{(-1.94)}{0.03*UN_{it}}$$

Telecommunication capital stock seems to be positively correlated with the GDP. This result, confirms those of the Granger test, and thus the role of the accumulation of the physical capital on the economic growth. In fact, the telephone penetration rate is strongly and positively correlated with the GDP (0.5). This result corroborates with the teaching of the Jipp curve and reflects the effect of positives externalities generated by these infrastructures. The labour and capital elasticity are estimated about respectively (0.51) and (0.95; a positive and significant coefficient (over-estimated)).

$$\textbf{Equation 2: } DLPENWL_{it} = \underset{(-13.93)}{2.67*DLGDPPOPT_{it}} - \underset{(-1.78)}{0.28*DLTELP_{it}}$$

Simultaneous causality is probably a thesis to be been defensible . Actually the sign of the coefficient of correlation between GDP and the effective demand of telecommunications is not only positive but also strongly significant. However, if we refer to the Granger test, the causal relationship GDP/PEN was among the weakest six tests carried out. The coefficient of the variable price is negative as stipulated by the micro-economic theory. Second explanation could be done, if we look at the extending waiting list. We could also conclude that demand is not elastic because of the coefficient of price elasticity is under 1

$$\textbf{Equation 3: } DLTTI_{it} = \underset{(9.42)}{-0.001*DGD_{it}} + \underset{(2.48)}{0.07*DLWL_{it}} + \underset{(5.10)}{0.56*DLTELP_{it}}$$

All considered variables appears to influence the sector supply is the price variable. Actually, fixed telephony and especially mobile telephony remain strongly taxed in the LDCs. The incapacity of supply to satisfy the increasing demand, leads to maintain rising price tendency. This variable might have a negative indirect impact on the rate saving and the household purchasing power.

$$\textbf{Equation 4 : } DLPENPEN_{it} = \underset{(1.98)}{0.06*DLTTI_{it}}$$

The telecommunication infrastructure production function, such as defined, displays a good correlation between the two variables and reveals an indirect positive impact of telecommunication investment on the GDP. It is obvious that the role of telecommunications in economic growth is considerable, since both capital accumulation and strong externalities measured it.

Critical mass:

According to Roeller and Waverman (2001), it would be necessary that the size of the telecommunications infrastructure reach a critical mass (PEN=40% for OECD countries), then positive effects and externalities of the telecommunications investments could be engaged. Since, LDCs suffer from under-economic development and, lack of telecommunications investment in the rural areas, they are not in a position to assume the obligation of universal service.

Empirically we affected the rate of telephone penetration into the first equation of the model by a "dummy variable". Considering that the dummy variable would be equal to 1 if the PEN is higher than 40% or even than 19.8%, if not it will take 0 value, this did worsen the results. We could assert that critical mass levelled by universal service constitutes a strong constraint for our sample countries.

6.Conclusion and Critical

Critical

While considering the constraints relating to the availability of the data sets, and those related to the estimation method, we have chosen the Roller and Waverman model to carry out our empirical study. However, the results found were not as relevant as those established by the two economists (very weak instruments (Sargan)). We think that this is due essentially to two factors:

* The determinants of growth are not the same for the various countries. Indeed, the industrialized countries and the developing countries have not the same problems involved in the development of the telecommunications sector. The first group forms the new information society and the second goes down sometimes to the level of 10 telephones for 1000 inhabitants! Thus it seems primordial to specify the model according to the real characteristics of the demand, the supply and the production of the telecommunications sector in the developing countries. We think

that it would be necessary to introduce more significant variables dealing with the governmental policy worked out for the telecommunication sector, in particular the national and international grants provided to the sector. The consideration of the opening rate of the sector and distinction in this case between private capital and public capital of telecommunication could bring significant improvements.

** According to C.Hultun(1999) the question of inefficiency of the supply (public sector) seems to be a critical point, which should be taken into consideration.

*** The fact of changing variables in first difference prevented us from taking in account individual specific effects. By noticing the significant heterogeneity of our sample, we thought that for a later work, it would be interesting to put the variables to be estimated in level and the instruments in first difference.

Conclusion:

The first part of this work allowed us, on one hand, to have an idea about the main theoretical projections of the debate on the role of the infrastructures in the economic growth, in particular telecommunication. On the other hand we devoted ourselves to the study of the recent questions dealing with the subject, like the existence of a double causality between the investment in telecommunications infrastructure and the economic development.

The description of the structure of the telecommunication sector, the extent of the characteristics of the telephone network, as well as, the governmental policy made to promote the sector, give us a starting idea regarding be the nature of the relations that should be estimated within our model. Indeed the telecommunications sector knows a significant wave of liberalisation and privatisation, for which the developing countries are not ready to assume, because of the failure of the majority of structural adjustment plan.

The results of the Granger causality test seem to privilege the causal relationship: telecommunication investment → economic growth. However, our relied upon model revealed a positive causality between economic growth and investment in telecommunication for LDCs. Far from ensuring the universal service, these countries can neither stand the competition imposed by the large foreign providers, nor quickly adopt Internet and new emerging information technologies.

They are simply taken within the trap of the universalization and ideal of the "Information Society", whereas many efforts have to be made, like effective improvement of the infrastructures, increase of investment volume instead of wasting these resources in non-productive plans.

Regarding future research, we propose some extensions: to consider the impact of the privatisation and the liberalization of the telecommunications sector in the economic growth and variables like government consumption, private telecommunication investment and indebtness ratio. These variables could allow us to introduce important economic factor explaining under-development in LDCs.

Notes

1) Ashauer.D, (1989): Is public Expenditure Productive?, Journal of Monetary Economics, 23: 177-200.
2) R.Barro and X.Salal-I-Martin. (1992c): Public Finance in Models of Economic Growth, *Review of Economic studies,* 59, 4 October:645-661.
3) Delong; J.Bradford and LH.Summers, (1991): Equipment Investment and Economic Gowth, *Quaterly Journal of Economics*. 106, 2 May: 445-502.
4) Lars-Hendricks Roeller and Leonard Waverman. "Telecommunications Infrastructure and Economic Development: a Simultaneous Approach". *The American Economic Review*. (2001) V91, n°4. Septembre.
5) Munnell, A. H. (1990b): How does Public Infrastructure Affect Regional Economic
6) Herreara.R, (2001) : Capital public, Infrastructures et Croissance Economique Dans les Pays En Développement, in : Infrastructure et Développement (98-106), L'Harmattan.
7) Jipp.A, (1963): Wealth of Nations and Telephone Density, ITU, Telecommunication Journal.
8) Roeller.L.H and Leonard Waverman, (2001): Telecommunications Infrastructure and Economic Development: a Simultaneous Approach, The American Economic Review, V91, n°4, September.
9) Dutta, A, (2001): Telecommunications and economic activity: An analysis of Granger Causality, Journal *of Management Information Systems, Armonk,* Spring 17, n°4

References

Books

1. Antonelli.C (1991): La diffusion des télécommunications de pointe dans les pays en développement.
2. Barro and X.Salal-I-Martin, (1995): Economic Growth, *McGraw-Hill*, Inc.

3. Bertrand Quelun et al, (1993): Innovation, déréglementation et concurrence dans les télécommunications, *Eyrolles,* p209
4. J.P Goulvestre, (1997): Economie des Télécoms, *Hèrmes, Paris*.
5. Charles I.Jones, (2000) : Théorie de la croissance endogène, *Ouvertures Economiques*.
6. P.Noumba, (1997): La privatisation des télécommunications, le cas des pays en développement*, L'Harmattan*.
7. P.Renaud, (2001) : La désertification des pays du sud in : Enjeux des technologies de la communication en Afrique, Karthala-Regards.
8. Saunders J.J Warford & B.Wellenius, (1994): Telecommunications and Economic Development, John Hopkins University Press.

Chapter in book

1. Meunier.C, (2001) : Peut on Evaluer le lien infrastructure-développement ? Les Risques d'une Transposition aux Pays En Développement, (71-86) in: Infrastructure et Développement. *L'Harmattan*.
2. Herreara.R, (2001) : Capital public, Infrastructures et Croissance Economique Dans les Pays En Développement, in : Infrastructure et Développement (98-106*), L'Harmattan*.

Articles

1. Antonelli C, (1991): La diffusion des télécommunications de pointe dans les pays en voie de développement, *Etudes du centre de développement OCDE.*
2. Ashauer.D, (1989): Is public Expenditure Productive? Journal of Monetary Economics, 23: 177-200.
3. Barro, R.J, (1990): Government Spending in a Simple Model of Endogenous Growth, *Journal of Political Economy*, 98: 103-125.
4. Barro, R.J. (1991): Economic Growth in a Cross Section of Countries, *Quaterly Journal of Economics*, 106, 2 May: 407-443.
5. Barro and X.Salal-I-Martin. (1992c): Public Finance in Models of Economic Growth. *Review of Economic studies,* 59, 4 October:645-661.
6. Beaubrun.R and Samuel Pierre. (2001): Technological Developments and Socio-economic issues of wireless mobile communications, *Telematics and Informatics,* V18, May-December: 143-158.
7. Bougheas and al, (2000): Infrastructure, Specialization, and economic growth, *Canadian Economics Association*, May Vol 33.
8. R.Capello and P.Nijkampt, (1996): Telecommunications Technologies and Regional Development: theoretical considerations and empirical eevidence, *Regional Sciences…*
9. Cronin.F.J and Colleran.E.K, (1991): Telecommunications Infrastructure and Economic Growth: An Analysis of causality, *Telecommunication Policy*, 15: 529-534.
10. Canning.D, (1999): Telecommunication and Aggregate output, *CAER II, Discussion Paper*, 56,December.
11. Delong; J.Bradford and LH.Summers, (1991): Equipment Investment and Economic Growth, *Quaterly Journal of Economics*. 106, 2 May: 445-502.
12. Dutta, A, (2001): Telecommunications and Economic Activity: An analysis of Granger Causality, Journal *of Management Information Systems, Armonk,* Spring 17, n°4

13. F.Gasmi and al, (2000): Competition, Universal Service and Telecommunication Policy in Developing Countries, *Information Economics and policy*, 12: 221-248.
14. L.Gille, (1984) : Croissance et Télécommunications, *Bulletin de l'Idate* n°16, juillet : 220-67.
15. Gramlich, (1994): Infrastructure Investment: A Review Essay, *Journal of Economic Literature*, V (32).
16. Grossman and Helpman, (1994): Endogenous Innovation in the Theory of Growth, Journal of Economic Perspectives.
17. Hulten C.R, (1997): Infrastructure Capital and Economic Growth: How Well You Use It May Be More Important than How Much You Have, mimeo, University of Maryland.
18. Holtz-Eakin.D, (1994): Public Sector Capital and Productivity Puzzle, Review of Economics and Statistics: 574-582.
19. Henner.H.F, (2001) : L'Impact des Investissements d'Infrastructure dans les économies en Développement », Infrastructure et Développement. L'Harmattan: 39-59
20. Jipp.A, (1963): Wealth of Nations and Telephone Density, ITU*, Telecommunication Journal.*
21. Jones.C.I, (2000): Introduction to Economic Growth, De Boeck University, Traduction par Fabrice Mazerolle (2000), Ouverture Economique.
22. Kemmerling.A and Stephan.A, (2001): The Contribution of Local Public Infrastructure to Private Productivity and its Political Economy: Evidence from Panel of Large German Cities, Discussion Papers FS I0114, Wissenchaftszentrum. Berlin.
23. Knight.P.T and Miller.J.W, (2002): Accelerating Economic and Social Development with Communications Infrastructure Emerging Economies: a Case Study of Jordan, Real Time Communication. 19 February.
24. Leff.N.F, (1984): Externalities, Information Costs, and Social benefit-Costs Analysis for Economic Development: An Example from Telecommunications, Development and Cultural Change, V32.n°2. January.
25. Madden.G and Savage.S.J, (1998): CEE Telecommunications Investment and Economic Growth, *Information Economics and Policy,* Vol 10.
26. Maddock.R, (1992): Telecommunications and economic development, *Telecommunisations and socio-Economic Development,* Elsevier.
27. Munnell.AH, (1992): Infrastructure Investment and Economic Growth, *Journal of Economic Perspectives*, Vol 6, n° 4: 189-198.
28. Munnell, A. H. (1990b): How does Public Infrastructure Affect Regional Economic
29. Performance, New England Economic Review: 11-32.
30. Norton, (1992): Transaction Costs, Telecommunications, and the Micronomics of Macroeconomic Growth, Economic Development and Cultural Change, N°1 Oct.
31. Neill.J.R, (1996): Fueling the Engine of Growth with Investment in infrastructure: A Lesson from Neoclassical Growth Theory, *Journal of Macroeconomics.Summer*, V (18), n°3: 521-529.
32. Parrot.L and Belaid.H, (2001): Les enjeux de la substitution Fixe-Mobile dans les pays émergents : le cas de l'Afrique du sud, l'Egypte, le Maroc et la Tunisie, Veille Internationale : Télécommunication, CFCE, septembre.
33. Rieber.A, (1999) : La contribution des infrastructures à la croissance économique : une vérification empirique, *Economie Appliquée*, 52(3): pp.83-96.

34. Richardson and Gillepse, (1996): Advanced Communications and Employment Creation in Rural and Peripheral Regions: A Case Study of the Highlands and Islands of Scotland, The Annals of Regional Science...
35. Roeller.L.H and Leonard Waverman, (2001): Telecommunications Infrastructure and Economic Development: a Simultaneous Approach*, The American Economic Review*, V91, n°4, September.
36. Rogers.M, (2002): A Survey of Economic Growth, Harris Manchester College, Oxford, Paper for Economic Record, July.
37. Sarantis and Kalyvitis, (2001): Public Investment Rules and Endogenous Growth with Empirical Evidence from Canada, CEPR Discussion Paper n°. 1479, August.
38. Solow, R.M, (1956): A Contribution to the theory of Economic Growth, *Quaterly Journal of Economics,V(* 70), 1st February: 65-94.