Telecommunications Policy xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Telecommunications Policy

journal homepage: www.elsevier.com/locate/telpol

Diffusion of mobile telephony: Analysis of determinants in Cameroon

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ARTICLE INFO

Keywords:
Mobile telephone technology
Technological diffusion
Access subsidies
Competition
Regulation*JEL classification:*
c13
C25
L1
L96
O3

ABSTRACT

This paper explores the diffusion of mobile telephone technology in Cameroon by identifying and analyzing the determinants of this diffusion. Studying the diffusion of mobile communications in African countries by integrating them into panels of developing countries is problematic. This approach is likely to mask the intrinsic differences as concerns the diffusion process. This survey shows, through the estimation of an S-shaped growth curve, that the Logistic model best describes the diffusion of mobile phone technology in Cameroon. Income, openness to competition and the use of SMS are key forces driving this diffusion. Forecasts indicate an increase of almost 70% in the demand by 2026 as far as mobile phone use in Cameroon is concerned. This implies not only an improvement in operators' and State's revenues, but also, the need to invest in infrastructures. Our recommendation therefore calls for a greater liberalization of the mobile phone market in Cameroon. In addition, given the complementary relationship between the core and the mobile networks, infrastructural investments are also needed in both sectors.

1. Introduction

The diffusion of mobile telephony in developing countries as a whole and Africa in particular enables many researchers to carry out studies on the issue from many perspectives. This work aims to analyze the determinants of the mobile telephony diffusion in Cameroon, focusing on other variables like income, the use of SMS and mobile payments. In this perspective, three major elements are retained: a presentation of the mobile phone market in Cameroon, an estimation of the demand in the coming years and a discussion on the main factors affecting the take up of mobile communications in this country. It is thus justified to be interested in this issue, given that since the early 1990s, mobile telephony has experienced an unprecedented development worldwide, and particularly in developing countries. Indeed, the regulation policy practiced by developing countries played a significant role in stimulating the demand. This regulation basically aimed at promoting competition by acting both on the increased number of operators as well as on the variety of services offered. In this regard and according to the 2012 report of the mobile phone observatory in sub-Saharan Africa, mobile phone connections number has increased by 44% per year since 2000, while the average for the same period stood at 34% and 10% in developing and developed countries respectively (GSMA, 2012). This trend is further confirmed by the GSMA report (2017) where West Africa is mentioned to have the fastest growing market in the world. This remarkable growth in the use of mobile phone made this device one of the key communication means in this continent. The gradual evolution of mobile phone technology is largely explained by the core network's deficiency. As a matter of fact, in most African countries, its state is still rudimentary and undeveloped, particularly characterized by an inefficient management: waiting lists amounting to thousands, waiting connection time estimated at several years and consequently, a telephone density less than 5%. This situation is highly

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https://doi.org/10.1016/j.telpol.2018.08.002
Received 19 December 2016; Received in revised form 3 August 2018; Accepted 12 August 2018

damaging for populations, as they cannot satisfy their many communication needs. In this context, mobile telephone then appears as an outstanding solution for many people discouraged by the core network's deficiency.

Mobile telephone as a means of communication is of great interest to African populations thanks to its microeconomic and macroeconomic impacts. Indeed, several studies show that the diffusion of mobile technology can render markets (especially agricultural markets) more efficient (Kiisa & Pederson, 2012; Aker, 2008, 2010; Muto and Yamano, 2009) by stimulating exchange and reducing prices' dispersion and volatility. Similarly, in recent years, practices like mobile payments have been intensified since the successful implementation of the M-PESA in Kenya (Chaix & Torre, 2015; Attali, 2015).

Consequently, a study on market trends as concerns mobile telephony is necessary, given the impact of mobile telephones on the telecommunications sector's development. In this regard, identifying the potential market and assessing the diffusion pace are some factors likely to facilitate the forecasts of the demand for services, operators' and State's revenues and especially investments needed to build the infrastructural network. It is worth noting that mobile telephony, because of its high potential profitability, requires a particular attention as one of the main business sectors receiving foreign[1]direct investments.

Investigations on mobile telephony diffusion were first carried out in European, Asian, and American developed countries. For most of the authors and with few exceptions, the technological dimension or digitization is proven to be one of the major diffusion determinants of mobile telephony [Gruber and Verboven (2000); Jang, Dai, and Sung (2005); Lee and Cho (2007); Frank (2004); Liikanen, Stoneman, and Toivanen (2004)]. Some of these works also considered openness to competition accelerating the diffusion, though this determinant is less significant than digitization.

Exept for Ahn and Lee (1999) investigations and in line with the above-mentioned studies, it then becomes clear that the" income" variable which proxy is generally the GDP per capita is not a diffusion determinant in developed countries. However, Garbacz & Thompson, 2007 who studied the demand for the telecommunications' services in developing countries and Penard, Poussing, Zomo Yebe, and Nsi Ella (2012) who, in the same vein, carried out a survey in Gabon, show that income appears as a factor likely to stimulate the adoption of the Information and Communication Technologies (ICTs). In this perspective and in line with Rouvinen (2006), saying that there is no difference in the diffusion determinants of mobile telephony in developed and developing countries can be questionable.[2]

Indeed, investigating on the diffusion of mobile telephony in African countries while integrating them into a panel of developing countries (as shown in most studies quoted in this work) masks the intrinsic differences which can affect the diffusion process. As a matter of fact, the deregulation process implemented by African countries was to create regulatory bodies, liberalize markets and privatize the incumbent operator. In the case of Cameroon, only the mobile sector is liberalized, the core network being still held by the incumbent in a monopoly situation. Moreover, this operator does not have a mobile license while the sector is witnessing an unprecedented popularity. This specificity inexorably impacts the diffusion of mobile telephony in Cameroun. In fact, according to Garbacz and Thompson (2007), a possible relationship (complementarity or substitution) between the core and mobile networks which depends on the dynamics of the two market segments can be a diffusion determinant.

Moreover, the technological level as a determinant for mobile phone diffusion seems different in Africa. In fact, in most cases, openness to competition coincides with digitization and the advent of mobile telephony. In this context as raised by Gruber (2001) in the case of the Eastern European countries, the technological variable is no longer relevant. This is the case of Cameroon where a study on other determinants can be useful. We will focus on variables like income, the use of SMS and mobile payments. These variables are chosen for many reasons: since the advent of mobile telephony in Cameroon, the SMS appears to be the second most popular service used after the voice communication. In addition, income is naturally chosen within the framework of this study, given that it reflects the purchasing power of any subscriber. Moreover, given the weak financial inclusion of populations, mobile payments allow subscribers accessing the financial services, thus enabling them to reduce their transaction costs.

The purpose of this study is threefold. Firstly, if many investigations are carried out on mobile telephony in Africa, very few are interested in estimating a diffusion model. Secondly, this paper examines the diffusion determinants of mobile telephony within the more global framework of the deregulation of the telecommunications' sector because the deregulation specificities in Cameroon have an impact on mobile telephony diffusion. Lastly, Cameroon like many other African countries has been experiencing a remarkable growth in the use of mobile payments with MTN and ORANGE Mobile Money which are superimposed on the traditional services of money transfer. This use increases the recourse to SMS, particularly in remote rural areas.

In addition, according to the 2015 activity report of the Telecommunications Regulatory Agency (TRA), the penetration rate of mobile telephony in Cameroon fell from 75.69% in 2014 to 71.85% in 2015 (ART, 2015). Can we then deduce that this fall is the result of the mobile phone market saturation or it is a purely statistical issue? An estimation of the diffusion curve can enable us to answer this question. Finally, the World Bank data show a penetration rate of 98% in the world in 2015: on which levers can Cameroon rely to catch up this delay?

To carry out this investigation, we base ourselves on the managerial reports of mobile operators and those of the Telecommunications Regulatory Agency in Cameroon which provide time series data on the market. The methodology consists in first choosing among the two functions commonly used in literature (Logistic and Gompertz), that which best models the diffusion curve.

[1] It should be highlighted that the recent international financial crisis has not reduced the foreign investors' enthusiasm. Many operators such as the Kuwaiti Zain, the French ORANGE, the South African MTN and the Egyptian ORASCOM decided to increase their investment shares in Africa (Recuero Virto, 2010).

[2] Even though for this author, some specific factors to developing countries must be taken into account.

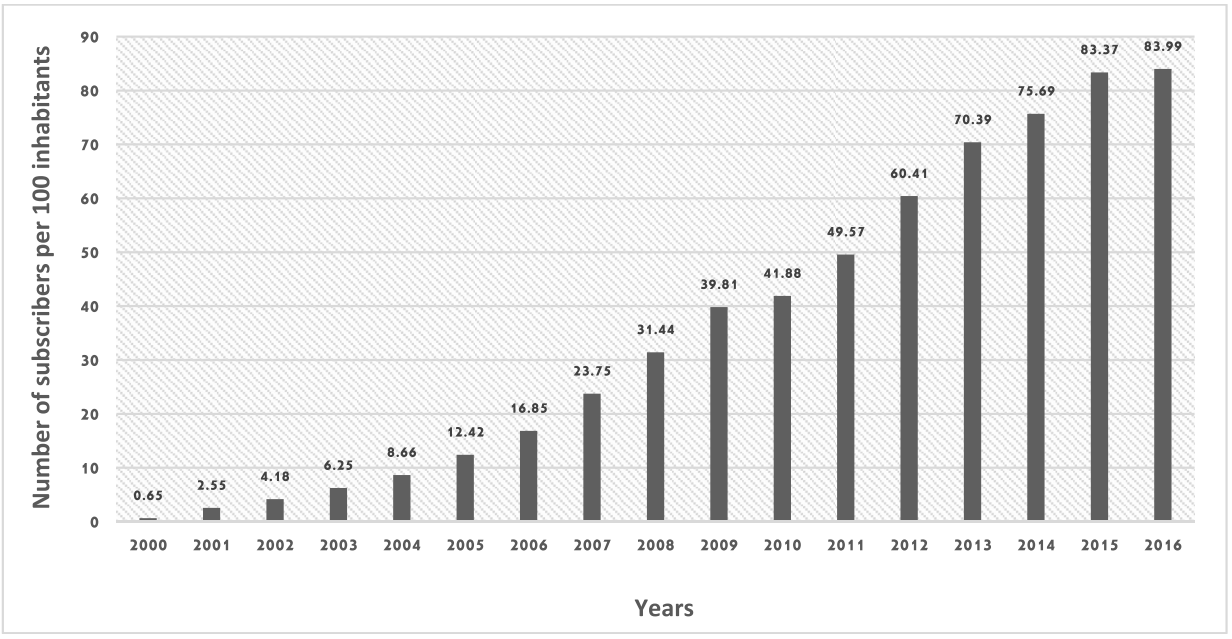

Fig. 1. Evolution of the penetration rate of mobile telephony in Cameroon (2000–2015).
Source: Author, using the International Telecommunications Union's (ITU) data.

In this respect, we privilege the *Mean Absolute Percentage Error* (MAPE)[3] criterion used by Singh (2008) in the case of India.[4] The selected model is then used to estimate the potential determinants of mobile telephony diffusion in Cameroon while drawing inspiration from Gruber (2001).

This study is organized as follows: After the introductory section, section 2 presents the mobile telephony sector in Cameroon while analyzing the operators' various strategies. Section 3 discusses the diffusion models used, Section 4 the findings and Section 5 concludes.

2. Mobile telephony market in Cameroon

The telephony market in Cameroon is the outcome of the implementation of the legal framework defined in this country after liberalization. Initially, the 1998 law governing the telecommunications enabled the issuing of two licenses: one in 1999 to ORANGE CAMEROON and the other in February 2000 through the purchase by MTN CAMEROON of CAMTEL MOBILE, the mobile section of the core operator CAMTEL. More than a decade later and taking into account the malfunctions observed, the 2010 law modifying the first and governing electronic communications in Cameroon was promulgated. Two other licenses were issued: one in 2012 to NEXTTEL and the other the same year to CAMTEL.

It is worth noting that ORANGE CAMEROON formerly called “Cameroon Mobile Phone Company” (or SCM-Mobilis) is a subsidiary company of France Telecom/Orange. It operated as a monopoly on the mobile sector for more than six months before being joined by MTN CAMEROON, the subsidiary of the South African multinational M-Cell which later became MTN INTERNATIONAL. Excluded from the mobile sector, the incumbent went back in this market in 2006 while adopting a different technology: the Code Division Multiple Access (CDMA). The advantage of this technology was its easy access and relatively low cost. CAMTEL thus hoped to capture the general public and tried to fill up the gap between the company and its competitors.

As shown in Fig. 1, mobile telephony has witnessed an unprecedented adhesion from the Cameroonian populations. In this respect, it is considered as a determining factor likely to ensure the universal access. However, if competition is effective in this sector, market structure is completely asymmetrical (Fig. 2). There is a clear dominance of the first two licenses MTN and ORANGE, with more than 90% of the market share. Neither NEXTTEL (4.66%) nor CAMTEL (1.47%) is able to challenge their leadership.

This market is analyzed while examining the price competition and the diversification of the mobile uses.

2.1. Price competition

Figs. 3–5 show the price evolution of the two main operators for intra-network, inter-network and international calls respectively.

[3] The MAPE is commonly used in quantitative forecasting methods because it produces a relative measurement of any adjustment. The absolute values of all the errors expressed in percentage are summarized and the average calculated.

[4] The choice of the diffusion model is done following different methods like that developed by Franses (1998) or Gamboa and Otero (2008).

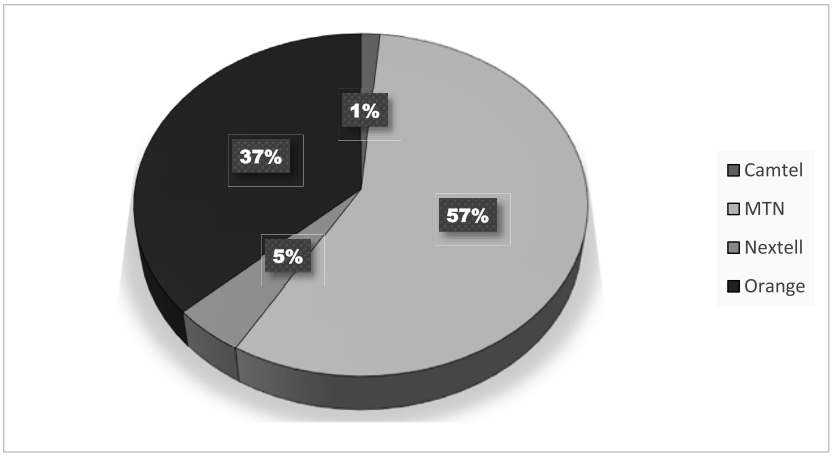

Fig. 2. Mobile Telephony Market Structure (**subscriber** base) in Cameroon (2016).
Source: Author, using the Telecommunications Regulatory Agency's (TRA) data.

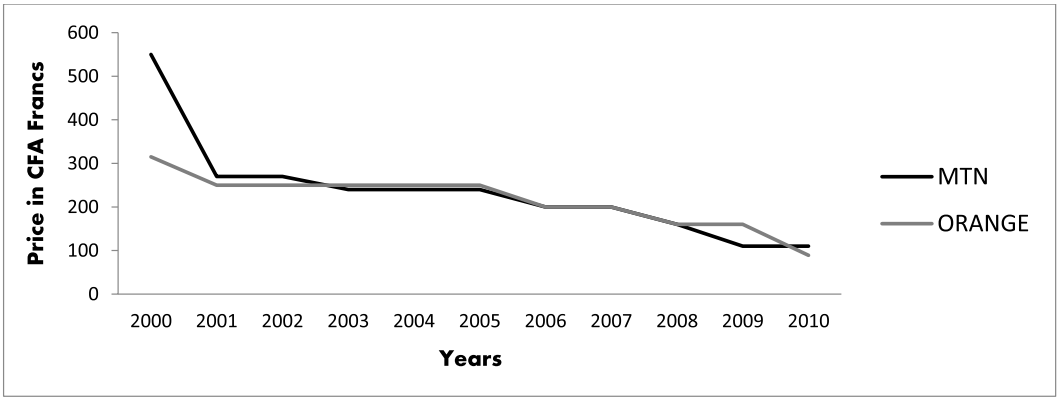

Fig. 3. Prices offered by MTN and ORANGE per minute of communication for intra-network calls.

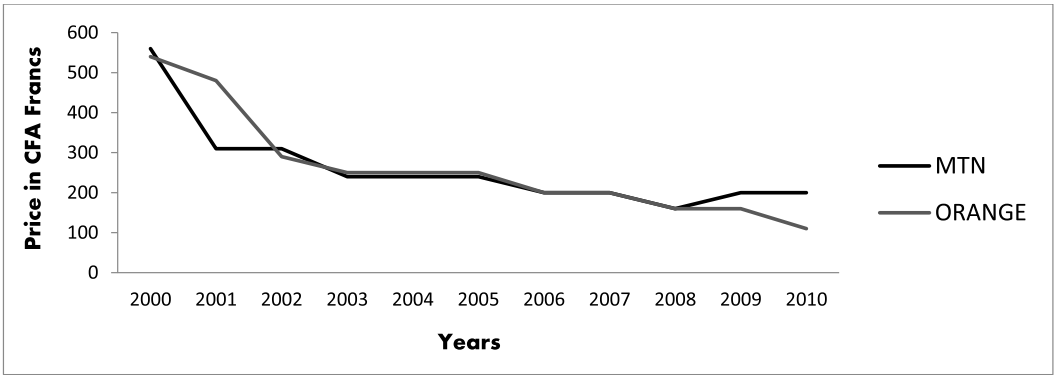

Fig. 4. Prices offered by MTN and ORANGE per minute of communication for intra-network calls.

An examination of these graphs reveals three stages: the first corresponds to the year 2000, the mobile telephony launching date with the arrival of ORANGE, followed six months later by MTN Cameroon. This period is characterized by very high prices and a limited service. The second period between 2001 and 2005 rather indicates a stable duopoly with relatively high prices. The year 2006 coincides with when the incumbent CAMTEL began exploiting its CDMA license. The competitive intensity instigated these operators to carry out lower prices estimated at about 60%. This period which went up to 2010 is characterized by a relatively stable[5] oligopoly

[5] It should be noted that the market remained a quasi-duopoly because the arrival of CAM MOBILE is viewed as slow, the first mobile operators

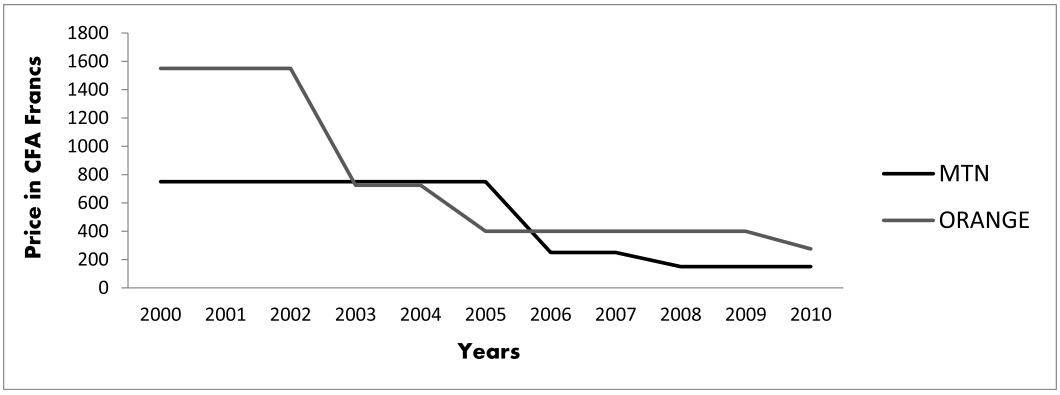

Fig. 5. Prices offered by MTN and ORANGE per minute of communication for intra-network calls.

with low prices.

These various stages are analyzed while laying much emphasis on the operators' conquest and different strategies.

2.1.1. The duopoly phase

At the launching of its activities, ORANGE Cameroon first targeted the corporate market, justifying its decision by the guarantee of payment and the subscription "continuity". To achieve this goal, the company sought to strengthen its network in two Cameroonian metropolises (Douala and Yaounde). It is only in the second year that this operator is interested in the general public[6] in order to extend its subscriber base. Six months later, MTN entered the market with its second GSM license and using a different strategy aimed at capturing the general public. In fact, with 95% of the mobile telephony market, it is on this segment that the outcomes of operators of the telecommunications' sector are decided. It is worth mentioning that not only MTN benefited from its experience in other African countries, this operator is also heir of the network and equipment of CAMTEL MOBILE.

On the commercial level, the two operators initially preferred a two-alternative offer, that is, a prepaid subscription and a monthly subscription. But this analysis is primarily focused on the first which traffic nearly represents 99% of the total traffic. In this context, operators practiced a pricing system including a fixed part (subscription) and a variable part (communication) apart from connection fees. With regard to the fixed part, in September 2000 for instance, the two networks priced the subscription at 30 Euros and connection fees at 60 Euros for ORANGE and approximately 200 Euros for MTN.

The following table shows the subscription and communication price evolution of operators since the opening to competition.

After the first managerial year characterized by very high prices, operators made substantial reductions in subscription and communication rates as from 2001. This is a joined result of price war and regulatory pressure. But after this period, tariffs are stabilized at a relatively high level, nevertheless with very slight falls from year to year. At the same time, we also note a parallelism in the two operators' behavior: It is at the same period that the almost identical prices are modified as shown in Figs. 4 and 5. From 2006, the incumbent began operating with its mobile license and one could witness new low prices (approximately 50%). It is worth mentioning that the lowering of prices is also attributed to the competitive intensity in which the two duopoly operators were engaged. However, interactions between competitors are different as concerns international calls. We also observe a significant unilateral price drop even before the arrival of the third operator on the market. In 2002, ORANGE aligned itself with MTN. In 2005, ORANGE also witnessed a unilateral price drop, followed by a more significant drop by MTN in 2006.

Several arguments can be raised to explain price evolution in the Cameroonian mobile telephony market. Before they began exploiting their GSM licenses, operators carried out ambitious investment plans aimed at deploying their networks in accordance with the specifications.[7] They focused on this argument to justify the calls' high prices: to obtain returns on investments within a reasonable period of time.

Also, given the characteristics of the GSM 900 (less suitable for high-density urban areas than GSM, 1800), operators set high prices in order to first obtain a network of an average density, and then sought to cover the entire territory. This explains why ORANGE initially targeted the corporate market.

Moreover, as the populations' enthusiasm accelerated the saturation of the 900 MHz band, operators began, in line with the regulation, to use higher bands going up to 1800 MHz. They thus strengthened their respective networks and increased their customers. This technical change could explain price drop during this duopoly period.[8] However, the low prices as concerns international calls can be attributed to the increasing use of the Internet protocol in data transmission, and especially to the competitive intensity in this market sector.

(*footnote continued*)

having taken a comfortable lead in terms of market share (98%).

[6] The general public accounts for about 95% of the total mobile telephone market.

[7] From June 2000 to December 2003 for instance, investments in mobile telephony amounted to about € 300 million (ART, 2004).

[8] Strategy used by Bouygues in France in 1996 thanks to the offer of packages (Pénard, 2001).

Finally, it can be noted that the high market concentration certainly encouraged the operators' collusive behaviors, particularly as concerns prices. In fact, as shown in Figs. 3–5, the alignment of prices over the reference period presumes that operators agreed themselves on the subject. The arrival of the third operator was supposed to disturb this tacit “agreement."

2.1.2. CAMTEL's CT phone launching and the duopoly « stability »

By launching the Code Division Multiple Access (CDMA) in 2006, CAMTEL targeted the general public market in order to bridge the gap with its competitors. Unfortunately, the network quality and especially the strong presence of the first mobile operators in the field delayed the take-off of this subsidiary company of CAMTEL known as CAM MOBILE. To get some market shares, CAMTEL effectively began exploiting its license by using a new frequency spectrum and implementing a true policy of services at lower prices. It also took advantage of its monopolist position in the fixed segment and that of manager of the spatial segment (local provider) to provide its customers with an integrated voice-internet better in terms of speed than that of its competitors.

If the high price's level at the market opening was a hindrance to the mobile network adoption in Cameroon, the subsequent competitive intensity enabled the general public to access network, thus facilitating the diffusion of this technology.

2.2. The diversification of the mobile use

The diversification of the mobile use played a major role in the diffusion of this technology. Two services particularly drew our attention: The Short Message System (SMS) and mobile payments.

As concerns the first, this service is available right at the opening of the Cameroonian mobile market. But its use is later intensified when subscribers became aware of its lowest cost to transmit information. This is particularly observed in countries like Niger (Aker, 2010). It is worth mentioning that the modest consumers' purchasing power and the relatively calls' high price are factors among others which favored the use of SMS. It is interesting to show in this context how the use of SMS enabled populations to free themselves from economic constraints. In this respect, Jensen (2007) revealed that in India, the mobile use (voice and SMS) enabled fisher men to better choose markets where they could sell their fish at highest prices. Similarly, Muto and Yamano (2009) showed how, due to the mobile network expansion, the increase in information flows reduced the marketing cost of agricultural products. It is worth noting that the use of SMS is further intensified with the mobile money transactions.

The arrival of mobile payment is also a potential determinant of mobile diffusion as well as a competitive ground for operators. In fact, we can recall with Chaix and Torre (2015) that mobile payment is a transaction carried out from a mobile phone and debited either on a bank card, an operator's invoice or an electronic wallet. It appears that in developing countries characterized by a low banking coverage, mobile payment is a determinant of mobile expansion because it is a new opening in the adoption of Information and Communication Technologies (ICTs) in banking activities.

The success of this service is witnessed by all in Africa for more than a decade since the launching of the Celpay in Zambia in 2001. But unlike other African countries like Kenya where the M-PESA is successfully implemented since 2007, mobile payment use began in Cameroon in 2010. MTN, the mobile phone leader launched this service in August 2010, followed one year later by ORANGE. The success of MTN and ORANGE Money is visible, given that this service mostly targets households and companies. It facilitates the payment of water and electricity bills from remote areas. It is also used for subscriptions, to buy air tickets in some companies, insurance policies, fuel in stations and for shopping in supermarkets: therefore, mobile payment can be considered as a factor of mobile diffusion in Cameroon.

The progressive margin characterizing the adoption of this service is very significant. In fact, as shown in Table 2, the CFAO's survey shows less than 20% of Cameroonians using mobile money in 2015, 42% in Ivory Coast and more than 88% in Kenya. It is worth mentioning that prospects are many when reasons of mobile money use by households, companies or the State are taken into account. In this respect, diffusion models appear to be excellent analytical tools (see Table 1).

3. The diffusion models

Literature on the diffusion of an innovation reveals that the expansion of a successful innovation follows an S-shaped growth curve. The idea behind this curve is the slow penetration rate in the market at the beginning. Then, because of consumption externalities, an accelerated period follows as the result of the adoption of a new product by the majority (known in literature as the critical mass), and the growth rate slows down again so that the sales' level of the new product converges towards a certain saturation

Table 1
Prices (in Euros, VAT inclusive) of the GSM services during the duopoly.

Operators		2000	2001	2004	2005	2006	2011
ORANGE	Subscription	30	30	15	15	15	1.5
	Communication	0.7	0.4	0.4	0.4	0.3	0.13
MTN	Subscription	30	15	7.5	7.5	7.5	0.76
	Communication	0.9	0.41	0.36	0.36	0.3	0.1
CAM MOBILE	Subscription	–	–	–	–	26	15
	Communication	–	–	–	–	0.18	0.09

Source: The Telecommunications Regulatory Agency's (TRA) activity report.

Table 2
Mobile money use in some African countries.

Countries	Cameroon	Ivory Coast	Kenya
Mobile money Use (in %)	Less than 20	42	More than 88

Source: CFAO (2015), "Study on the New African Subscribers' profile".

level (Geroski, 2000). However, as underlined by Meade and Islam (2001), there is no perfect model able to describe any diffusion process. Models commonly used in literature are the Logistic and the Gompertz.

The Logistic model can be written as follows:

$$Y_t = \frac{\alpha}{1 + \beta \cdot e^{-\gamma \cdot time}} + \varepsilon_t \tag{1}$$

Where Y_t is the mobile penetration rate per year t, that is, the number of subscribers to the mobile network per 100 inhabitants; *time* the trend, α a positive parameter which indicates the saturation level, β and γ are positive parameters of localization and form and ε_t the error term.

For the Logistic function, the inflection point is reached when $t^* = \frac{\log \beta}{\gamma}$ and the ordinate corresponding to this inflection point is $Y_t = \frac{\alpha}{2}$: this is the point at which the growth rate is maximum $\left(\frac{\alpha\gamma}{4}\right)$ and which corresponds to 50% of the saturation level of the mobile telephone density. The Logistic function's curve is symmetrical relative to its inflection point, the point at which the diffusion rate reaches its maximum (Gruber, 2001).

The Gompertz model is given by:

$$Y_t = \frac{\alpha}{e^{\beta \cdot e^{-\gamma \cdot time}}} + \varepsilon_t \tag{2}$$

The parameters here have the same significance as in the previous case. The inflection point or the maximum growth rate $\frac{\alpha\gamma}{e}$ is reached when $Y_t = \frac{\alpha}{e}$; in other words, when the telephone density is about 37% of its saturation level.[9]

We can also use an alternative to these models by replacing the penetration rate Y_t with the number of subscribers N_t (or consumers). In this case, if α gives the exact number of subscribers, the growth rate γ is the same as with the first version.

These models are very important because of their ability to define the saturation level and the corresponding date. However, as Singh (2008) points out, the saturation level of the mobile density of a country varies according to whether it is a developed or developing country. It is about 150% for the first and 120% for the second. Cameroon being a developing country, its saturation level is about 120%. However, the estimation of diffusion models can sometimes lead to aberrant saturation levels (Gruber, 2001). It can be plausible to propose exogenous saturation levels; for instance: 70, 80, 90, 100, 120, 150 mobile telephones per 100 inhabitants (Singh, 2008).

Once the diffusion model estimated, a projection of the growth trend can therein be deduced in order to assess the future demand for mobile telephony with all the expected implications notably as concerns investments in the infrastructural network. In this context, the diffusion determinants issue is of paramount significance.

4. Findings and analyzes

4.1. The diffusion modeling in Cameroon

The parameters of the Logistic (1) and Gompertz (2) models are estimated, using the version 11 of the STATA software. Both models are first estimated without specifying the saturation level, and then, by setting the saturation level at 70, 80, 90, 100, 110 and 120. The MAPE[10] (Mean Absolute Percentage Error) calculated from the last three years is used to select the best model and the appropriate saturation level.

The time variable takes the value 1 for the 1996 first quarter and the value 60 for the 2010 fourth quarter. Estimates are presented in Table 3. Globally, the estimated parameters have the expected signs, and they are all significant at 1%. Based on the R^2 and the ajusted R^2 values, we can conclude that the models satisfactorily fit the data.

When no restriction is imposed on the saturation levels, we obtain 14.50 and 26.78 for the Logistic and Gompertz models respectively. For a country like Cameroon where there is a strong increase in the penetration rate of mobile telephony (Fig. 1), the saturation level cannot be low. We will therefore focus on the models' results with restrictions on the saturation level.

To choose the best model and the value of the appropriate saturation level, we compare the predicted and the actual values of the mobile telephony density over the last three periods (the 2010 2nd, 3rd and 4th quarters). The MAPE's values vary between 0.07 and 6.73 for the Logistic model and between 0.10 and 6.73 for the Gompertz. Based on the MAPE, we thus conclude that the Logistic

[9] For other mathematical properties of the Logistic and Gompertz functions, see Franses (1998).

[10] The MAPE enables to appreciate the adjustment degree of a model. We make a forecast, using the estimated model and calculating the sum of the absolute values of the forecasting errors over the last three years.

Table 3
Estimated Parameters of the Logistic and Gompertz Models (T-statistics in brackets).

Model	Estimated Parameters					
Without restriction on the saturation level						
Logistic (1)	α = 14.507 (33.12)	β = 463.534 (10.97)	γ = 0.127 (0.002)	R^2 = 0.998	Adj. R^2 = 0.998	MAPE = 7.88
Gompertz (2)	α = 26.782 (8.40)	β = 11.435 (27.16)	γ = 0.044 (0.001)	R^2 = 0.996	Adj. R^2 = 0.996	MAPE = 3.06
Saturation level α = 70						
Logistic (1)		β = 335.676 (8.12)	γ = 0.073 (31.21)	R^2 = 0.986	Adj. R^2 = 0.985	MAPE = 6.73
Gompertz (2)		β = 8.487 (37.39)	γ = 0.027 (50.54)	R^2 = 0.995	Adj. R^2 = 0.994	MAPE = 6.73
Saturation level α = 80						
Logistic (1)		β = 371.831 (8.09)	γ = 0.072 (30.72)	R^2 = 0.985	Adj. R^2 = 0.985	MAPE = 3.27
Gompertz (2)		β = 8.401 (38.31)	γ = 0.025 (49.24)	R^2 = 0.994	Adj. R^2 = 0.994	MAPE = 0.20
Saturation level α = 90						
Logistic (1)		β = 408.563 (8.07)	γ = 0.071 (30.35)	R^2 = 0.985	Adj. R^2 = 0.985	MAPE = 0.13
Gompertz (2)		β = 8.350 (39.12)	γ = 0.024 (48.19)	R^2 = 0.994	Adj. R^2 = 0.994	MAPE = 0.16
Saturation level α = 100						
Logistic (1)		β = 445.673 (8.05)	γ = 0.070 (30.07)	R^2 = 0.985	Adj. R^2 = 0.984	MAPE = 0.10
Gompertz (2)		β = 8.321 (39.84)	γ = 0.023 (47.32)	R^2 = 0.994	Adj. R^2 = 0.994	MAPE = 0.13
Saturation level α = 110						
Logistic (1)		β = 483.042 (8.03)	γ = 0.070 (29.85)	R^2 = 0.985	Adj. R^2 = 0.984	MAPE = 0.08
Gompertz (2)		β = 8.307 (40.49)	γ = 0.022 (46.58)	R^2 = 0.994	Adj. R^2 = 0.993	MAPE = 0.11
Saturation level α = 120						
Logistic (1)		β = 520.597 (8.02)	γ = 0.070 (29.66)	R^2 = 0.984	Adj. R^2 = 0.984	MAPE = 0.07
Gompertz (2)		β = 8.302 (41.08)	γ = 0.022 (45.95)	R^2 = 0.993	Adj. R^2 = 0.993	MAPE = 0.10

model best adjusts the data than the Gompertz. The MAPE's value is lower (0.07) for the 120 saturation level. Thus, this model will be used to make projections of the mobile telephony density.

We thus have $MOB_t = \frac{120}{1 + 520{,}597e^{-0{,}07t}}$.

The curve inflection point will be obtained on date $t = \frac{\ln \beta}{\gamma}$, that is, $t = 89$, which corresponds to the 2017 first quarter. In other words, in line with this finding, the rate of growth of mobile-density is supposed to increase until the first quarter of 2017, and start declining thereafter.

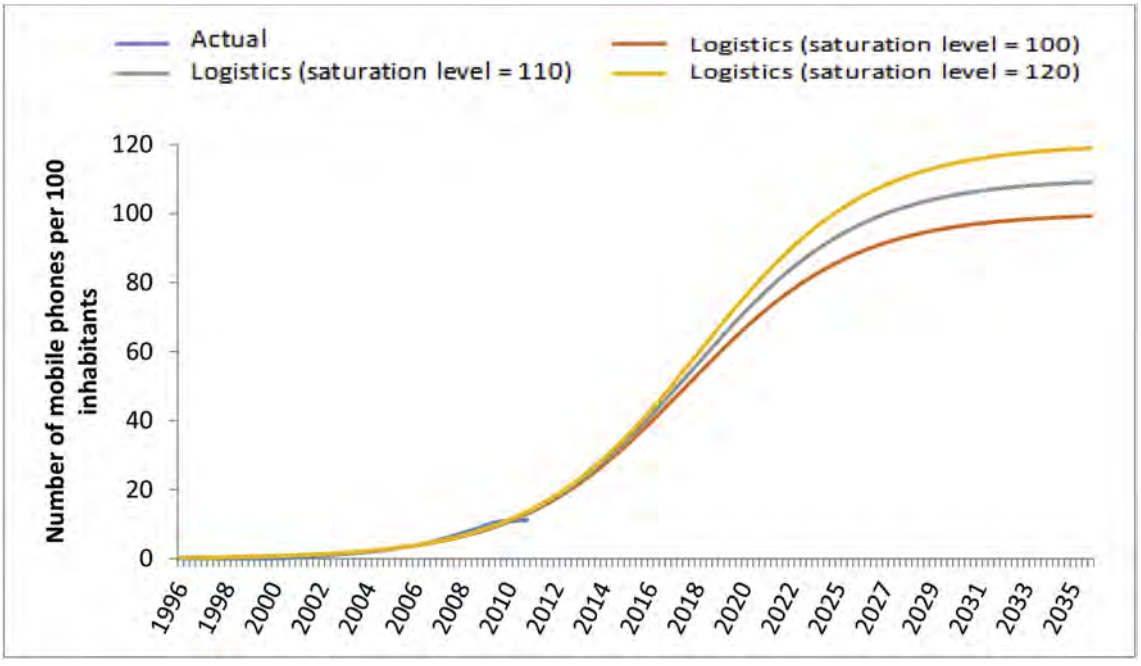

Fig. 6. Penetration rate projection of mobile telephony in Cameroon.

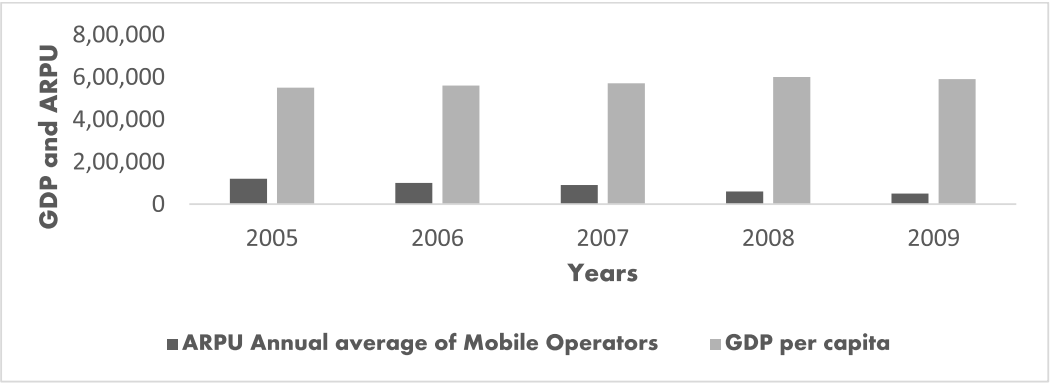

Fig. 7. Decrease of the average revenue per user of mobile phone.
Sources: Market observatory, ministry of posts and telecommunications, Cameroon (2010).

From the 120 saturation level, the penetration rate is projected up to 2035 (Fig. 6). The curve projection on the axes shows 2026 corresponding to a penetration rate of 100 in the next ten years. In addition, the *World's Population Prospect database* envisages an average growth rate of 2.5% over the next 10 years. On this basis, the demand for mobile telephony will approximately rise to 31 million in 2026. Thus, in Cameroon, this demand will rise from 17 million in 2015 to 31 million in 2026, that is, an increase of almost 80% (see appendices).

The evolution of this demand has undeniable implications on operators' and State's revenues. With regard to operators, it is worth recalling that their incomes depend on the number of subscribers and the Average Revenue Per User (ARPU). Though the ARPU decreases each year in Cameroon as shown in Fig. 7, it is worth stressing that this indicator can be improved, not only because of optimistic demand forecasts as shown in Fig. 6, but also, thanks to the multiplication of the value-added services. In fact, in addition to voice services, subscribers increasingly use applications like e-learning, telemedicine, teleworking and mobile payments which allow diversifying operators' incomes and therefore increase the demand.

An increase in the State's revenues can also be foreseen. First of all, the arrival of new operators in mobile telephony as well as in other market segments generated income from the acquisition of business licenses, regulatory fees like the frequency spectrum, the contribution to the financing of the universal service, the interconnection fees, just to name the few. Moreover, according to the Market Observatory of the Ministry of Posts and Telecommunications, tax income in the telecommunications' sector accounts for about 6% of the total tax revenues. This enables us to foresee an increase in public revenues following an increase in operators' incomes.

But beyond the income increase, increase in the demand will also involve logistic and strategic challenges for the players, particularly as concerns the installation of a reliable and viable infrastructural network able to ensure an acceptable quality of services at lowest costs. In this regard, the analysis of the mobile telephony diffusion determinants is necessary.

4.2. The determinants of mobile telephony diffusion in Cameroon

The previous diffusion models (1) and (2) are also used to identify the determinants of this diffusion. However, they have some potential variables able to explain this diffusion.

$$Y_t = \frac{a}{1 + e^{-b_t \cdot time}} + \varepsilon_t \tag{3}$$

$$Y_t = \frac{a}{e^{e^{-b_t \cdot time}}} + \varepsilon_t \tag{4}$$

Y_t is the mobile penetration rate (Mob).

$$b_t = u + Z_t' v$$

Z_t' represents the set of variables relating to the supply and demand which arguments are defined below:

- CMP is a variable reflecting competition and representing the number of operators;
- FIX is the penetration rate of the fixed network which measures the substitution effect between the fixed and the mobile telephony;
- GDP is the Gross Domestic Product per capita which reflects the economic situation of the country;
- DSMS is a binary variable equal to 1 when the SMS appeared on the Cameroonian market and 0 before;
- DMM is a binary variable equal to 1 when the mobile payment service appeared on the market and 0 before.

Models' (1) and (2) estimates are presented in Table 4. Based on R^2, they show the Logistic model best presenting the diffusion

Table 4
Diffusion determinants of mobile telephony.

Model	Logistic	Gompertz
Variables		
a	9.187*** (0.487)	11.664*** (0.672)
CMP	0.042*** (0.006)	0.014** (0.007)
FIX	0.060*** (0.005)	0.022*** (0.007)
GDP	0.0003*** (0.000)	0.005*** (0.004)
DSMS	0.051** (0.024)	0.221*** (0.286)
DMM	−0.003 (0.003)	−0.001 (0.004)
U	−7.792*** (0.013)	−0.320*** (0.028)
R^2	**0.970**	**−0.086**
Ajusted R^2	**0.968**	**−0.207**
Number of observations	**60**	**60**

Significance: ***1%, **5%, *10%.

determinants of the mobile technology in Cameroon. We first note that the GDP per capita, proxy of the purchasing power, is significant. This shows that in developing countries like Cameroon, income is a determinant of the mobile or the ICTs' adoption in general. This result converges with that of Penard et al. (2012), but diverges with that of Gruber (2001).

Similarly, the competition variable (CMP) has a positive and significant effect on the diffusion speed. Not only this result is similar to that of Jang et al. (2005), it is quite understandable insofar as openness to competition enables to liberalize the Cameroonian mobile sector. As recommendation, as long as market permits, the opening of new firms is necessary.

The same thing goes with the SMS which coefficient is significant. In other words, the use of SMS significantly improved the diffusion of mobile technology. This can be understood, given the low consumption cost of this service.

On the other hand, mobile payments (DMM) do not have a significant impact on the diffusion of mobile technology. Several reasons can explain this result: first of all, it is only in 2010 that this service is available in the Cameroonian mobile landscape, contrary to other countries like Zambia or Kenya (2001). In this respect, the survey carried out by the French West African Company (CFAO, 2015) shows only 20% of Cameroonians using this service. But populations' enthusiasm and many players' strategies towards the use of mobile money can make this service successful. It can intensify the use of the mobile technology.

Moreover, the availability of public phonebooths (or call boxes) and even the use of a telephone by many people particularly in rural areas are some reasons which enable to carry out mobile payments without requiring new subscriptions. Lastly, mobile payments are part of the value-added services which much determine the appropriation of the ICTs than their diffusion.

The penetration rate of the fixed network (FIX) is positive and strongly significant. This shows the existence of a complementary link between the fixed and the mobile networks. In fact, with a fixed teledensity of 0.6% in the 1990s, that is, at the opening to competition, many mobile subscribers could only take advantage of this technology. That's why, the advent of the mobile technology is perceived as a complement of the core network which in addition remains a factor allowing a better access quality to internet, particularly for the State and corporate bodies. This complementary relationship already highlighted by Gruber (2001) in an investigation carried out on the Eastern European countries, shows that the usefulness of mobile technology also depends on the core network efficiency. In this respect and in line with the complementary link observed, investments in the core network are also needed so as to make it much more compatible with the mobile network requirements (Curien, 2000).

5. Conclusion

This study aims at analyzing the diffusion determinants of mobile telephony in Cameroon in order to propose a modeling of this diffusion.

The diffusion of mobile telephony is analyzed by using an S-shaped growth curve. Findings show that the Logistic model adequately follows the diffusion curve of mobile telephony in Cameroon.

It appears that the rate of growth of mobile-density is supposed to increase until the first quarter of 2017, and start declining thereafter. In addition, estimates show that in 2026, there will be 100 mobile telephones per 100 inhabitants in Cameroon. In other words, for a population estimated at 31 million in 2026, there will be 31 million mobile telephones in this country. Consequently, as from 2027, we predict the number of mobile telephones exceeding the size of the total population.

In this perspective, the expansion of mobile telephony services is likely to lead to economic, logistic and strategic challenges for the stakeholders: an increase in operators' and State's revenues, but also, an increase in investment needs, taking into account the extension of the infrastructural network.

Findings also reveal the Logistic model best describing the diffusion determinants of mobile telephony in Cameroon. The income variable represented here by the GDP per capita is a major determinant of mobile telephony diffusion in this country. Three other significant determinants are identified: openness to competition which accelerates the diffusion; the use of SMS; the complementarity between the mobile and the core networks, the first being only the complement of the second and not its substitute.

That's why, recommendations are primarily in favor of investment incentives, as long as market permits, both in the mobile and core networks, given the complementary relationship identified between the two. Finally, it is worth noting the importance of mobile

money as a potential determining factor of the mobile telephony diffusion in Cameroon.

Appendix 1

Table A1
Some Descriptive Statistics of the Variables

Variable	Average	Standard deviation
MOB	3.278	3.812
FIX	0.234	0.167
GDP	215.959	56.131

Appendix 2

Table A2
Correlation **Matrix** of the Variables

	mob	fix	gdp	cmp	dsms	dmm
mob	1.0000					
Fix	0.9096	1.0000				
Gdp	0.9196	0.6907	1.0000			
Cmp	0.8432	0.6471	0.8347	1.0000		
Dsms	0.6775	0.4345	0.7706	0.7759	1.0000	
dmm	0.8741	0.8962	0.7318	0.6047	0.4082	1.0000

Appendix 3. Elements to Calculate the Demand Forecasts

We consider the saturation level of 120.

Then, we use the *World's Population Prospect* database which predicts an average population growth rate of 2.5% within a period of ten years.

The curve projection corresponding to the saturation level of 120 on the axes enables us to see that 2026 corresponds to a penetration rate of 100.

From the expression $penetration\ rate = \frac{the\ number\ of\ subscribers}{\textbf{total}\ population} \times 100$, we can have the number of subscribers which is an estimate of the demand. See the table below:

Table A3
Estimate of the forecasting demand

Years	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Population (in million)	23	24	24	25	26	26	27	28	28	29	30	31
Penetration rate (in %)	71.85											100
Forecasting mobile demand	17											31

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