Access and Communication Pricing and Club Effect

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Network economics

ABSTRACT

Network services are specified by external positive effects direct as well as indirect. So, the utility provided by a network service depends positively on the network size, the users of such a service. In this article, we focus on the direct externality, called also *club effect*: the access of new users improve user's satisfaction. Thus, new access may affect the pricing of the telecommunications operator. It has been shown, theoretically, that there is a certain relationship between the access price and the network size. Therefore, we want to study, in this paper, the impact of the evolution of network size on the user's access rate to the fixed telephone network on one hand, and to analyze, on the other hand, the relationship between the price of connection and that of traffic carried on such a network, which is none other than the communication service, and this is in the context of Tunisian telecommunications sector[3].

From a simple model globally significant, we conclude that the club effect is, in short-term, low enough to affect the pricing policy of the Tunisian incumbent in monopoly position. However, users of fixed telephony of Tunisie Telecom can benefit, in long-term, of a decrease in rates both of access and traffic carried on the fixed telephony network, notably the local and the long distance calls. In contrast, international communications behaves, in long-term, as an independent variable.

1. Introduction:

Network economics shows that telecommunications networks are characterized by externalities beneficial to all network users. Thus, over the network increases, customer satisfaction becomes more important. Some studies - Rohlfs (1974), Littlechild (1975), Curien (1987), and Gensollen Curien (1987) and (1991), Picard (1988), Bonnisseau (1992) - were performed to analyze the pricing of network access in the presence of club effect. According to these studies, authors such as Rohlfs (1974) showed that there is a positive relationship between access price and size of the network regardless of the charging of network use. Thus, other theorists such as Littlechild (1975), Curien (1987) and Picard (1988), have studied this relationship by integrating network usage in their models. They showed that the increase in the size of network phone generates lower access prices (Curien (1987)). Other analysts have shown that the access price varies in opposite directions with the traffic price and externalities that result, lead to a lower connection tariff.

In this article, our goal is to study the effect of evolution of the number of connected on the access rate of network users, by studying the nature of the relationship between access price and traffic price carried on the network studied of the Tunisian telecommunications sector. The traffic carried is the communications service. It consists of three services:

- The local communications
- The long-distance communications and,
- International calls

In other words, we wish to analyze:

- The impact of increasing of the network size on access price, on the one hand and,
- The effect of changing of communications prices on the connection rate, on the other hand

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[3] This study was made when the fixed telephony sector was in monopolistic structure.

2. Theoretical review, data and model:

Before presenting the data and the model, it is necessary to take a look at the theoretical review interested by the connection pricing in the presence of direct network externality.

2-1. A theoretical review of the literature of access pricing to the network in the presence of club effect:

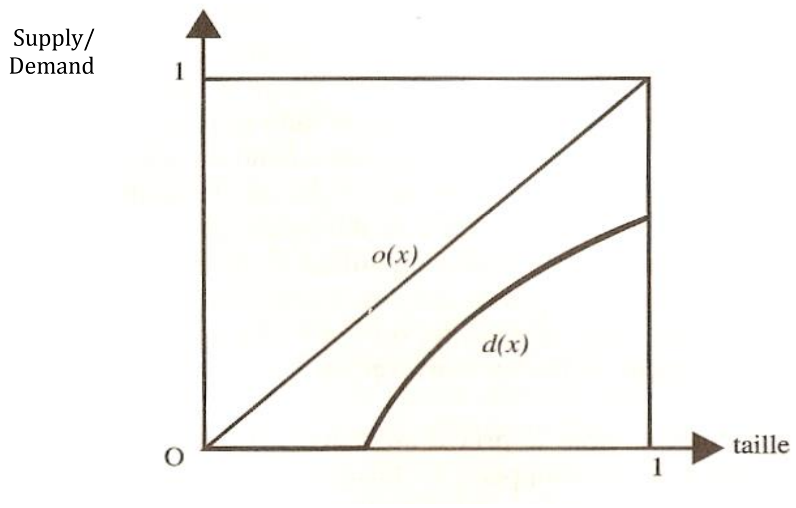
Several authors as Rohlfs (1974), Curien (1987), Picard (1988) and Bonnisseau (1992) attempted to determine and explain the access pricing in the presence of the club effect. In this paragraph, we suggest to summarize the studies of Katz and Shapiro (1986), Rohlfs (1974) and Curien (1987).

2-1-1. Connection Rate and Club effect[4]:

According to network economics, direct externality depends on the number of network users. It creates a positive feedback effect of supply over demand connection. Over the network is large, the club is more attractive, and therefore the demand for network membership would be more significant. In contrast, following the model of Katz and Shapiro (1986), the size of the network depends heavily on agents' decisions to be or not be joined. These decisions depend on, the income threshold of each individual and the connection rate. If the income threshold of an individual is less than the effective one, then he wants to join. Moreover, this income threshold increases when the access price increases and therefore decreases when the individual anticipates a large network. Two cases are then distinguished:

a. The access price is very high:

When the connection rate is very high, no one wants to connect to the network. The demand is therefore null. Indeed, when the connection rate is set at a very high level, individuals anticipate a small network size. In addition, the income threshold is higher than the effective one for all agents, even the richest. But, if the membership price is set at a given level, the demand triggers when the network size anticipated by those most interested and richest people increases. The demand of individuals, who are less interested, manifests through the club effect: more the anticipated network size is great, more important will be the connection demand. The following diagram shows the supply curves of access o(x) = x and of demand d(x) plotted against the anticipated size of the network:



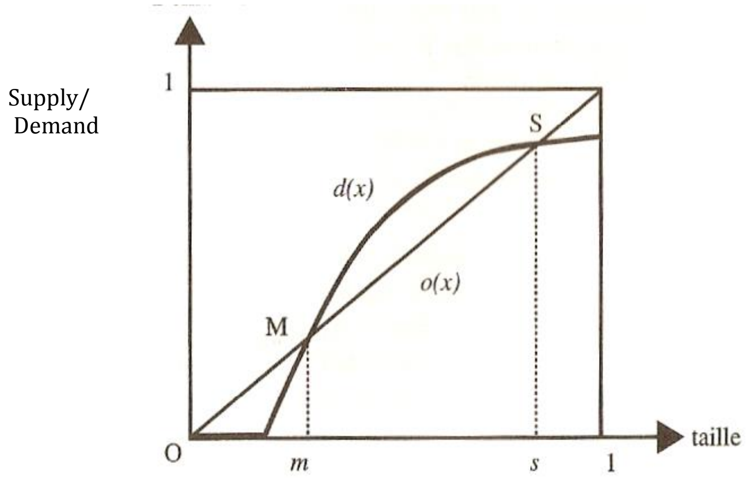
Source : Curien, N., (2000), « Economie des réseaux », Repères La Découverte

[4] This paragraph in inspired from Curien (2000).

According to this graphic, the demand curve is always under the supply one, when the access price is very high: whatever the anticipation of the network size, the latter leads to an insufficient level of demand for that effective supply confronts anticipation. The origin, the only point of confrontation of the two curves of supply and demand, constitutes the stable equilibrium. This point is interpreted by the absence of the network: zero-network implies zero supply and zero demand.

b. The access price is affordable:

When the connection rate is affordable, economic agents anticipate a large number of interlocutors and therefore an important network size. The demand can therefore meet the supply of the network operator, as this graphic show:



Source : Curien N., (2000), « Economie des réseaux », Repères La Découverte

In this diagram, the demand curve d (x) meets the supply one o (x) on two occasions, at M and S, also the origin O. Several situations have to be set:

The first situation: on the left of M and on the right of S, the demand is insufficient to achieve the supply. The latter must drop to confront in the first case the point O and in the second case the point S. In these two points, the network is in stable equilibrium, since the demand and supply are compatible.

The second situation: between M and S, the demand is greater than the supply. In this case, the supply must increase to meet demand at point S.

The third situation: at the point M, the demand and supply are also compatible in m, but this equilibrium is not stable, because, if we deviate a little, we move away irreversibly:

- If we deviate to the left, we converge to zero-network in the point O.
- If we deviate to the right, we converge to the saturation network at the rate *s*.

The unstable rate *m* is interpreted as a critical mass. As the mass *m* is not reached, the only feasible state is the absence of network. But, if it is exceeded, the network grows until it reaches its saturation state.

- **The connection tariff influences strongly the evolution of the telecommunications network size.**

2-1-2. Recapitulation of some studies on access pricing in the presence of club effect:

We choose in this paragraph to summarize respectively the results of models of Rohlfs (1974) and Curien (1987).

a. The study of Rohlfs (1974):

In an analysis[5] following the approach of Rohlfs (1974), it was shown that the connection price is an increasing function of the population, and therefore the number of connected which is a fraction of this population. Thus, it was shown that, despite the rising of access price, an increase in population size or network size leads to increasing the profit of the monopoly, the utility of consumers connected and therefore the social surplus.

b. The approach of Curien (1987):

After showing that the individual connection demand is a decreasing function of both access charges and network usage and increasing of the network size, basing on the surplus notion, Curien (1987) showed in his article "l'accès et l'usage téléphoniques", that when the number of telephonic park grows by one unit holding constant the traffic price, the surplus of each subscriber increases. This increase is due to the reduction of subscription tariff necessary to attract the new subscriber.

- **Theoretically, the size of the telephonic network and the access pricing are two interdependent components: one affects the other.**

In theory, it was shown that there is a strong and certain relationship between the access price and the network size. It is necessary to verify such a relationship in the telecommunications practice. By integrating traffic price in our empirical analysis focused on Tunisian data, we will try in the next paragraph to study such a relationship.

2-2. Data and Model:

To answer the questions posed above, we used annual data of the Tunisian incumbent, "Tunisia Telecom". These data are spread over the period 1991-2006. They are from the official journals of the Tunisian Republic, statistics from the National Institute of Statistics (NIS) and the World Bank (WB).
As mentioned above, our goal is to analyze the effect of the changing of the network size of Tunisia Telecom and call prices on the universal service tariffs. To do it, the variables used in our study are:

- PA: the access price to the network of Tunisia Telecom;
- PCLO: the unit price of one minute of a local call;
- PCLD: the unit price of one minute of a long distance call;
- PCI: the unit price of one minute of an international call;
- TR: the size of the fixed telephone network of Tunisia Telecom;

Our model is written as follows:

$$PA_t = c_1\, TR_t + c_2\, PCLO_t + c_3 PCLD_t + c_4\, PCI_t + \varepsilon_t \qquad (1)$$

To homogenize the model, we applied the napierian logarithm on the series. The model becomes, then, as follows:

$$LPA_t = c_1\, LTR_t + c_2\, LPCLO_t + c_3\, LPCLD_t + c_4\, LPCI_t + e_t \qquad (2)$$

[5] See seminar (2007) : « Economie des réseaux », Cité des sciences.

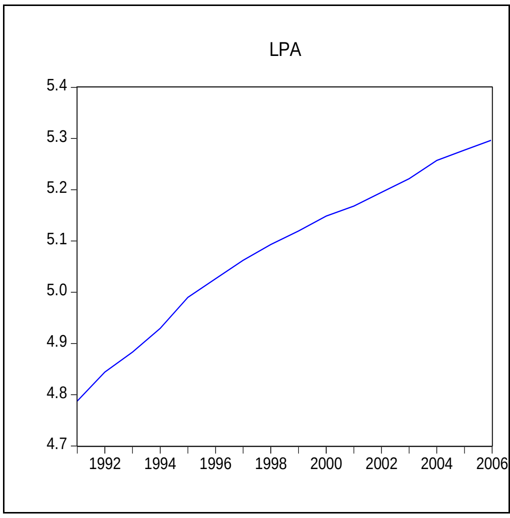
3. Graphical analysis, estimation and interpretation

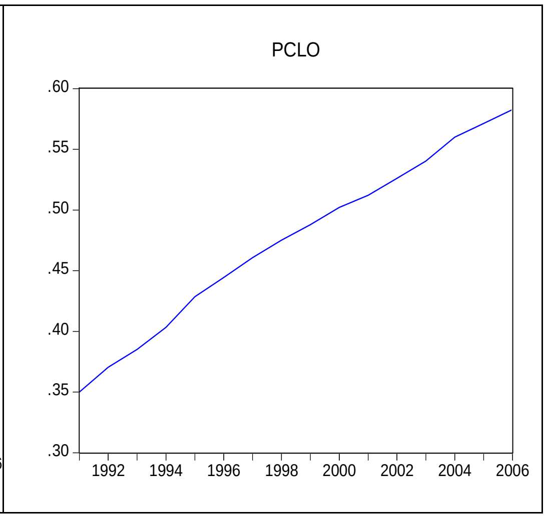
Before turning to the model estimation and interpretation of results, we will firstly analyze the graphic evolution of series and their dynamics throughout the study period.

3-1. Graphical analysis:

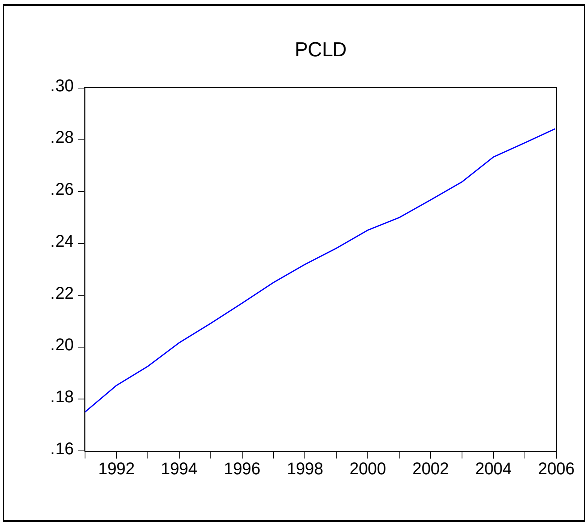
We study, here, the individual and combined evolution of all model variables.

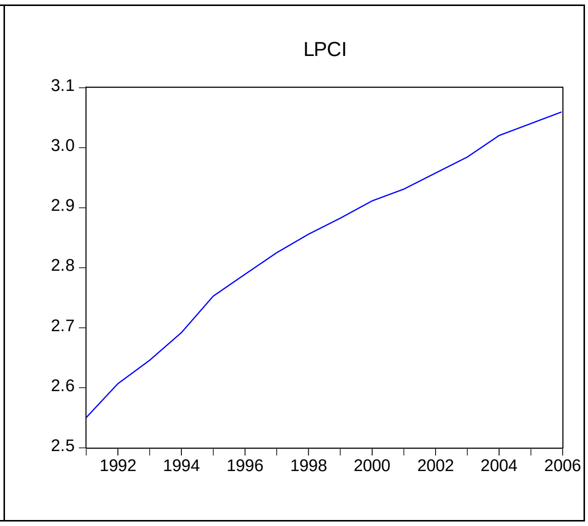
3-1-1. Individual analysis:



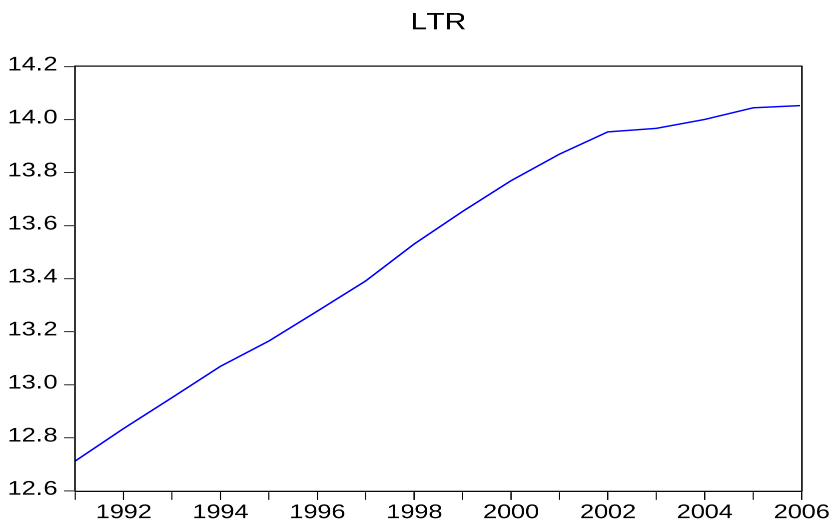


We observe, from these two curves, that the access price (LPA) and the unit price of one minute of local call (LPCLO) grow during the study period. They follow, so, the same dynamics.



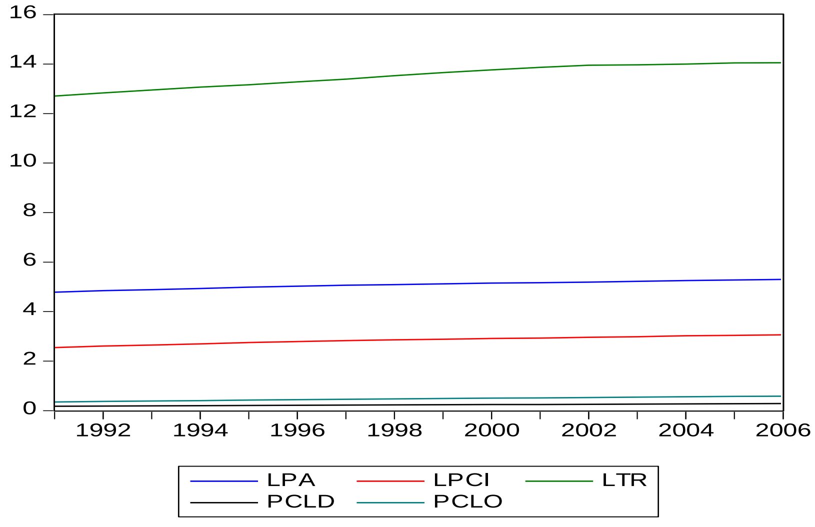


According to these graphs, the price of a minute of long distance communication increases during the concerned period. The growth rate of this variable is almost constant as the curve approaches to the linear form. Also, the tariff of a minute of an international call follows a net growth from one year to another.



The evolution of the network size follows a rising curve over the period studied. It increases with a high growth rate between 1991 and 2002. However, this growth rate slowed between 2002 and 2005 then it stagnates. This negative change of the growth rate can be explained by the emergence of mobile in Tunisian telecommunications market.

3-1-2. Global analysis:



From this overall graphical representation, we find that there is, in the long term, a certain relationship between the variables of the model.

3-2. Estimation of the model by OLS:

Testing the linear relationship of the model returns to test the global significance of the equation (2). We are interested in testing the null hypothesis against the alternative one as follows:

$$\begin{cases} H_0: c_i = 0 & \text{for all } i = 1,\dots,4 \\ H_1: \text{there is at least one } c_i \neq 0 \text{ for all } i = 1,\dots,4 \end{cases}$$

Under the null hypothesis, the model is generally not significant: the exogenous variables do not explain the endogenous variable. Otherwise, we decide the alternative hypothesis.

The estimation of equation (2), gives the results summarized in the following table:

Estimation of the linear relationship by OLS

Coefficient	Estimated value	Ecart-type	t-Student	Probability
c_1	0.030079	0.045104	0.666872	0.5175
c_2	-5.548565	1.300721	-4.265762	0.0011
c_3	6.783087	2.504133	2.708757	0.0190
c_4	2.014728	0.254747	7.908738	0.0000

$R^2 = 0.996277$

The estimated equation of the model is so:

$$LPA_t = \underset{(0.6668)}{0.0300} * LTR_t - \underset{(-4.2657)}{5.5485} * LPCLO_t + \underset{(2.7087)}{6.7830} * LPCLD_t + \underset{(7.9087)}{2.0147} * LPCI_t. \quad (3)$$

The values given in parentheses indicate the statistical Student's *t*. We note, according to this statistic, the coefficients c_2, c_3 and c_4 are significant. Only the coefficient of the network size is not significant. Basing on the results obtained through the method of ordinary least square, and taking into account the value of the determination coefficient R^2, we can conclude that our model allows to characterize the dynamics of the dependent variable that is the access price (PA) throughout the study period, well explained by exogenous variables introduced in the regression.

3-3. Interpretation of results:

The results that we want to interpret are summarized in the following table:

	Network size	Price of local communications	Prise of long distance communications	Price of international communications
Access price	+[6]	---[7]	+++[8]	+++

3-3-1. The effect of increasing of the network size on the access price:

We note from these results that the coefficient of the network size is positive but insignificant. In addition, the value of this coefficient is very low, which ensures its non-significance. This latter can be explained by the high value of the tariff offered by the monopoly operator, which sets its prices independently of consumer's desires. Costumers hesitate to be connected to the telephone network. Such behavior influences

6 Insignificant positive effect.
7 Significant negative effect.
8 Significant positive effect.

directly the evolution of network size, which increases with a very low growth rate over the studied period. The telephonic network size is so small to generate externalities susceptible to attract new users.

3-3-2. The effect of the changing of prices communications on the access tariff:

Call prices affect significantly the access price of agents to the "Tunisia Telecom" network. The series of local calls prices produce a negative effect on the connection tariff: the increasing of the price of a minute of local call causes the decrease of the access price. This effect can be explained by the funding strategy adopted by the monopoly. The increase in revenue collected on the local segment fills more and more the fixed cost of infrastructure installation of "Tunisia Telecom". Subsequently, the access price decreases. However, the price series of long-distance and international communications produce a significantly positive effect, they cause its increase.

After estimating the model and interpreted the results, it is necessary to study the stationarity of the estimated variables to study the long-term relationships between the endogenous variable and its determinants.

3-4. Study of the stationarity of the series: ADF Test

ADF test in levels

Variable	t-ADF	CV à 1%	CV à 5%	CV à 10%
LPA	-1.8750	-4.7283	-3.7597	-3.3249
LTR	1.9093	-4.7283	-3.7597	-3.3249
LPCLO	-1.5441	-4.7283	-3.7597	-3.3249
LPCD	-2.5338	-4.7283	-3.7597	-3.3249
LPCI	-1.8750	-4.7283	-3.7597	-3.3249

From these results, we observe that all variables are non-stationary since the ADF test statistic associated with each variable is higher than the critical value of the test for the three levels of risk. To make them stationary, we must differentiate them. Determine so the integration order. To do this, we integrated once these variables and made again the ADF test. The results are summarized in this table:

ADF test in difference

Variable	ADF-t	CV à 1%	CV à 5%	CV à 10%
LPA	-5.4012	-4.8000	-3.7911	-3.3422
LTR	-2.2467	-2.7406	-1.9684	-1.6043
LPCLO	-3.4386	-4.8000	-3.7911	-3.3422
LPCD	-4.1598	-4.8000	-3.7911	-3.3422
LPCI	-4.2148	-4.0048	-3.0988	-2.6904

By comparing the statistics of unit root test (ADF-t) for different critical values, we can conclude that:

- The variable "LPA" is integrated of order 1 (LPA ~ I (1)) at the 1% level.
- The variable "LPCLO" is integrated of order 1 at 10% level.
- The variable "LPCLD" is integrated of order 1 t the 5% level
- The variable "TPA" is integrated of order 1 at the 1% level.
- The variable "LTR" is integrated of order 1 at the 5%level.

In conclusion, the series integrated of order one are stable at 10% level. Therefore, we can use the cointegration technique to study the long-term relationship between different variables of the model.

3-5. Standard Tests for cointegration:

We studied the cointegration relationship by two methods: the Engel and Granger test and Johansen test.

3-5-1. Test of Engel and Granger:

The existence of a cointegration relationship between the series of tariffs of network access and its explanatory variables is confirmed by the existence of a stationary linear combination between them. To test the existence of such a relationship, we apply such a test on the residuals series (e_t) resulting from the following linear equation:

$$LPA_t = c_1\, LPCLO_t + c_2\, LPCLD_t + c_3\, LPCI_t + c_4\, LTR_t + e_t$$

The search for a cointegration relationship is a two steps process:

- First step: to estimate the above equation by OLS to get residuals.
- Second step: to apply the unit root test (ADF) on the residuals series to test its stationarity.

After calculating residuals series (έt), we established the stationarity test. The results obtained are shown in this table:

Results of unit root test (ADF) on the residuals series

series	p	ADF test	CV 1%	CV 5%	CV 10%	Prob.*
resid	**0**	**-2.565903**	**-2.728252**	**-1.966270**	**-1.605026**	**0.0142**

*MacKinnon (1996) one-sided p-values.

These results show that the null hypothesis of no cointegration cannot be rejected for the risk level of 1% while, the residual series are stable at the risk of 5% and 10%. Therefore, the vector C' = (c_1, c_2, c_3, c_4) is a cointegration vector.

3-5-2. Johansen Test:

This test appears to be most appropriate to identify a long-term relationship between the stable variables in first difference. According to the Johansen test, the decision is made basing on:

• Statistic of the null hypothesis indicates the existence of p cointegration relationships against p+1 relationships determined by the statistics of the proper value or on,

• The test statistic associated with the null hypothesis stipulating the existence of. This statistic is defined by λ trace.

Test of the trace

Hypothesis	λ_{Trace}	CV at 5%	λ_{Max}	CV at 5%
Zero cointegration relationships	107.2689	40.17493	61.62976	24.15921
At most one cointegration relationship	45.63915	24.27596	36.31260	17.79730
At most two cointegration relationships	9.326547	12.32090	9.315836	11.22480

By applying both the Johansen cointegration tests (1988), the maximum proper value and the trace value, we reject the null hypothesis that refuses the existence of any cointegration relationship. It is the same when going to test the null hypothesis of existence of at most one cointegration relationship. While, the null hypothesis of existence of at most two cointegration relationships is accepted.

Estimating cointegration relationships

LPA	LPCLO	LPCLD	LTR
1.0000000000	0.0000000000	-21.24891 (1.92473)	0.097689 (0.003728)
0.0000000000	1.0000000000	-2.878221 (0.11465)	0.019407 (0.00222)

Log likelihood= 293.3047

Values in parentheses are standard deviations associated with coefficients. The two equations estimated relationships are so:

$$\mathbf{LPA_t = - 0.0976\ LTR_t + 21.2489\ LPCLD_t} \quad (4)$$

$$\mathbf{LPCLO_t = - 0.0194\ LTR_t + 2.8782\ LPCLD_t} \quad (5)$$

From these two long-term relationships, we can conclude that the series of access prices and prices of local and long distance calls, behave the same way. They represent the same long-term dynamics. However, access and local calls tariffs behave in the opposite direction with the network size. They do not have the same dynamic. In the long term, the increasing of users' number induces lower access prices, which confirms the result obtained by Curien (1987), and lower local calls too. Consequently, users benefit from the decline of charges they pay to be connected to the network and to consume local traffic through the externality generated by the park's telephone of "Tunisia Telecom".

3-6. Granger causality:

Here, the question is to know whether there is a causal relationship between access prices and the other variables of the model. From this test, we focus on the three following relations:

Null hypothesis (H_0)	Obs.	F-Statistic	Probability
TR doest not cause in the meaning of Granger PA. PA doest not cause in the meaning of Granger TR.	14	5.75892 4.07376	0.0236 0.1307
PCLO doest not cause in the meaning of Granger PA. PA doest not cause in the meaning of Granger PCLO.	14	5.88141 3.03742	0.0225 0.1634
PCLD doest not cause in the meaning of Granger PA. PA doest not cause in the meaning of Granger PCLD.	14	6.28483 1.92527	0.0017 0.2183

From these results, we can make the following interpretations.

- The causal relationship between TR and PA:

We tested the null hypothesis that means the network size (TR) does not cause the access price (PA), against the alternative hypothesis involving the opposite. The test is like that:

H_0: TR does not cause PA.
H_1: TR causes PA.

The probability of accepting H_1 is equal to 0.0236. According to Granger Causality, we reject, then, H_0 and we accept H_1 at the risk 5%. The network size conditions so the connection tariff. However, the inverse (PA causes TR) is not true at the risk 5% (probability = 0.1307). The price access does not condition network size.

- The causal relationship between PCLO and PA:

In this case, we tested the null hypothesis against the alternative as fellow:

H_0: PCLO does not cause PA.
H_1: PCLO causes PA.

H_1 is accepted at 5% level of risk (probability = 0.0225). According to the Granger causality, the price of local calls causes the access price. While the reciprocal relationship is not valid at the level of risk equal to 5% (probability = 0.1634) that is to say, the connection tariff is not dependent on local calls price.

-The causal relationship between PCLD and PA:

To study this relationship, we performed the test the following hypotheses:

H_0: PA does not cause PCLD.
H_1: PCLD causes PA.

According to the results of the third relationship of Granger causality test, we accept H_1 at risk of 5%. Hence, the price of long distance communication that conditions access tariff. However, the later does not condition the first as the null hypothesis is accepted at 5% of risk (probability = 0.2183).

- **Then, there exists a strong and unidirectional relationship between the price of local and long distance calls, network size of "Tunisia Telecom" and the access price.**

According to this test, we find that the variable PCI, prices of international calls, behaves as an independent variable. It may depend on other variables or factors such as, agreements between interlocutors' countries, international norms of telecommunications...

4. Conclusion:

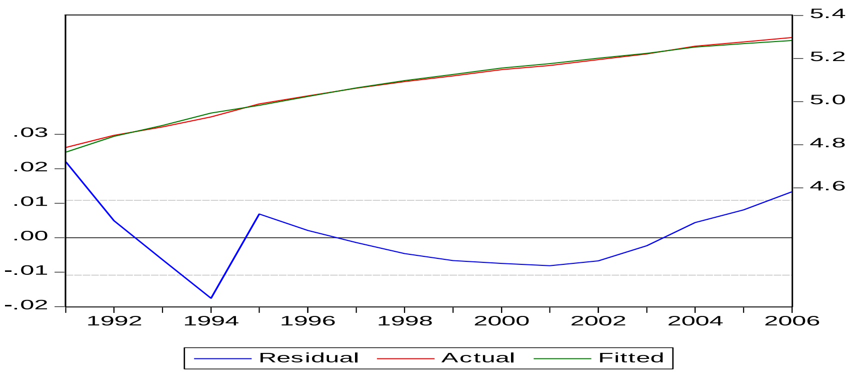
Certainly the telecommunications networks provide, theoretically, to its users positive externalities. With each new membership, the utility of connected individuals improves and the network access price decreases. However, in our empirical study on the telecommunications sector of Tunisia, users do not benefit in the short term, of such externalities in terms of pricing. This result is explained by the mighty power of the monopoly that sets his access price without considering the desires of consumers and their needs.
To practice a high access price leads to a slow growth of network size especially as the majority of the Tunisian population has low incomes. In addition, the cointegration test has shown that network externalities affect, in the long term, the behavior of monopoly: the increasing of the network size decreases the adhesion tariff and the local calls price.

The prices of local calls, when they increase, induce in the short term lower access price, while prices of long distance and international communications, which cause its increase. In addition, in long term, the relationship between the price of long distance communications and the access tariff remains positive.

From the Granger causality test, it was shown that there is a strong unidirectional relationship between the access price, network size and local and long distance calls prices: the last three condition the connection price while it does not condition them. Despite its positive impact on access price in the short term, the international calls tariffs behave, in the long term, as an independent variable.

In total, the club effect does not exercise, in the short term, great influences on the pricing policy of Tunisian telecommunications monopoly. Thus, users do not benefit from large declines in prices of services provided on the network of Tunisia Telecom. This is due to the strategies of any monopoly that abuses of its position and of its market power to maximize its profit by absorbing the surplus of consumers. However, the club effect generates, in the long term, reductions in tariffs of connection and traffic carried especially local calls.

Annex :




2.5
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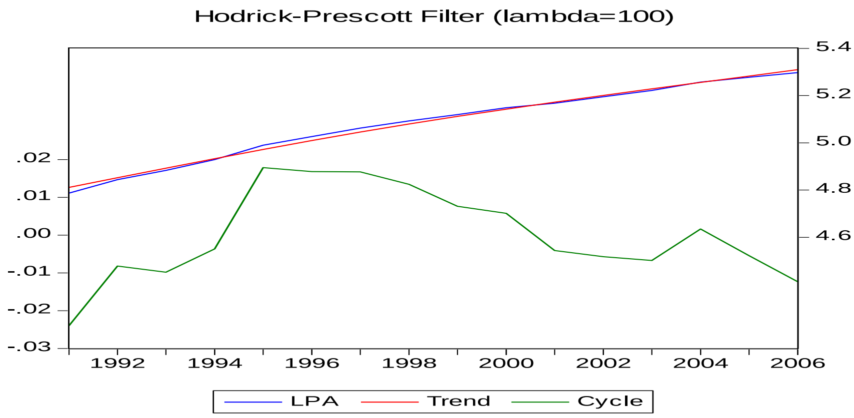
Standardized Residuals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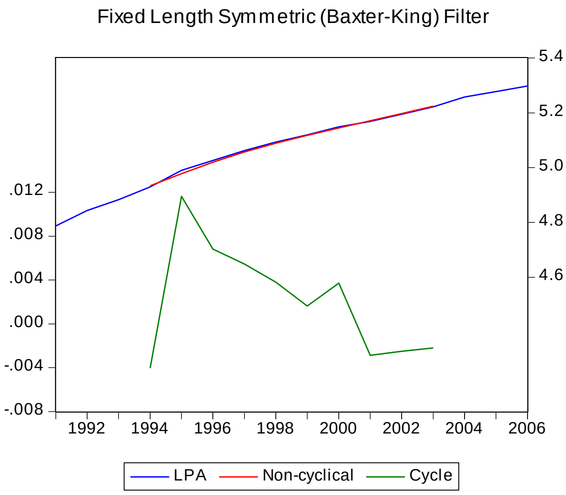
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Non-cyclical
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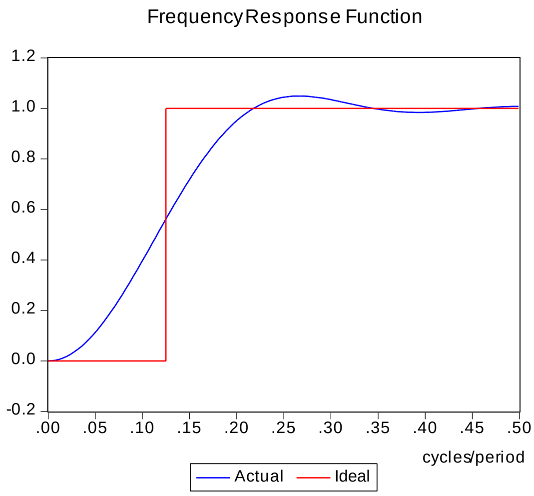
Frequency Response Function
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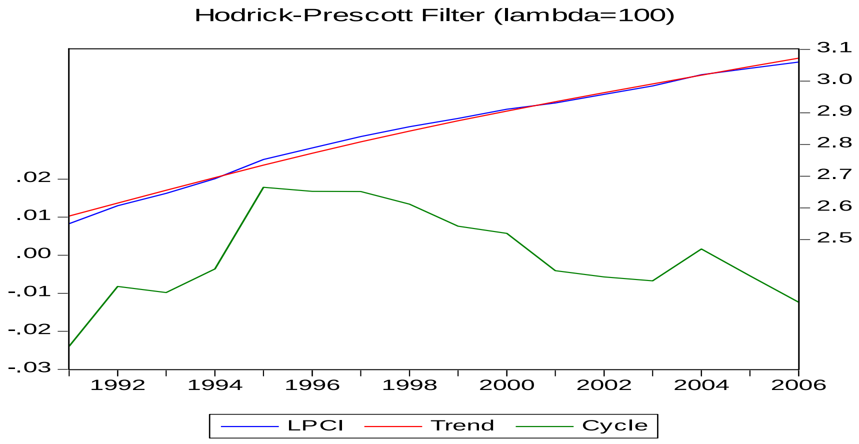
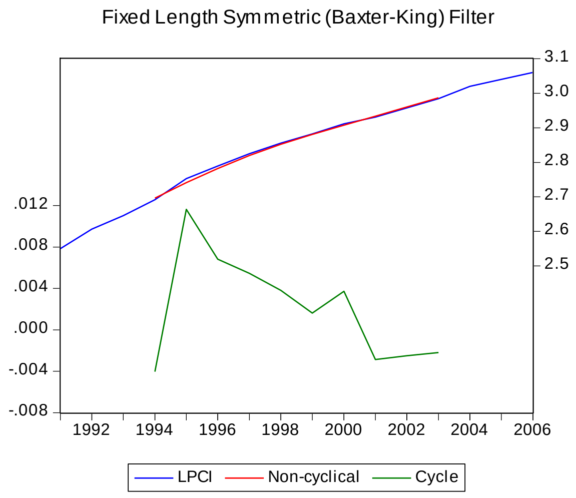
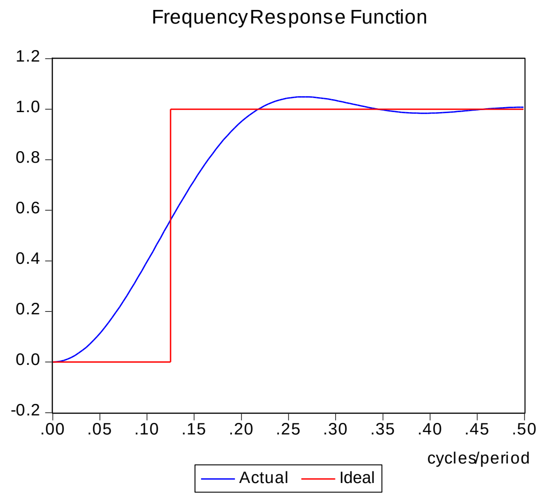
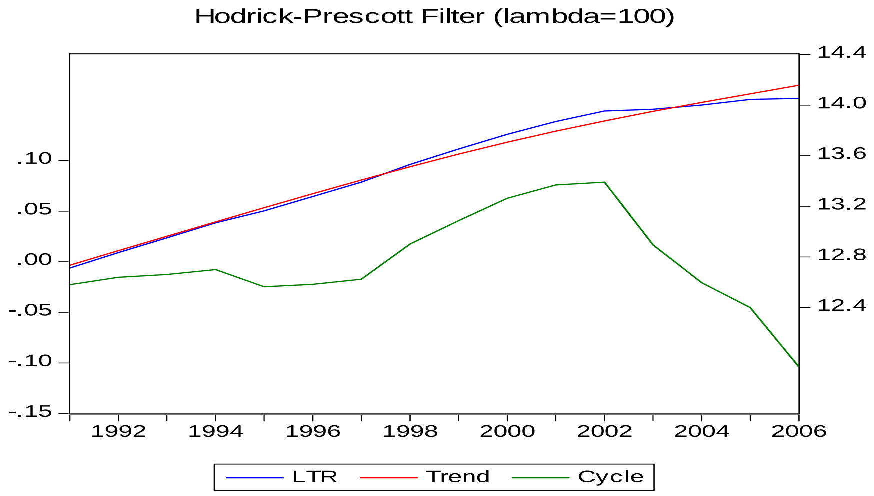
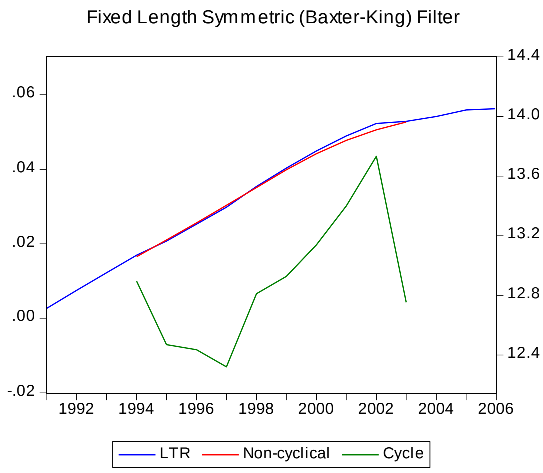
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
.00
.05
.10
.15
.20
.25
.30
.35
.40
.45
.50
cycles/period
Actual
Ideal

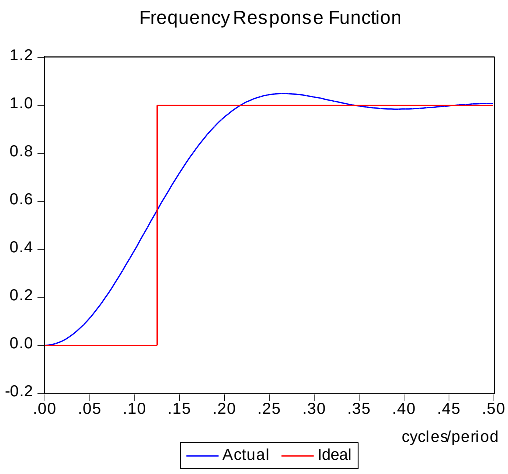

Hodrick-Prescott Filter (lambda=100)
3.1
3.0
2.9
2.8
2.7
2.6
2.5
.02
.01
.00
-.01
-.02
-.03
1992
1994
1996
1998
2000
2002
2004
2006
LPCI
Trend
Cycle

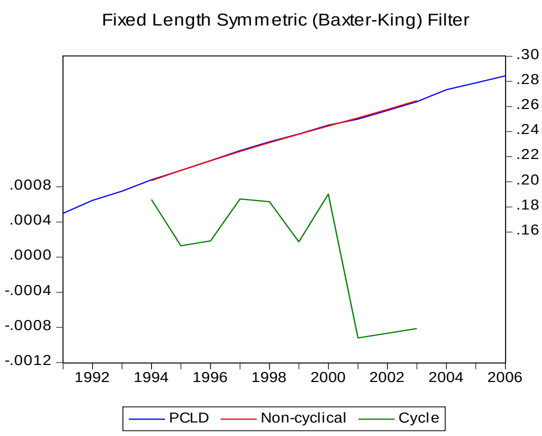

Fixed Length Symmetric (Baxter-King) Filter
3.1
3.0
2.9
2.8
2.7
2.6
2.5
.012
.008
.004
.000
-.004
-.008
1992
1994
1996
1998
2000
2002
2004
2006
LPCI
Non-cyclical
Cycle

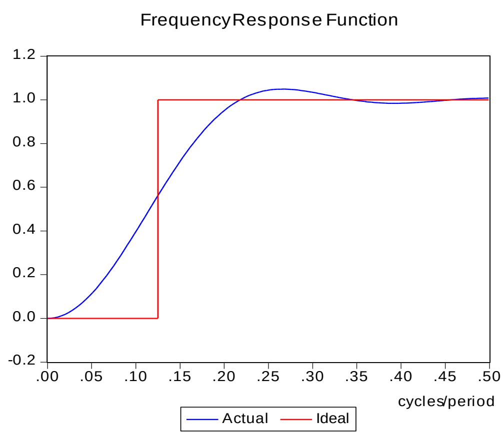

Frequency Response Function
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
.00
.05
.10
.15
.20
.25
.30
.35
.40
.45
.50
cycles/period
Actual
Ideal

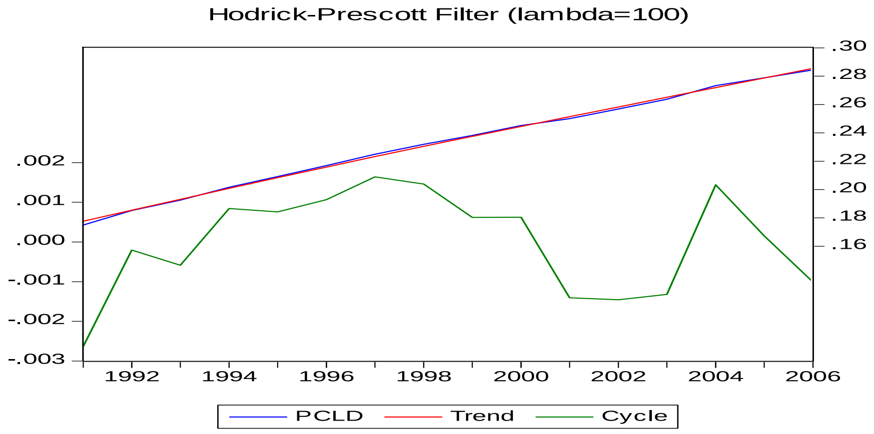

Hodrick-Prescott Filter (lambda=100)
14.4
14.0
13.6
13.2
12.8
12.4
.10
.05
.00
-.05
-.10
-.15
1992
1994
1996
1998
2000
2002
2004
2006
LTR
Trend
Cycle

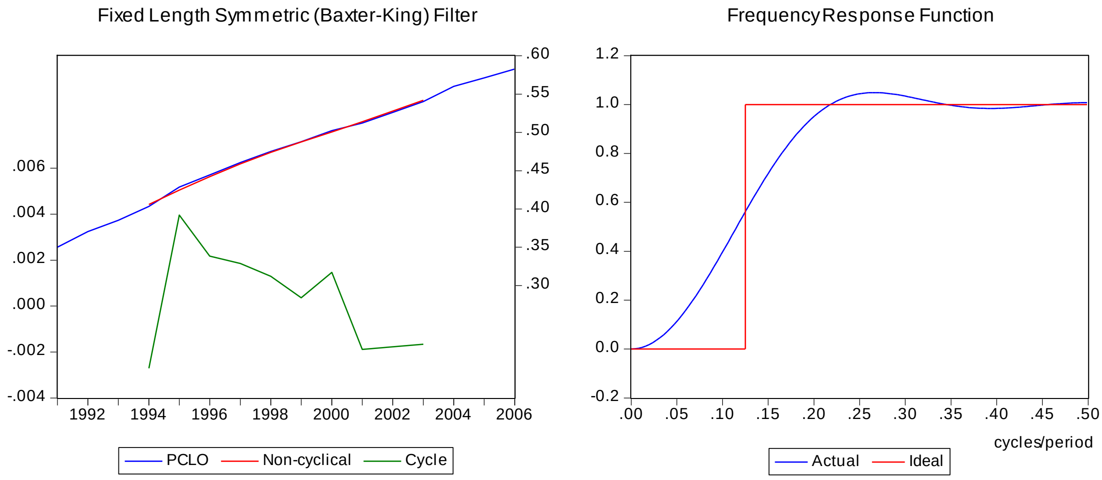

Fixed Length Symmetric (Baxter-King) Filter
14.4
14.0
13.6
13.2
12.8
12.4
.06
.04
.02
.00
-.02
1992
1994
1996
1998
2000
2002
2004
2006
LTR
Non-cyclical
Cycle

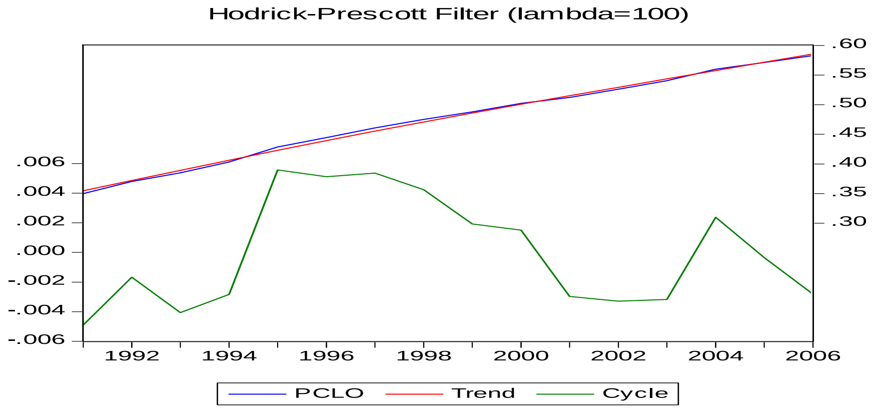

Frequency Response Function
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
.00
.05
.10
.15
.20
.25
.30
.35
.40
.45
.50
cycles/period
Actual
Ideal


Fixed Length Symmetric (Baxter-King) Filter
.30
.28
.26
.24
.22
.20
.18
.16
.0008
.0004
.0000
-.0004
-.0008
-.0012
1992
1994
1996
1998
2000
2002
2004
2006
PCLD
Non-cyclical
Cycle


Frequency Response Function
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
.00
.05
.10
.15
.20
.25
.30
.35
.40
.45
.50
cycles/period
Actual
Ideal


Hodrick-Prescott Filter (lambda=100)
PCLD
Trend
Cycle


Fixed Length Symmetric (Baxter-King) Filter
PCLO
Non-cyclical
Cycle
Frequency Response Function
cycles/period
Actual
Ideal


Hodrick-Prescott Filter (lambda=100)
PCLO
Trend
Cycle

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