Global Trade Analysis Project
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This paper is from the
GTAP Annual Conference on Global Economic Analysis
https://www.gtap.agecon.purdue.edu/events/conferences/default.asp

Determinants of Competition in a Context of Services Trade Liberalization: Analysis of Market Power of Firms in African Telecommunications Industry

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Abstract

This paper assesses the determinant of market power in telecommunications industry in Africa using multiple-indicator-multiple-causes (MIMIC) of a single latent variable estimation. Based on aggregated data from 30 African countries between 1997 and 2004, three sets of results emerge from our empirical analysis: the African telecommunications industry face significant market power practices. Three main policy factors seem to be affecting negatively this market power: the unilateral efforts in terms of liberalization (increasing in number of operators) as well as strengthening of sectoral regulation, and the multilateral commitments to liberalize in the framework of the GATS. However, it appears that multimarket contact of telecommunications operators is an important factor enhancing the cooperative pricing behavior.

1 Introduction

While it is commonly accepted that the increasing liberalization of telecommunications services with the technical progress that accompanies it have significantly improved access to services in the world during the past decade, its actual effect on the price trends, however, remains in many respects ambiguous (ITU, 2004).

This applies particularly to African countries where one decade after the launch of the first liberalization campaign, prices have not dropped (on average) in the two main segments of telephony, that is, local fixed and mobile telephone. As table 1 illustrates, between 1996 and 2004, the prices of local fixed telephone have increased; in the segment of mobile, prices are higher in the countries supposed to be in competition (more than one operator) than in those with a monopoly.

Table 1. Tests of prices averages differences

Segment	**Tests**	**Africa**	**World**
Price of mobile	**Monopoly vs. competition**	Price increase	Price unchanged
	(1997-1999) vs. (2000-2003)	Price unchanged	Price decrease
Price of local fixed	**Monopoly vs. competition**	Price unchanged	Price increase
	(1997-1999) vs. (2000-2003)	Price increase	Price unchanged

Source: author's calculation

Therefore, the process of liberalization, which consists in distributing licenses to more than one operator in the case of African countries, seems to be a non sufficient condition for the systematic decline in prices in light of the competition. While regulatory bodies and institutions of competition are particularly poor on the continent (ITU, 2004) and that operators announce significant profits particularly in the segment of mobile telephony[1], the objective of this paper is to estimate the market power and its sources in the African telecommunications industry.

Particularly, we are interested in the role of the following factors in attenuating market power in telecommunication industry: (1) the services trade liberalization(number of operators

[1] The boom in mobile telephony in Africa has generated a financial windfall estimated at over 10 billion U.S. dollars in terms of revenues, and more than 1 billion U.S. dollars of profits (Cf. UIT 2004).

allowed in each segment); (2) the quality of regulation including, the effectiveness of regulations at sectoral level (autonomy and experiences of regulatory authority) as well as the quality of governance at national level (quality of country institutions); (3) the organizational structure of telecommunications industry captured by the multimarket contact effect (reflecting the situation of two operators whose parent companies would be competing in more than one market).

From the perspective of decision-makers (trade negotiators or policies), this analysis can provide useful insights with respect to questions such as the following: Is the consumer welfare in a particular country penalized by firms' market power? What are the potential reasons for this market power? In the case of telecommunication services, what are the sources of the market power? Does it result from the limited number of competitors, the absence of commitments in the framework of GATS, the market saturation, the multi-market arrangements, or the lack of effective regulation?

The few studies measuring the market power in telecommunications use the New Empirical Industrial Organization (NEIO) model of conjectural variation (Breshnan, 1989) and are generally based on the American economy. Our study makes contributions to the literature as follows:

First, it is to our knowledge the first attempt to estimate the determinants of market power in the African telecommunications.

Second, instead of the traditional method of conjecture variation, this study adopts the "multiple-indicator multiple-causes" (MIMIC) model, for the first time in telecommunications. Based on the models of latent variables, the MIMIC approach followed here has been developed in Joreskog and Goldberger (1975) and adapted by Mccluskey and Quagrainie (2004) to model market power in apple market in United State.

The intuition of the MIMIC approach is to represent the market power as a latent variable, which has causes and effects that are observable. Thus there are two kinds of observed variables in the model, "causal" variables and "indicator" variables, which are connected by a single unobserved latent variable. This approach, despite its own drawbacks (See section II), would circumvent some limitations of the conjectural variation approach. These include

notably the subjective choice of non linear form of demand function indispensable to identify market power parameters in NEIO models [2.]

Thirdly, instead of measuring separately market power in telecommunication segments, either on mobile segment (see Parker and Roller (1997); Nunn and Sarvary (2004)), or on fixed segment (see Ward, 1995), this study considers simultaneously the two segments. This is possible thanks to MIMIC model which implies simultaneous estimation of at least two equations that share the market power as independent variable. In this study, we consider two equations representing prices in fixed and mobile telephone segments.

Fourthly, we account for a major critics of MIMIC model, relative to the absence of economic theory to guide the specification, by presenting a theoretical framework (through the pricing rule in imperfect competition) justifying the relationship defining our latent variable (i.e. market power).

Our empirical findings suggest the existence of significant market power in African telecommunications industry, which allowed the operators to keep the price at a level higher than in the competition condition. The market power of firms seems to be mitigated by three variables: the number of operators in fixed and mobile segments, the effectiveness of regulations at sectoral level and the subscription of the commitment at WTO. It is amplified by the situation of multi- market contacts.

The paper is structured as follows. The next section describes the context of African telecommunications industry. Section III provides the survey of literature measuring the market power. Section IV presents the model to be estimated. The empirical findings and discussion of the results are reported in section V. The paper ends with some concluding remarks.

[2] See Mccluskey et al (2004) for a critical analysis of conjecture variation method.

2 Telecommunications liberalization in Africa

Traditionally, telecommunication systems in Africa were run by the government. The existing telecommunications infrastructure of the colonial area was inherited by the state after its independence. Public ownership of the telecommunications sector also squared with the economic thinking of the 1970s, which favored large investments in key sectors that were expected to stimulate economic growth. Telecommunications in Africa were often under the control of a specifically created ministry or, for instance in Gabon, due to their "particular strategic importance", they were part of the Ministry of Defense (Ebang and ILEAP, 2005).

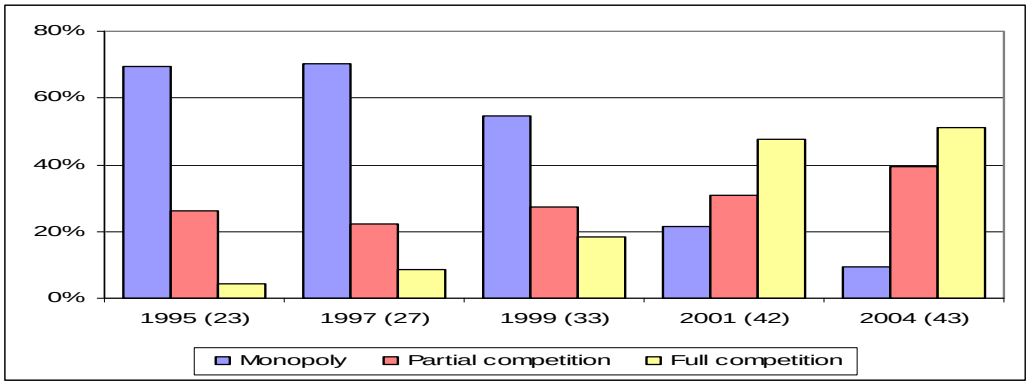
However, several factors contribute to crucial change in 1990s toward more liberalization. These include notably: (i) the need for greater efficiency of networks (see Plane, 2002); (iii) the technological innovations which amplified the costs of protection;[3] (iv) the debt crisis of the 1980s which exposed the poor management of many publicly-owned enterprises in the context of structural adjustment programs by the IMF and World Bank. These led to evolution not only at national level, but also to a coordination of efforts at the sub-regional level, like in the case of the Southern African Development Community (SADC).[4]

Figures 1 and 2 illustrate the evolution from state monopolies to a more liberal market environment in the African telecommunications sector for both fixed and mobile telephony. Between 1995 and 2004, the share of African countries maintaining a state monopoly in the mobile segment has dropped from 70 per cent to less the 10 per cent. Liberalization in the fixed-line segment has been somewhat slower, but progress has been made over the last five years. While all fixed operators in 1995 were state monopolies, this was still the case in only 44 per cent of African countries by 2004.

[3] Modern switching techniques, for instance, led to the spread of call-back services. Call-backs allow users to circumvent higher prices in the domestic market and benefit from more competitive conditions offered abroad. Voice services over the internet enable users to make international phone calls at the local rate. Technological developments of that nature increasingly undermined the view that basic telecommunications services constituted a natural monopoly. For a more extensive discussion see Doumbouya (2004)

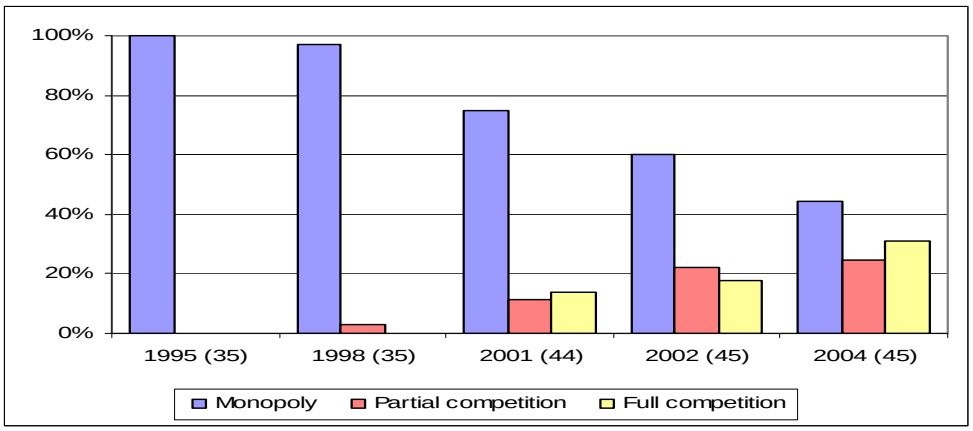
[4] The membership of the Telecommunications Regulators Association of Southern Africa (TRASA) comprises the regulatory agencies of each SADC member state. It was established to coordinate regulatory matters with the ultimate objective of promoting the establishment and operation of efficient, adequate and cost-effective telecommunications networks and services in the Southern Africa region. For more see http://www.trasa.org.bw.

Figure 1. Evolution of competition in the mobile telephony segment in Africa, selected years (per cent)



Source: authors' calculation from ITU (2004)
Notes: Partial competition: two operators; Full competition: more than two operators. Total number of countries in brackets.

Figure 2. Evolution of competition in the fixed-line telephony segment in Africa, selected years (per cent)



Source: authors' calculation from ITU (2004)
Notes: Partial competition: two operators; Full competition: more than two operators. Total number of countries in brackets.

Table.2 provides the characteristics of liberalization in individual African countries in 2004 in terms of the level of competition in different market segments - i.e. mobile telephony, fixed telephony (local, domestic long distance, international) and internet - and the status of the regulatory authority.

In short, competition in most African telecom regimes only began to be introduced around the year 2000. Yet, by 2004, Africa had gone from a continent of monopoly control over fixed services to one in which less than half of countries still maintained these monopolies. A number of governments, however, initiated duopolies in fixed telephony, rather than full competition. In mobile telephony, by 2004, the proportion of African countries maintaining

monopoly service had shrunk to around 10 percent. In practice, it is not uncommon for an African country to have 3 to 4 suppliers of mobile services. As the monopolies were opened up, foreign investment was generally permitted at one level or another, both in the former monopoly as well as in the new entrant fixed and mobile providers.

Table 2. Competition and regulation in Africa in 2004

Country	Local	Long distance	International.	Mobile	Internet	Year of creation of regulatory authority	Independence of regulatory authority	Decisions by committee (if yes, number of members)	WTO Basic Telecom Commitments
Angola	C	C	C	P	C	1999	No	Yes: 5	
Benin	M	M	M	C		2002	Yes	Yes: 5	
Botswana	M	C	M	C	C	1996	Yes	Yes: 5	Yes
Burkina Faso	M	M	M	C	C	1998	Yes	No	
Burundi	C	C	C	C	C	1997	No	No	
Cameroon	M	M	M	C	C	1998	Yes	No	
Cap-Verde	M	M	M	C	C	2004	Yes	Yes: 3	
CAR	M	M	M	C					
Chad	M	C	M		C	1998	No	No	
Congo	C	C	P	C	C				
DRC	C	C	C	C		2002	Yes	Yes: 7	Yes
Côte d'Ivoire	P	P	P	P	C	1995	Yes	Yes: 10	Yes/RP
Eritrea	M	M	M	C	C	1998	No	No	
Ethiopia	M	M	M	M	M	1996	Yes	No	
Gabon	M	C	C	C	C	2001	Yes	Yes: 6	
Gambia	M	M	M	P	C	2004	Yes	Yes: 6	Yes
Ghana	P	P	P	P	C	1997	Yes	Yes: 7	Yes/RP
Guinea	P	P	P	P	C	1992	No	No	
Guinea-Bissau	M	M	M	P	C	1999	Yes	Yes: 3	
Kenya	P	P	P	P	C	1999	Yes	Yes: 11	Yes/RP
Lesotho	P	P	P	C	C	2000	Yes	No	(value added only)
Liberia	P	P	C	C					
Madagascar	M	M	C	C	C	1997	Yes	No	
Malawi	M	M	P	P	P	1998	No	Yes: 8	
Mali	P	P	P	P	C	1999	Yes	Yes: 3	
Mauritius	C		C	C	C	2002	Yes	Yes: 7	Yes
Mozambique	M	M	M	C	C	1992	Yes	Yes: 5	
Namibia	M	M	M	M	C	1992	Yes	No	
Niger	M	M	M	C	M				
Nigeria	C	P	P	P	C	1992	Yes	Yes: 9	Yes
Rwanda	C	C		C	C	2001	Yes	Yes: 7	
S. Tomé & P.	M		M						
Senegal	C	C	C	C	C		Yes	No	Yes/RP
Seychelles	P	P	P	P	P				
Sierra Leone	M	M	P	C	P				
South Africa	C	C	C	P	C	2000	No	Yes: 7	Yes/RP
Swaziland	M	M	M	M					
Tanzania	M	M	M	C	C	1994	Yes	Yes: 7	
Togo	P	M	P	P	C	1998	Yes	Yes: 7	
Uganda	P	P	P	P		1997	Yes	Yes: 7	Yes/RP
Zambia	M	M	M	P	P	1994	No	Yes: 8	
Zimbabwe	C	P	P	C	C	2000	Yes	Yes: 7	(value added only)

Source: authors' calculation from ITU (2004)
Note: M: Monopoly; P: Partial competition; C: Full Competition; and RP: Reference Paper.

Formal liberalization of non-facilities based telephony, such as international simple resale and voice over Internet calls, has yet to take hold in Africa, but most countries have now opened up value-added services, such as e-mail and data base access, to competitive forces. In the course of the post-2000 liberalization, African countries have been able to draw on the work of regional and international telecom organizations and secure aid to hire regulatory experts. As a result, the new regulatory frameworks put in place tend to be largely consistent with notions of best practice in the sector, as well as the WTO Reference Paper. Countries are moving towards greater autonomy to the authority of regulation. Thus, in 2004, over 77 percent of African countries were equipped with a separate regulatory authority of the traditional operator and supposedly autonomous in their decision making.

Thirteen African countries committed at WTO to market access for foreign telecom suppliers, through agreements of Uruguay round in 1993 and on basic telecommunications in 1996. In the context of the Uruguay Round (1986-1994), six African countries committed to liberalize. For example, Nigeria had committed to open its mobile markets and Lesotho, Nigeria, and Zimbabwe had committed on value added services.

WTO negotiations on basic telecommunications (in 1996) came too early for more than a handful of African governments to contribute. As figures 1 and 2 above show, most governments began liberalizing well after the WTO talks ended in early 1997. This is why the WTO commitments reflect so little of the liberalization Africa has accomplished to date. Seven governments committed in the basic telecommunications negotiations (Côte d'Ivoire, Ghana, Kenya, Mauritius, Senegal, South Africa and Uganda). Like other developing countries in the negotiations, they generally took so-called "phased-in" commitments to liberalize on a given date, in line with their reform plan. Some, such as Uganda, committed to allow a duopoly. Six of them (all but Mauritius) added the Reference Paper to their commitments, thus providing a guarantee to investors of a pro-competitive regulatory regime.

In the new trade round, called the Doha Development Agenda, none of the recently liberalizing African countries has, as yet, made an offer to take on market access commitments in the telecommunications sector.

3 Litterature survey

The empirical literature estimating the market power can be grouped in three main categories: (1) the approach of demand elasticities, (2) the approach of New Empirical Industrial Organization (NEIO) so-call the conjectural variation and (3) the approach of "multiple-indicators multiple-causes" (MIMIC models).

The first approach measures the degree of market power by estimating firms-specific demand elasticities. The reciprocal of the own-price elasticity, the Lerner index, provides an estimate of the percentage price markup over marginal cost for an unconstrained, profit maximizing firm. Finally, estimates of this price-cost margin provide the basis for measuring the potential deadweight loss from supra-competitive pricing. Ward (1995) applied this approach in long distance telecommunications in United State. The study concludes the existence of market power that induces a potential deadweight loss of at most 0.36% of total industry revenues during 1988-1991. However, if the method allows determining the markup, it is silent on their causes.

The second approach from the New Empirical Industrial Organization (NEIO) is more refined and more widely used. It relies on the conjectural variation and allows the estimate of conduct and cost parameters of firms, even when full data on costs is not available. The parameter of conjectural variations of the firm (i) is estimated through the standard conjectural variations equation proposed by Bresnahan (1989):

$$PX_{it} - MC_{it} = \frac{\Omega_{it}}{N_t} \frac{d\left(PX_{it}(X_{it})\right)}{d\left(X_{it}\right)} X_{it}$$

where $\Omega_{it} = \frac{d(X_t)}{d(X_{it})}$ is the expected variation of rivals output when output of firm i varies, MC is the individual marginal costs, PX is the market price, X_t is the aggregate quantity produced in the market (country), X_{it} is firm i's output, and N is the total number of firms in the market.

Assuming a non linear demand function in order to address the issue of identification (see Fageda, 2004), the model estimates the parameter of industry conduct, defined as $\lambda_{it} = \frac{\Omega_{it}}{N}$, as

the proxy of market power. The NEIO approach has been widely applied, in various industry including, the finance (Sjöberg, 2004), aviation (Fageda, 2004), electricity (Vassilopoulos, 2003) and cable television (see Rubinozvitz, 1993), but rarely in basic telecommunications. Among the few exceptions are the studies of parker and Röller (1997) and Nunn and Sarvary (2004).

Parker and Röller (1997) consider the impact of regulation policy limiting entries on the American mobile telephone market. The empirical analysis uses panel data over the period 1983-1988 covering different American telephone areas. Estimates of market power reveal that the prices are both higher than those of perfect competition and those of non-cooperative duopoly. In addition, they evidence that situations of “cross-properties” (when a firm detains shares in its competitor) and "multi-market contact» are strong determinants of the practice of non-competitive price.

Nunn and Sarvary (2004), have resumed the same pattern as that of Parker and Röller (1997) relying on 10 OECD countries. Their results indicate that a larger number of operators in a country do not seem to result in any additional effects on the power market. But the antitrust commitment of a country contributes to the decline of the market power. Finally, the authors identify the lasting of reign of a monopoly before the opening to competition as a factor contributing to the rise of the market power. The authors conclude that the market power in various countries could have two sources: the price collusion between operators and the cost of changing suppliers for consumers.

However, as pointed out Mccluskey et al (2004), the approach of NEOI considering the market power by inference has several limitations including notably the subjective choice of non linear form of demand function indispensable to identify market power parameters in NEIO models.

These criticisms have encouraged the adoption of a latent variable approach based on the so-called "multiple-indicator multiple-causes” (MIMIC) presented in Joreskog and Goldberger (1975). This approach based on the assumption that even if the firm’s market power is not observable, it still has operational implications between observable variables that could be considered as indicators of behavior.

The method has its origins in the factor analysis literature of psychometrics (to analyze the quality concepts as intelligence) and are increasingly used in economic to estimate the underground economy (See Giles and Tedds, 2002; Bajada and Schneider, 2005; Dell'Anno and Schneider, 2003). The only application of MIMIC in estimating the market power is provided by Mccluskey et al (2004), who study the market of fresh apple in the United States. They represent the market power as a latent variable or index, which has causes and effects that are observable but which cannot itself be directly measured. Thus, a model is defined by connecting two kinds of observed variables ("causal" variables and "indicator" variables) with a single unobserved index. The fitted index predicted from the econometric estimation of the model is considered as an estimate of the magnitude of the market power. Our analysis adopts this approach.

However, there is a major criticism which is quite common when latent estimation procedures are used. It refers to the reliability of "causes" and "indicators" in explaining the variability of the latent variable. Smith (2002), Hill (2002) and Breuch (2005) criticize the modeling of underground economy, especially the absence of economic theory to guide the specification. This critic could also be applied to Mccluskey et al (2004) study where they assumed subjective Constant elasticities of substitution (CES) function to characterize the link between the shipment of apple and the market power in the American market of apple. To face this criticism, we present in this study a theoretical framework (through the pricing rule in imperfect competition) justifying the relationship defining our latent variable (i.e. market power).

4 Model: MIMIC model to estimate market power in telecommunications industry

Before introducing the MIMIC model to be estimated, we present the basic model of pricing rule in imperfect competition, relating the market power in telecommunications market and price.

4.1 Pricing rule in imperfect competition

The Telecommunications markets are characterized by oligopolies. To explore oligopoly interactions we use a Cournot conjectural variations model.[5] It is assumed that each firm produces a homogeneous product, faces a downward sloping demand curve and adjusts output to maximize profits, with a common market price as the equilibrating variable. The telecommunications industry is assumed to consist of N identical firms producing a collective output $X_{ct} = NX_{ict}$

Where, X_{ict} is the quantity supplied by firm i in country c and period t

Using a representative profit function yields the first order condition for each firm i in country c and period t:

$$MR_{ict} = MC_{ict} \tag{1}$$

i.e. marginal revenue MR_{it} equals marginal cost MC_{it} with

$$MR_{ict} = PX_{ict} + X_{ict}\frac{d(PX_{ict})}{d(X_{ct})}\frac{d(X_{ct})}{d(X_{ict})} \tag{2}$$

where PX_{ict} is the price of telecommunications services in firm i in country c and period t.

Given N identical firms, the equilibrium condition (1) can be written as

$$\frac{PX_{ict} - MC_{ict}}{PX_{ict}} = \frac{\Omega_{ict}}{N_{ct}\varepsilon_{ct}} \tag{3}$$

yielding the oligopoly pricing rule, with ε_{ct} being the price elasticity of demand.

(3) can be rewritten as

$$PX_{ict} = \frac{MC_{ict}}{(1-\frac{\Omega_{ict}}{N_{ct}\varepsilon_{ct}})} \tag{4}$$

$$PX_{ict} = MC_{ict}\left[1+\left(\frac{1}{(1-\frac{\Omega_{ict}}{N_{ct}\varepsilon_{ct}})}-1\right)\right] \tag{5}$$

$$PX_{ict} = MC_{ict}\left[1+\phi_{ict}\right] \tag{6}$$

[5] For an overview of alternative specifications of market structure see also Francois and Roland-Holst (1997).

Where $\phi_{ict} = \left(\frac{1}{(1 - \frac{\Omega_{ict}}{N_{ct}\varepsilon_{ct}})} - 1 \right)$ represent the mark-up and hence a measure of an operator's. It is the percentage of surplus imposes by firms on marginal cost.

For $\Omega \to 0$ or $N \to \infty$ or $\varepsilon \to \infty$, $PX \to MC$ with the quantity produced by each firm approaching the perfect competition output and rents being eliminated. Conversely, for N=1, we obtain a monopoly situation (total collusion of firms) with the mark-up corresponding to the inverse demand elasticity.

For the rest of our analysis we consider the indicator θ_{ict} to capture the market power[6] such as:

$$\theta_{ict} = [1 + \phi_{ict}] \quad (7)$$

By introducing the equation (7) into the (6), the logarithmic transformation of equation (6) yields the following structural equation:

$$\log(PX_{ict}) = \log(MC_{ict}) + \log(\theta_{ict}) \quad (8)$$

expressing the log of price as the sum of the logs of marginal cost and market power .

4.2 MIMIC model

The structural model defined above, in equation (8), is in line with the standard form of a MIMIC model since it contains an unobserved variable, $\log(\theta_{ict})$, connecting two set of observed variables, the causes variables ($\log(MC_{ict})$) and the consequences variables ($\log(PX_{ict})$). For a given country (c), we assume the firms to be identical within each segment (mobile or fixed), but different between segments. Thus, the following relationship is writing without the index of firms (i), but with the introduction of subscript (s) indicating the segments of telecommunication.

[6] We are not using this indicator as the measure of market power, it is just an intermediate stage that would facilitate the market power determination.

The model to be estimated is of the following form:

$$\log\left(PX_{ct}^{s}\right)=\lambda^{s}\log\left(\theta_{ct}^{s}\right)+\alpha_{0}^{s}+\sum_{k=1}^{K}\alpha_{k}^{s}\log\left(S_{kct}^{s}\right)+\varepsilon^{s}\ \text{where}\ s=1,2 \qquad (9)$$

This equation consists of a system of two supply relations, one for each segment.

ε^{S} are measurement errors with zero mean that are independently distributed over (c) and have a finite variance–covariance matrix.; α_{0}^{s} is the intercept.

S_{kct}^{s} are k's exogenous factors on the supply side explaining the marginal cost for the segment (s) in the country (c) at the time (t). α_{k}^{s} is the coefficient corresponding to the k's variable. Determinants of marginal cost consist of the output quantity $SUBR_{ct}^{s}$, the output (services) quality, $QLTE_{ct}^{s}$, the economic structure indicators and the production cost components. The production costs determinants include the energy prices index, $ENERG_{ct}$ the wage index, $WAGE_{ct}$, the interest rate and the lending price index $RENT_{ct}$. The economic structure variables include the population POP_{ct}, the density of population, $DSTE_{ct}$ and the GDP per capita, GDP_{ct}.

The log of the latent industry conduct variable $\log\left(\theta_{ct}^{s}\right)$ captures the market power. The model assumes the market power to be common in mobile and fixed segment. The market power measured in our model is therefore an average market power of telecommunication market for a given country. It can be specified in the following relationship, without index (s)[7]:

$$\log\left(\theta_{ct}\right)=\beta_{0}+\sum_{k=1}^{\mathrm{K}}\beta_{k}\log\left(F_{kct}^{s}\right)+\nu_{ct} \qquad (10)$$

Where ν_{ct} is an independently distributed random disturbance with zero mean and finite variance; F_{kt}^{s}'s are observed independents variables that determine the market power and β_{k},

[7] The market power is assumed to be the same in the fixed and mobile segment for a given market.

the corresponding coefficient. The determinants of market power $\left(F^{s}_{kct}\right)$ include variables at segment level (with index (s)), and variables at sectoral and national level (without (s)). They include, the variables of liberalizations (domestics, $LIBER^{s}_{ct}$, and multilateral, $GATSLIBER_{ct}$), the legal environment in the country $GOUV_{ct}$, the quality of regulation, as measured by unilateral regulatory authority effectiveness, REG_{ct}, and the multilateral (GATS, Reference Paper) regulatory quality $GATSREG_{ct}$. The last determinant considered is concerned with the characteristics of the market: the market saturation, SAT^{s}_{ct}, and the multimarket contact, $MMARKET_{ct}$ [8].

Substituting into (9), $\log\left(\theta_{ct}\right)$ with its value of the equation (10), gives the reduced-form equation

$$\log\left(PX^{s}_{ct}\right) = \lambda^{s}\left(\beta_{0} + \sum_{k=1}^{K}\beta_{k}\log\left(F^{s}_{kct}\right) + v_{ct}\right) + \alpha^{s}_{0} + \sum_{k=1}^{K}\alpha^{s}_{k}\log\left(S^{s}_{kct}\right) + \varepsilon^{s} \qquad (11)$$

then

$$\log\left(PX^{s}_{ct}\right) = c^{s} + \sum_{k}^{K}\varphi^{s}_{k}\log\left(F^{s}_{kct}\right) + \sum_{k=1}^{K}\alpha^{s}_{k}\log\left(S^{s}_{kct}\right) + w^{s}_{ct} \qquad (12)$$

Where the new random term is $w^{s}_{t} = \lambda^{s}v_{ct} + \varepsilon^{s}$ (13)

The constant term is $c^{s} = \lambda^{s}\beta_{0} + \alpha^{s}_{0}$ (14)

and $\varphi^{s}_{k} = \lambda^{s}\beta_{k}$ (15)

The regression of the model implies estimating a system of two equations (12) (one equation for each segment) under the constraints of equations (14) and (15). However, the identifications of all parameters in equation (12) and (10) required the imposition of cross-equation proportionality restrictions that differentiate the MIMIC model from the traditional approach of estimating structural equations (see Mccluskey et al, 2004). This consist to

[8] The choice of these factors represents a compromise between possible determinants of firm behavior and data availability for the maximum number of African countries.

normalize the industry conduct (λ^s) in order to identify the parameters of market power, β_k. This is equivalent to assume λ^s equal to one in one of the two equations. Other restriction aiming to identify β_0, required to consider the intercept of one of the two equations, α_0^s, equal to zero.

An important criticism of MIMIC model (particularly those measuring the underground economic) by Breuch (2005) is the subjective normalization of a parameter necessary to identify the latent variable parameters. Following Mccluskey et al (2004), all restrictions, including the normalization, imposed in our model would be tested using the specification test of Gertler (1988).

5 Regressions

5.1 Data descriptions and sources

The data used in this study cover 30 Sub- Sahara African countries on the period from 1996 to 2003[9] divided in four sub-periods of two years. The table.3 below provides an overview of all variables and data sources.

Table 3. Data description and sources

Variable	Variable description	Description	Source
PX_{ct}^s ; $s = 1$	**Price mobile**	Costs of 3 minutes call from one mobile to another; annual bill of average subscriber	ITU
PX_{ct}^s ; $s = 2$	**Price local fixed**	Costs of 3 minutes call from local fixed line; annual bill of average subscriber	ITU
$SUBR_{ct}^s$; $s = 1$	**Mobile output**	Number of Mobile subscribers	ITU
$SUBR_{ct}^s$; $s = 2$	**Fixed output**	Number of Fixed line subscribers	ITU
$QLTE_{ct}^s$; $s = 1$	**Mobile quality**	**share digital subscribers**	ITU
$QLTE_{ct}^s$; $s = 2$	**Fixed quality**	**share of fixed calls failed**	ITU
SAT_{ct}^s ; $s = 1$	**Penetration mobile**	Percentage of population subscribed and having telephone service activated within the last 9 months	ITU

[9] The list of countries is contained in annex Table A.2

Table continued

Variable	Variable description	Description	Source
SAT_{ct}^{s} ; $s = 2$	**Penetration fixed**	Percentage of population subscribed	ITU
$LIBER_{ct}^{s}$; $s = 1, 2$	**Unilateral openness (liberalization)**	Number of operators per segment	ITU
REG_{ct}	**Unilateral regulation**	Independence score of the regulatory authority multiplied by the numbers of years in existence	ITU
$GATSLIBER_{ct}$	**Multilateral openness (liberalization)**	GATS commitments score	WTO
$GATSREG_{ct}$	**Multilateral regulation**	Reference Paper score	WTO
$MMARKET_{ct}$	**Multimarket effect**	the total number of time that the firms in a given country are in competition in others African countries	Collected by author
GDP_{ct}	**Income**	GDP per capita	WDI
$DSTE_{ct}$	**Population density**	Percentage of population per square kilometer	WDI
POP_{ct}	**Population size**	Total number of inhabitants	WDI
$GOUV_{ct}$	**Governance**	Kaufmann governance indicators: regulatory quality, policy stability, corruption control	WB
$RENT_{ct}$	**Rent**	Lending prices index	WDI
$ENERG_{ct}$	**Energy**	Energy prices index	WDI
$WAGE_{ct}$	**Wage**	Wage index	ILO

Source Author's construction

5.1.1 Dependent variable: PX_{ct}^{s}

The data for the dependent variables, the price (PX_{ct}^{s}), come from the International Telecommunications Union (ITU). The prices for mobile and local fixed telephony are measured by the official price of a three minutes phone call. However, this price does not account for discounts that are generally available in countries enjoying some level of competition.[10] Hence, it is possible that this indicator suffers from a measurement error that is non-homogenous between countries. This may lead to the attenuation bias (i.e. underestimation of liberalization effects on price).

5.1.2 Variables affecting market power

Liberalization measure:

[10] Boylaud and Nicoletti (2001) estimate that discount prices in OECD countries are on average 25 per cent lower than regular rates.

For the liberalization indicator, we adopt an approach that examines both the domestic policies actually applied in the telecommunications sector as well as the level of commitments as specified in WTO Members' GATS schedules.

To measure the level of actual (unilateral) domestic liberalization, $LIBER_{ct}^{s}$, we rely on ITU survey data (ITU, 2005a like Mattoo et al. (2006), Li and Xu (2004), Fink et al. (2001)) and Wallsten (2001). However, we go further than these studies in a number of respects. Notably, we measure the degree of competition for each telecommunications segment separately instead of employing only a "hybrid competition score". The latter approach makes it difficult to disentangle the direct effect that competition within each segment has on segment performance. Wallsten (2001), for instance, simply approximates the degree of competition in the fixed-line segment by the number of mobile operators not owned by the incumbent. Li and Xu (2004) employ one dummy variable to describe the competitive situation in the fixed and mobile telephony segments together. Thus, The degree of competition is characterized by the existing market structure in each segment, with a score of "1" indicating a monopoly, "2" a duopoly and "3" three and more operators.

Unlike most other studies, we also include multilateral liberalization commitments, $GATSLIBER_{ct}$, which may lead to additional effects, not accounted for by unilateral measures.[11] In particular in the African context, where political instability and insecurity are major drags on the level of investment, the quasi-irreversible character of external commitments in the GATS framework is expected to enhance the credibility of reforms, namely that the regulatory framework will be consistent, fair and predictable, thus lowering investment risks (Marchetti, 2004).[12] GATS commitments are used as an indicator of a country's openness to foreign competition. It is measured by a dummy variable that takes the value of "1" for a country with at least one commitment under the GATS and "0" otherwise. This indicator is then interacted with the number of years since the commitment subscription date. This variable is quite weak as a liberalization indicator, since it does not contain any

[11] Given the strong partial correlation we find between the unilateral and multilateral indicators of openness and regulation, we have also explored how each performs separately in the regression. This robustness check leaves our results unaffected.

[12] Marchetti (2004) notes that not every commitment may have the same effect on enhancing investor confidence. Specific requests by mode and sector in the current negotiations may give an indication of the kind of regulatory assurances investors are looking for.

information on the type or level of commitments. Moreover, as was said before commitments in the WTO may be far less liberal than actual practice[13].

Effectiveness of regulation

Three regulatory indicators are considered:

REG_{ct}, the sectoral regulatory quality is approximated by a combination of two components: The principal element is the degree of independence of the regulatory authority from the government according to a range of criteria, such as legal autonomy (i.e. whether or not it is affiliated with the administration), budgetary dependence and process for appointment of members. "1" is attributed to countries where the regulatory authority is independent, while "0" where it is not. The independence indicator is then interacted with the number of years for which the regulatory authority has been in existence[14]. This term allows for the fact that the degree of autonomy and its competence (proxied by its years of experience) may depend on one another. However, if the condition of "autonomy" is presented by UIT (2004) as necessary for an efficient regulation, it could not be a sufficient condition in particular context of African countries, as discussed in Plane (2001): Because of its proximity with the operators, it is not excluded that the regulator uses its discretion for purposes of personal interest in a corrupted environment, creating therefore the possibility for collusions[15].

$GOUV_{ct}$, the governance indicators represented the quality of economy regulation and the political stability is from Kaufman et al. (2005).

$GATSREG_{ct}$, the third regulatory quality indicator is the adherence to the Reference Paper. A dummy is constructed taking the value of "0" for countries that have not subscribed to any regulatory disciplines in the telecommunications sector (beyond general GATS rules), "1" for countries which have committed themselves in regard to certain regulatory disciplines, but not the Reference Paper, and "2" for countries having adopted the Reference Paper in total or in

[13] This variable has been multiplied by the number of years since the submission of commitment at WTO by the country. This allows the utilization of fixed effect technique.

[14] Alternatively, we use the size of the regulatory authority in terms of staff numbers (proxy for its overall resource endowments) to measure its competence. But this variable turn out to be non significant in all our regressions.

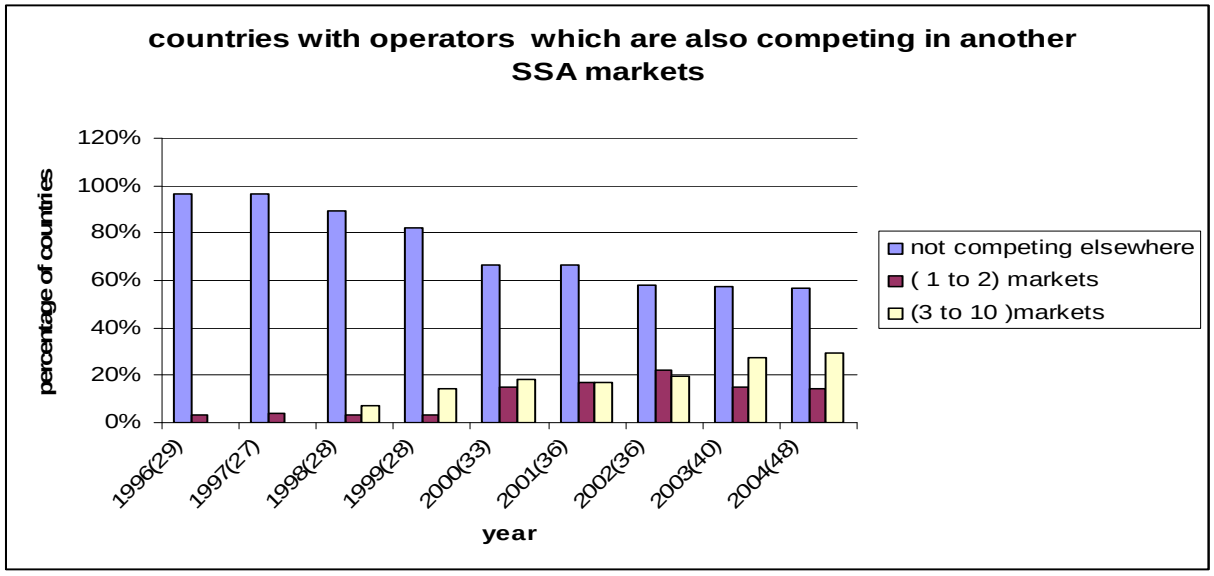
[15] The effective "autonomy" of regulator will be guaranteed if regulatory mechanism impose the plurality of control (see Laffont and Martimort, 1997), or a multi-sectoral and/or multi-regional regulation (Eustache and Martimort, 1999). But these points are not accessed in this study.

part. The indicator is then interacted with the number of years since the commitment subscription date[16].

Multimarket contact $MMARKET_{ct}$

Multimarket contact is perceived to be one of those factors, which can facilitate and sustain implicit collusion among firms engaged in non cooperative rivalry according to "mutual forbearance" assumption (See Bernheim and Whinston, 1990). This is notably possible through the mechanism of "strategic effects" which allow the firms to distribute their market power "through pooling the incentive constraints" across the markets: they can reduce prices and renounce a part of profits in the more collusive markets in order to facilitate collusion, raise prices and augment profits in the more competitive markets, as long as their total profits are maximized (See Bernheim and Whinston, 1990).

Figure 3. Evidence of firms multi-contacts in South Sahara African Mobile market



Sources: author estimation from data collected from UIT and nationals sources via internet.

The multimarket contacts, $MMARKET_{ct}$ (alternatively, multimarket competition, multipoint rivalry) is measured by the total number of time that the firms in a given country are in competition in others African countries. The data were collected specially for this study through the internet sources.

[16] As this indicator show not effect probably because of little number of African countries (only 5) that have adopted this reference document, we have excluded its from our regressions.

The IUT provides the e-mails list of all telecommunications regulatory authorities or minister in the world. These sources provide us the history of each operator in the market, while giving the name of multinationals contributing to its capital. The figure3 above gives the proportion of countries with operators which are also competing in another South Saharan African Country. It appears clearly that the multimarket contacts are growing quickly in African market. The share of country whose firms have no multimarket contacts decrease from 98% in 1997 to 58% in 2004.

Market saturation

SAT_{ct}^{s}, the level of market saturation is proxy by the penetration.[17] The Market saturation variable is expected to have a negative correlation with market power. More a market is saturated, more the operators would have incentive to adjust their price in order to attract new consumers.

5.1.3 Economy structure and supply side variables (S_{ct}^{s})

The economic structure variables—the population of the country, per capita GDP and density. —were all available from the World Development Indicators (WDI) 2005 data base of the World Bank (World Bank, 2005). On the supply-side, $ENERG_{ct}$, the index of electricity prices across countries and $RENT_{ct}$, the real interest rate were available from WDI. The average monthly wage of workers ($WAGE_{ct}$) in the country was collected from the ILO. The quantity of telecommunications output, $SUBR_{ct}^{s}$, measured by the number of subscribers in each segments is provided by ITU. The quality of telecommunications services, $QLTE_{ct}^{s}$, have been measured by the share of calls failed. But as this indicator is not available for mobile sector, we considered a different indicator, which is the share of digital subscribers in the country. The two quality indicators were collected from ITU. We have also included the time trend and the country fixed effects.

[17] Nunn and Sarvary measured this variable as the cumulative growth rate of the telephone industry since introduction. The penetration seems to be more relevant as it captures the extent of the market to be conquered by the firms.

5.2 Econometric issues

The first choice estimation technique in the context of simultaneous equations model is the 3SLS (see Green, 2001). Thus, the simultaneity bias is corrected for by using internal instruments. The 3SLS estimation procedure is set out in Zellner and Theil (1962): First, the exogenous variables are taken as instruments for the endogenous variables using ordinary least squares (OLS). Then, each endogenous variable is regressed on both the exogenous variables and the predictions of the endogenous variables. This is the common two stage least squares procedure (2SLS). Finally, the generalized least squares (GLS) estimator is calculated in order to use the additional information of the contemporaneous correlation of the error terms.

The main advantage of using 3SLS compared to the 2SLS is an increase in the efficiency of the estimations. However, if the 3SLS is asymptotically better, they have the disadvantage that any specification error in the structure of the model will be propagated throughout the system while the 2SLS estimator will confine a problem to the particular equation in which it appears. Therefore, we will present results for the two estimators.

5.2.1 Endogeneity problems and choice of instrument

We consider that the indicator of liberalization (number of operator) is endogenous (possibility of simultaneous bias). This relies on the fact that countries with high price or market power could have more incitation to introduce liberalization, in particular for economy under Adjustment structural Plan. As instrument for this indicator, we consider the market size (expressed as the ratio of national GDP on global African GDP). The empirical estimations showed that this variable is a strong determinant of the number of operator in a given market (see Boylaud and Nicoletti, 2001). However, there is theoretically possibility of correlation between the market size and the price, trough the scale economy effect. This instrument is qualified as “external instrument”, since the 3SLS estimates assume all exogenous variables of the model as additional instruments (i.e. internal instruments) [18]. The validity of these instruments is tested using the test of Hansen-Sagan presented, below.

The indicator of GDP has been introduced with the lack with a period to circumvent a potential problem of simultaneity bias between the price and the GDP.

[18] See table. A4 for the identification details

5.2.2 Over-identification problem in simultaneous equation model[19]

The estimation of a simultaneous system requires each equation to be identified. Two conditions have to be verified: the order and the rank conditions.

The order condition require for each equation "s" that the number of exogenous variables included in the system, but excluded from equation (X_s) is greater or equal to the number of endogenous variables in equation (s) minus 1.

$$X_s \geq G_s - 1$$

Our model contains two equations, and each equation has two endogenous variables (dependant variables plus the indicator of liberalization measured by the number of operators). Therefore, the condition of rank is verified in our model, since for each equation included in the system, the number of excluded exogenous variables is always more than one.

But this condition is necessary but not sufficient for identification. The rank condition is sufficient: and imply that the matrix of parameters for the excluded variables in each equation must have rank equal to number of equations in the system minus one. In practice this is always true if the order condition is met with $X_s = G_s - 1$.

But, if $X_s \geq G_s - 1$, as in our case, the model is say to be over identified and a test is necessary to verify the rank condition[20]. The most using test is that of Hansen-Sargan for over-identifying restrictions in regression estimated via the 3SLS in which the number of instruments exceeds the number of regressors (see Baum, Schaffer and Stillman, 2006). This is the test for the joint null hypothesis that the excluded instruments are valid instruments, i.e., they are uncorrelated with the error term and correctly excluded from the estimated equation. A rejection casts doubt on the validity of the instruments in 3SLS. The test computes a p-value comparing the Hansen-Sargan statistic, J, (which is the minimum value) to a criteria build by Davidson & MacKinnon (2004).

The criterion is that of the estimation in « minimum-distance » expressed as follow:

[19] All results presented in this section are proved in Green (2004).
[20] See table. A4 for the identification details

$$\text{criteria} = \text{resid}' \left((\text{nbeq})^{-1} \otimes \text{EXO} * \left(\text{EXO}' \text{EXO} \right)^{-1} \text{EXO} \right) \text{resid} \sim \text{Hansen} / \text{Sargan stat(J)}$$

Where, *EXO* and resid are the matrix indicating the exogenous variables and the residue

Under the null hypothesis $J \sim chi2(DL)$

With $DL = nbeq * nbEXO - nbcoef\,(net)$

DL is the Degree of Freedom, *nbeq* is the number of equation, *nbEXO* is the number of exogenous and *nbcoef* (*net*) is the number of parameters net of parameters in constraints.

If the Hansen-Sargan Chi2 p-value >5% the null assumption of the validity of instruments cannot be rejected.

5.2.3 Test of model specification validity

The validity of restrictions (14) and (15) as well as the normalization constraint on MIMIC model is tested using the minimum-distance test statistic described in Gertler (1988). This test allows to circumvent the problem of the subjective choice of the parameter of normalization in the reduce model as points out Breusch (2005). The following discussion is based entirely on Gertler (1988) in which results are proved.

The statistic of the test is:

$$g(\psi) = \left[\hat{\delta} - f(\psi) \right]' \hat{\Omega}^{-1} \left[\hat{\delta} - f(\psi) \right] \sim \chi^2(b) \qquad (16)$$

$\hat{\delta}$ is the matrix of OLS estimate of the reduced form equation in (12)

$f(\psi)$ is a function expressing the coefficients of reduced form equation (12), using the vector of parameters ψ (λ^S, β_k, α_k) estimated through the restrictions of MIMIC model.

b is the difference between the number of parameters in the unrestricted reduced-form equations in (12) (i.e. number of $\hat{\delta}$) and the number of parameters in the restricted equations (9) and (10) (i.e. number of β_k plus α_k). Therefore, the (joint) null hypothesis of this test is that the normalization and proportionality restrictions (i.e. equations 14 & 15) imposed by the MIMIC model are valid.

Ω is the covariance matrix of residue of price in equation (11). It can be formulated as follow:

$$\Omega = E\left[\left(\lambda^{s} v_{ct} + \varepsilon^{s}\right)'\left(\lambda^{s} v_{ct} + \varepsilon^{s}\right)\right] \quad (17)$$

Following Mccluskey et al (2004), $\Omega = \lambda\lambda' + \sum$

where λ is a vector of market power coefficients and $\sum$ is a diagonal matrix of variances, i.e. diag (σ_1^2, σ_2^2) with $s = 2$ indicating the number of equations (segments) of the system.

5.3 Results

5.3.1 Descriptive statistics (see Table A.1: in annex)

Simple correlation analysis, presented in Table A.1, reveals that, among the variables expected to influence market power, only the effectiveness of regulation (quality of regulation in the country and the quality of regulatory authority) and the mobile saturation are significantly correlates with prices in both mobile and fixed segments. Clearly, this analysis provides limited insight. Table A.1 also shows that GDP per capita is correlated with other economic and demographic variables. Interestingly, although most of variables included in our model are correlated, none of these correlations is very high. Only one correlation between (institution and fixed line saturation) exceeds 0.5. Multicollinearity, therefore, does not seem to be a serious problem.

5.3.2 Econometric results

Before interpreting the results, it is relevant to test the validity of the hypothesis concerning the MIMIC model. The test relies on the statistic of Gertler in equation (16). The joint hypothesis that the normalization and proportionality restrictions are valid cannot be rejected at the 5% significance level. The value of the test statistic is 40, which is distributed as chi-squared with 8 of freedom. Table.4 presents the estimates of the structural MIMIC model. The column (4) and (5) in on hand and the columns (6) and (7) on other represent the estimates of the MIMIC (system) model using respectively the 2SLS and the 3SLS. For each methodology, the first column represents the parameters of the equation related to mobile

segment and the second represent those of fixed segment. As expected, the 2SLS estimates are less efficient than those of the 3SLS. Therefore, the interpretations below are based exclusively on the 3SLS method.

To test the validity of internal exogenous plus the market size as valid instruments of our model, we perform the Hansen-Sargan identification test. The statistic and test are presented in the last line of table 4. The test can not reject the null hypothesis that the instruments are valid (p-value =84%). The 3SLS estimates are then validated.

We analyze our estimates results following successively the parameters of cost determinants, (α_k^s), Parameter of market (λ^s), and parameters of market power determinants (β_k). To be interpreted, the parameters, β_k, of market power determinants would necessitate the coefficient λ^s to be significant**.**

Parameters of Cost determinants (α_k^s)

We are first interested in the **various demand elasticities**, indicated by the coefficients related to the telecommunications output (as measured by the log of the number of subscribers in each segment). As expected, the direct demand elasticities in both mobile and fixed segments are negative with the values of (-0.19) and (-0.25), respectively. However, if the result is strongly significant (at 1%) in the case of mobile telephone, it turns out to be no significant in fixed line segment. The absence of significance in fixed line may reflect the relatively important consumer switching costs across fixed operator services providers, due to longtime monopoly reign on this market[21]. It's more likely that the markup in fixed segment would result in the decrease in minutes of calls, rather than changing the operator.

The **cross elasticity** between the mobile and the fixed segments is positive, suggesting a potential complementary effect between the two segments. However, the result is not significant.

[21] Nunn et al (2004) evidence, in the case of mobile telephone, that the number of years that the first market entrant enjoyed a monopoly prior to competition contributes significantly to reduce the sensitivity of consumer to price decrease, because of the existence of switching costs.

As far as **the services quality indicator** is concerned, the results point to a positive (0.72) and significant (5%) coefficient for the mobile segment, while showing no significant coefficient for the fixed segment. In the case of mobile where the quality is measured by the share of digital (opposite to analogy), the result traduce the fact the operators amputate to the consumer their investments efforts in modernizing telecommunications infrastructure. For the fixed, the absence of significant correlation between the price and the share of calls failed is consistent with the monopoly market structure that characterized this segment in most countries until the starting of years 2000.

Concerning the economic structures variables, the GDP coefficient is positive as expected but not significant. This result suggests that the telephone price through the continent is independent to the level of the country's wealth. The variable of population dispersion as measured by the population density has the expected negative sign, which suggests that price decreases with the density. This relationship is however only significant in the case of the fixed telephone, interpreting the higher potential of network effect in this segment compared to the mobile.

Concerning the variables of production inputs, the energy price index and the wage index have positive and significant coefficients, for both mobile and fixed segments. This result is different from that of Nunn and Sarvary (2004), which find no significant effect of wage and a negative effect of energy price.

Finally, the real interest rate has not significant effect, which is not consistent with the literature. Both Nunn and Sarvary (2004) and Parker & Roller (1997) evidence a strong positive effect of lending rate on mobile price. They justified their results by the fact that the credit financing is a common practice in the cellular industry. However, the absence of correlation in our case could be due to the fact that most of telecommunications operator in Africa are constituted of foreign capital and therefore are less sensitive to local interest rate.

Parameter of market power (λ^S)

This parameter is the test on the existence of market power practice in a given segment (s).
The result accords with the a priori expectation. The estimated market power parameter is 1.09 for mobile telecommunications and is significant at the 5% level. The positive

relationship between industry market power and the price of mobile telecommunication implies that a higher market power leads to the increase of the prices in mobile and fixed telecommunications, which is consistent with economic theory.

Our estimation results also provide information regarding the relationship between the two segments in terms of exercising market power. The positive sign of the estimated market power parameter for mobile segment suggests that an increase in market power in the telecommunication market would cause the price of mobile to increase relative to the fixed telephony.

This finding suggests an ordering of telecommunications segments in the potentiality to exercise market power, i.e., the mobile segment has a greater potentiality than the fixed segment. The existence of market power therefore makes it interesting to explore its origins among the more recurrent factors in the literature: regulatory policy, market saturation, the number of competitor, the international commitments and the multi-contact effect.

Parameters of market power determinants (β_k).

The saturation (market penetration)

The degree of market saturation, as measure by the penetration, contributes to the decreasing of telecommunications market power. The saturation parameter is negative (-0.07) and significant at 5% level. This result is consistent with the empirical finding of Nunn et al (2004). It also supports the theoretical hypothesis (Tirole, 1988) that, as the market grows to the saturation, the firms are obliged to compete on price in order to gain new market share from the competition. This suggests that the particularly high market power in telecommunications observed in Africa is partly related to the low level of penetration.

Regulation

The indicator of the quality of telecommunications regulation interacting with the independence and experience features a negative (-0,71) and significant (at level of 5%) correlation with the market power. This result is consistent with our expectation and the literature, while advocating for the strengthening of regulation efforts that have been undertaken in the continent this last years.

As the sector regulation, the whole economy regulation quality turns out to be not significantly linked to market power although its coefficient of correlation is negative as expected. This result is in opposition of a It should be noted that this indicator does not vary a lot in the time, then most of its effect could be already captured in fixed effects correction.

Unilateral Liberalization: Market structure

The parameter estimate for the number of competitors in both mobile and fixed segments is negative (-0.13). However, it is poorly significant at 10%. This finding is consistent with the theory, as the increasing number of competitors reduces the firms' market power. It's however in opposite of studies by Parker and Roller (1997) on US cellular markets, and by Nunn et al (2004) on a sample of CDEO countries[22].

Multilateral liberalization

As expected, the multilateral liberalization contribute to attenuate the market power in telecommunications industry, as its coefficient turn out to be negative (-0,20) and significant. Its seems that the quasi-irreversibility of the GATS commitments lower the investment risks and then enhance operators to build a longer term strategy of rentability instead of a short term rental extraction. However, the pertinence of the GATS indicator considered here is to be questioned since it does not capture the differences between countries in terms of breadth (e.g. sub-sectors and modes of supply covered by the commitments) and quality of commitments.

Multimarket contact

Finally, the last important result is that, as expected, we find an empirical support for multimarket effect. The result in table shows a positive (0.06) and significant (at 10%) effect of multimarket parameter. This result brings a support to the model of Barnheim and Whinston (1990) and confirms the finding of Parker et al (1997), based on mobile telephone market in US. The similar results has also been evidenced on airlines industries by Evans and Kessides (1994) who show that tariff are higher on a routes where competing carriers have interoute contacts.

[22] Parker and Roller (1997) study justified their result by the fact that the FCC restricted the number of operators in American market to two, a situation which facilitated the collusion behaviors. Nunn et al (2004) justified their own result by a potential multicollinearity problem. Our study doesn't suffer from any of those problems.

Table 4. 3SLS with fixed effect

Variables categories'	Variables	**2SLS**		**3SLS**	
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
		Eq1 (S=Mobile)	**Eq2 (S=Fixed)**	**Eq1 (S=Mobile)**	**Eq2 (S=Fixed)**
Parameters of Cost determinants(α_k^s)	Constant	-21,76 (-0,20)	0	-18,00 (-0,29)	0
	Density	-0,18 (-1,17)	-0,35 (-1,77)*	-0,16 (-2,13)**	-0,31 (-2,25)**
	Wage	1,14 (2,85)***	0,67 (1,75)*	1,17 (3,41)***	0,68 (1,73)*
	Lag of GDP	1,65 (0,91)	1,77 (1,01)	1,55 (1,02)	2,29 (1,28)
	Population	3,65 (0,73)	2,22 (0,46)	3,28 (0,78)	3,03 (0,62)
	rent	-0,32 (-0,37)	0,11 (0,13)	-0,46 (-0,63)	-0,04 (-0,04)
	energy	1,07 (1,05)	0,57 (1,58)	1,20 (1,59)	0,81 (1,80)*
	Mobile output quantity	-0,18 (-1,79)*	0,10 (0,81)	-0,19 (-2,45)**	0,08 (0,97)
	Fixed output quantity	0,10 (0,81)	-0,22 (-0,55)	0,08 (0,97)	-0,25 (-0,95)
	Mobile quality (share digital)	0,72 (1,71)*		0,78 (2,15)**	
	Fixed quality (share calls failed)		-0,05 (-1,12)		-0,05 (-1,41)
	Trend	0,05 (1,39)	0,03 (0,88)	0,04 (1,48)	0,03 (0,81)
Parameter of market power (λ^s)	**Market power**	**1,06 (2,39)****	**1**	**1,09 (3,06)*****	**1**
Parameters of market power determinants (β_k)	Constant	-58,05 (-0,89)	-58,05 (-0,89)	-45,39 (-0,71)	-45,39 (-0,71)
	Multilateral liberalization (GATS commitment)	-0,20 (-1,99)*	-0,20 (-1,99)**	-0,15 (-1,84)*	-0,15 (-1,84)*
	Unilateral liberalization in fixed (number of fixed operator)		**-0,13 (-1,36)**		**-0,15 (-1,67)***
	Unilateral liberalization in mobile (number of mobile operator)	**-0,13 (-1,36)**		**-0,15 (-1,67)***	
	Multimarket effect	0,06 (1,66)*	0,06 (1,66)*	0,06 (1,69)*	0,06 (1,69)*
	Unilateral regulation	-0,29 (-1,42)	-0,29 (-1,22)	-0,71 (-1,73)*	-0,71 (-1,73)*
	Governance	9,70 (0,60)	9,70 (0,60)	-2,81 (-0,19)	-2,81 (-0,19)
	Saturation: Mobile penetration	-0,07 (-1,81)*		-0,07 (-2,11)**	
	Saturation: Fixed penetration		-0,07 (-1,81)*		-0,07 (-2,11)**
Statistics and tests	Countries	**30**	**30**	**30**	**30**
	OBS: 30 X 4	99	99	99	99
	Hansen-Sargan test	J=34.351 H0: Chi-sq(22), pval = 0.35		J=14.612 H0: Chi-sq(22), pval = 0.64	
	Durbin-Watson stat	1.926	1.957	1.926	1.957
	R^2	**0.35**	**0.17**	**0.35**	**0.16**

Absolute value of z statistics in parentheses : significant at 10%; ** significant at 5%; *** significant at 1%*

Notes: (1) the eq1 and eq2 are the two equations constituting our model. They have been simulated simultaneously; (2) by assumptions, the parameters of market power determinants are the same in mobile and fixed segment; (3) Among, parameters of marginal cost, we have assume the intercept of fixed segment to be zero($\alpha_0^{s=2} = 0$ *). We have also normalized the coefficient of market power related in fixed segment equation to one (* $\lambda^{s=2} = 1$ *).*

Structure of market power in Africa

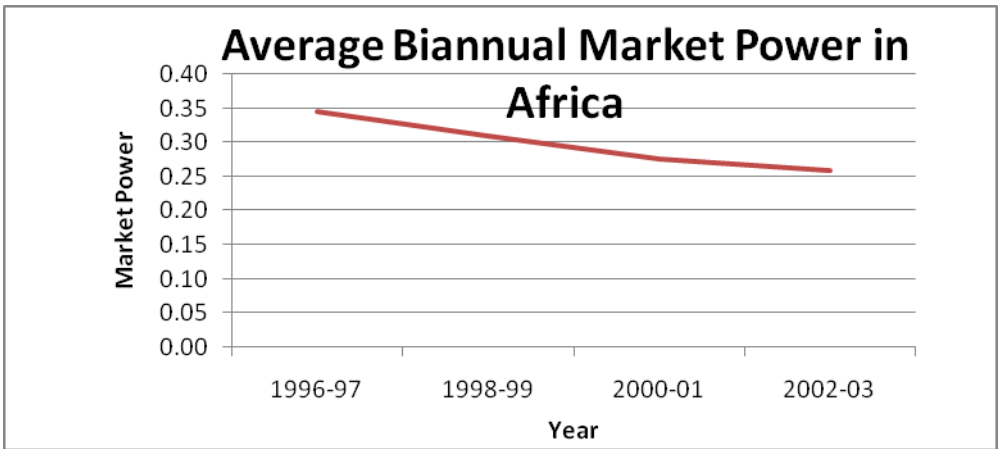
After showing the evidence of the existence of market power and its determinants, we rely on the above estimates to compute (predict) its amplitude. The market power is derived from equations (4) and (10) following the formulation below:

$$\hat{\phi}_{ct} = 1 - EXP\left[\hat{\beta}_0 + \sum_{k=1}^{K} \hat{\beta}_k \log\left(F_{kct}\right)\right] \qquad (18)$$

Our calculations reveal average amplitude of market power (between 1996 and 2003) of 0.29. The minimum is 0.14 and the maximum is 0.37 (standard deviation of 0.05). This implies that the telecommunication price in Africa is majored on average by 29% because of the existence of market power practices.

It's particularly instructive to follow the evolution of the market power through the time. The figure4 below, show the prediction of the biannual average of market power in Africa between 1996 and 2003.

Figure 4. Evolution of market power from 1996 to 2003 in Africa



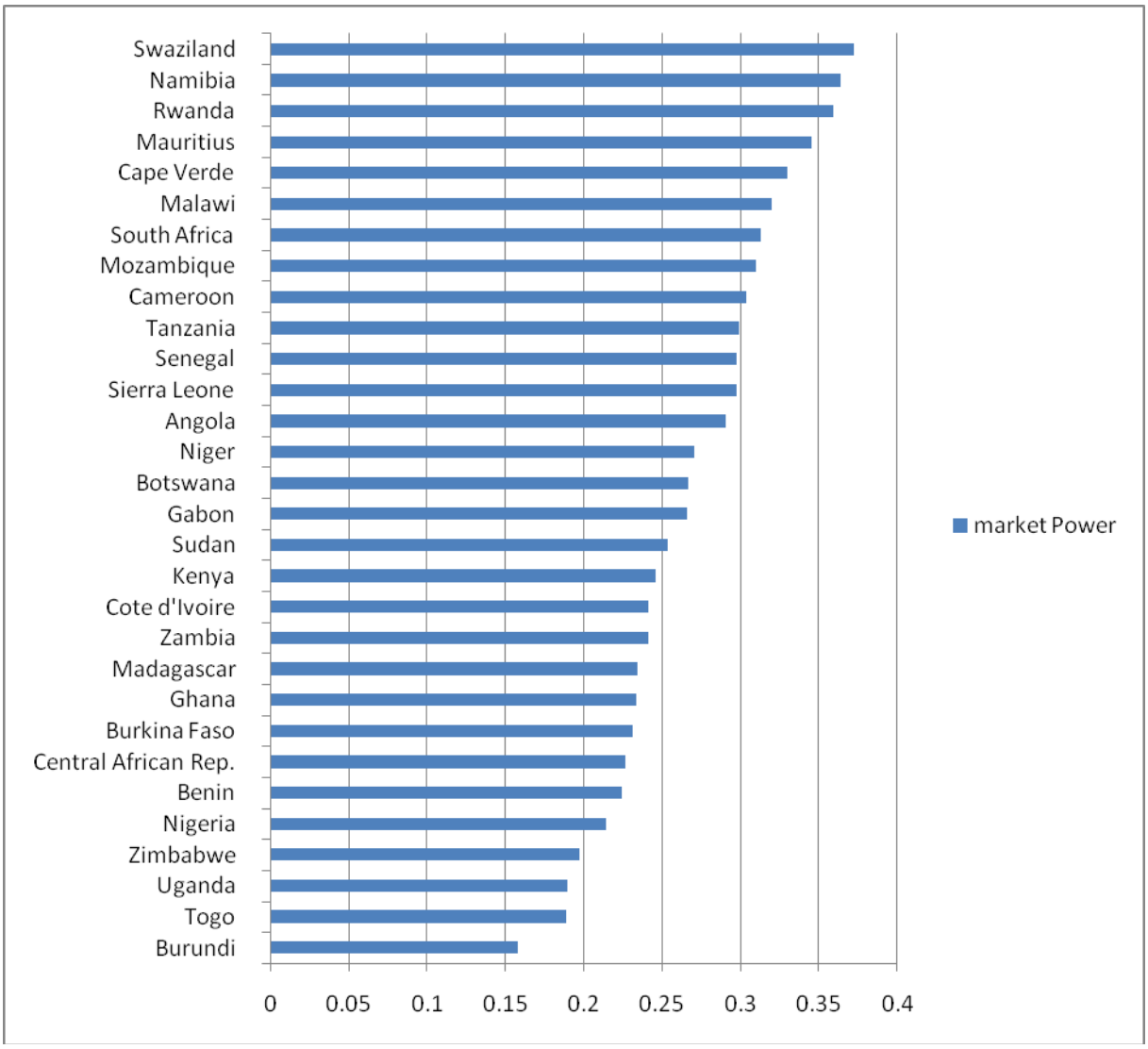
Source: Author's construction

The market power is following a slowing trend, moving from 0.37 in 1996 to 0.28 in 2003. This is the manifestation of the efficiency (even limited) of the reforms undertaken during that

period and which turn out to have significant effect in our estimates (increasing in number of operators, multilateral liberalization). It's also due to the pressure imposing by the increasing saturation of market which constraints operators to reduce their price if they want to gain new market share.

As the telecommunications policies are undertaken at national level, analyzing market power for individual countries could be of particular interest. The figur5 below reveals the prediction of market power for the 30 African countries of our sample in 2003.

Figure 5. Prediction of Market power in African countries for the period of 2002-03



Source: Author construction

The country with the least important market power is the Burundi (0.16), while the one with the more important is the Swaziland (0.37). The average African position is occupied by Angola with 0.29. The table A4 in annex ranks countries in the figure 5 according to the

market power amplitude while displaying the relevant level of competition prevailing in each segment of telecommunications. Globally, the countries on the top of the list of market power practice seem to be those maintaining monopole in all telecommunications segments. Conversely, the countries where the competition has been introduced partially or fully have least important market power practice[23].

[23]This observation is a confirmation of the significant correlation perceived in our estimates and does not exclude others markup determinants reveal by our model.

6 Conclusions

In this study, we use The MIMIC model to estimate the market power and its sources in telecommunication industry. The empirical estimate is based on aggregate price and quantity biannual data from 30 African countries between 1996 and 2003. We consider two "indicators variables" (or dependent variables) in our MIMIC model: the prices in mobile and fixed telephony segments. As "causes variables", three set variables are used: (1) the variables of liberalization, including unilateral liberalization (number of operators allowed in each segment), and multilateral liberalization (subscriptions of commitments in the framework of GATS); (2) the variables of regulations at sectoral level (autonomy and experience of regulatory authority) and at national level (Kaufmann governance indicators: regulatory quality, policy stability, corruption control); (3) the organizational structure variable captured by the multimarket contact (reflecting the situation of two operators whose parent companies would be competing in more than one market).

Three main results emerge from our estimates: First, the African telecommunication industry faces a strong and significant market power, which maintains the continent prices above the competition level. Second, beyond the increasing in penetration which contributes to attenuate the market power, three policy factors seem also to be affecting it negatively: the unilateral (domestic) efforts in term of liberalization (increasing in number of operators) as well as strengthening sectoral regulation, and the multilateral subscriptions of commitments to liberalize in the framework of the GATS at WTO. Third, it appears, as evidenced by Parker and Roller (1997), that multimarket contact of telecommunications operators is an important factor explaining the cooperative pricing behavior.

While our findings may suffer from many limitations (see below), a number of policy implications can be drawn with respect to the telecommunications trade at domestic, regional and multilateral levels. At local level, it's relevant to allow more licenses,

particularly in fixed segment where monopole still exists in numbers of African countries. The strengthening of regulation authority autonomy and competencies should remain a priority. Moreover, it seems that a regulation with a regional perspective would be more fruitful. Our finding that the multimarket contact enhances market power clearly advocates for current projects to establish sub-regional or regional regulatory institutions in Africa. Finally, in the current context of multilateral trade negotiations on services, our findings provide evidence that the commitments subscribed in the framework of GATS could be a complementary factor in enhancing competitiveness in telecommunications market in Africa.

Our analysis has some important limitations. First, and most importantly, in our data set, price and quantity data are only available at an aggregate level for each country. Furthermore, the aggregate nature of the data and the resulting empirical model do not allow for differences across firm behaviors.

Second, as all international studies, ours also suffers from the lack of available variables across a large number of countries. Thus, for our main variable of interest, market power, we may have an omitted variable problem. For example, the literature evidences that cross-ownership across cellular operators (See. Parker and Roller, 1997), and the number of years that the first market entrant enjoyed a monopoly prior to competitive, are important predictor of market power. But we did not have data to test this hypothesis in our international context.

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Annexes

Table A.1: Partial correlation of main variables in market power model

	Mobile price	**Fixed Price**	**GDP/ capita**	Institu-tion	Mobile saturation	Interest rate	Electric cost	Rent Indices	Mobile penetration	Fixed penetration	GATS Commit ment	DOC REF	Operators collusion	Nbre mobile operators	Nber fixed operators	Nber inter optors	density	urban Popult	Regulator quality	POP	Nber Mobile lines
	1	**2**	**3**	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Mobile price	**1**																				
Fixed price	**0.6577***	**1**																			
GDP	**0.5954***	**0.7154***	**1**																		
Institution	**0.0059**	**-0.1523***	**0.0523**	1																	
Mobile saturation	**-0.2807***	**-0.1062***	**0.1177***	0.3352*	1																
Interest rate	**0.1275**	**0.0177**	**-0.0298**	-0.2279*	-0.1987*	1															
Electric cost	**-0.1122***	**-0.0283**	**-0.1566***	-0.057	0.0011	0.0802	1														
Rent indices	**-0.2536***	**0.0351**	**-0.0721**	-0.0012	0.1875*	0.0339	0.3279*	1													
Fixed saturation	**-0.1360***	**-0.0042**	**0.3507***	0.5788*	0.5867*	-0.1714*	-0.045	0.0624	0.5867*	1											
GATS commitment	**0.0892**	**0.0523**	**0.0266**	0.017	0.0415	-0.094	0.2236*	0.1415*	0.0415	0.0417	1										
DOC REF	**0.0203**	**-0.1161***	**-0.0584**	0.1945*	0.1580*	-0.0696	0.1742*	0.0535	0.1580*	0.1914*	0.5413*	1									
Operators collusion	**0.0533**	**-0.0541**	**-0.1548***	-0.0883*	0.1211*	0.0626	-0.0494	0.0351	0.1211*	-0.1700*	-0.1581*	-0.0716	1								
Nber mobile operators	**0.017**	**0.0341**	**-0.1121***	0.0117	0.2423*	0.0233	0.0221	0.0519	0.2423*	-0.1291*	-0.0309	0.0741	0.1792*	1							
Nbr fixed oprtors	**-0.2569***	**-0.0758**	**-0.2174***	-0.2552*	0.1722*	0.0449	0.2299*	0.0442	0.1722*	-0.1658*	0.1454*	0.0418	0.0292	0.2378*	1						
Nber inter operators	**-0.1910***	**-0.0556**	**-0.2100***	-0.1910*	0.2117*	0.1042	0.2975*	0.1213*	0.2117*	-0.1759*	0.1007*	0.0432	0.082	0.3571*	0.7616*	1					
density	**0.0187**	**0.1371***	**0.0253**	0.0631	0.0756	0.0471	0.0674	0.1514*	0.0756	0.1915*	-0.0141	0.0927*	0.0294	-0.0382	0.0067	0.0456	1				
urban Popult	**0.1107***	**0.1584***	**0.3713***	0.0019	0.3187*	0.045	0.0627	-0.0672	0.3187*	0.3896*	0.3410*	0.2355*	-0.1371*	0.0549	0.0395	0.0053	-0.3101*	1			
Regulator quality	**-0.1814***	**-0.2060***	**-0.2631***	0.05	0.1542*	-0.0568	0.2049*	0.0279	0.1542*	-0.0036	0.0635	0.0651	0.1647*	0.0498	0.1923*	0.0988*	-0.051	-0.0107	1		
POP	**-0.1750***	**-0.3763***	**-0.5869***	-0.2070*	-0.2822*	0.0765	0.2383*	-0.0992*	-0.2822*	-0.4660*	0.2053*	0.2694*	0.1411*	-0.0129	0.2593*	0.2009*	-0.1018*	-0.2686*	0.4169*	1	
Nbr Mobile lines	**-0.3966***	**-0.3102***	**-0.2419***	0.1435*	0.7673*	-0.1436*	0.1403*	0.1074*	0.7673*	0.1800*	0.2334*	0.3353*	0.1928*	0.2641*	0.3628*	0.3559*	0.0318	0.1569*	0.4327*	0.3495*	1

Table A.2. List of countries included in our econometric sample

Number	Countries
1	Angola
2	Benin
3	Botswana
4	Burkina Faso
5	Burundi
6	Cameroon
7	Cape Verde
8	Central African Rep.
9	Cote d'Ivoire
10	Gabon
11	Ghana
12	Kenya
13	Madagascar
14	Malawi
15	Mauritius
16	Mozambique
17	Namibia
18	Niger
19	Nigeria
20	Rwanda
21	Senegal
22	Sierra Leone
23	South Africa
24	Sudan
25	Swaziland
26	Tanzania
27	Togo
28	Uganda
29	Zambia
30	Zimbabwe

Source: Author construction

Table A.3. Ranking of African countries in term of telecommunications market power practice and the relevant level of competition in 2003

Rank	Country	MARKUP	Number of mobile Competitors in 2003	Number of fixed Competitors in 2003
1	Swaziland	0.37	M	M
2	Namibia	0.36	M	M
3	Rwanda	0.36	M	M
4	Mauritius	0.35	P	M
5	Cape Verde	0.33	C	M
6	Malawi	0.32	C	M
7	South Africa	0.31	C	M
8	Mozambique	0.31	C	M
9	Cameroon	0.30	C	M
10	Tanzania	0.30	C	M
11	Senegal	0.30	C	M
12	Sierra Leone	0.30	C	M
13	Angola	0.29	P	P
14	Niger	0.27	C	C
15	Botswana	0.27	C	P
16	Gabon	0.27	C	P
17	Sudan	0.25	M	C
18	Kenya	0.25	P	P
19	Cote d'Ivoire	0.24	P	P
20	Zambia	0.24	C	M
21	Madagascar	0.23	C	C
22	Ghana	0.23	P	P
23	Burkina Faso	0.23	P	M
24	Central African Rep.	0.23	C	M
25	Benin	0.22	C	M
26	Nigeria	0.21	P	C
27	Zimbabwe	0.20	C	C
28	Uganda	0.19	P	P
29	Togo	0.19	P	P
30	Burundi	0.16	C	C

Source: authors' calculation

Note: M: Monopoly; P: Partial competition; and C: Full Competition

Table A.4 **Identification of the model**

Category of variables	**Number of variables (category) in each equation**	**variables**
Dependant variable		Price of telecommunications
Endogenous variables:	$G_s = 2$	Price of telecommunications
		Unilateral liberalization (number of operators)
Internal exogenous variables		Density
		Wage
		Lag of GDP
		Population
		rent
		energy
		Trend
		Multilateral liberalization (GATS commitment)
		Multimarket effect
		Governance
		Unilateral regulation
		Quality of services
		Services Output
		Saturation
Excluded exogenous variables	X_s=2	Saturation
		Quality of service
External exogenous variables (instruments)		Market size (ratio of national GDP on global African GDP);
		Lagged of Market size (-1)

Source: Author construction

Notes: (1) G_s *is the number of endogenous variables in equation (s) . (2)* X_s *is the number of exogenous variables included in the system, but excluded from equation (s). (3) The order condition require for each equation "s" that* $X_s \geq G_s - 1$.