Diploma Thesis

A Study on the Impact of Mobile Telecommunication on the Welfare of Sub Saharan African Countries

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Introductory remarks

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Abstract

Africa: A continent is waking up. Not through aid or wealth from the exploitation of natural resources, but through a technological revolution. The access to affordable mobile telecommunication. Inspired by deregulation and pioneered by local champions who have taken a lead in what is today's fastest growing mobile market in the world. There is money to be made in these markets, attracting more and more operators from the northern hemisphere. However positive the short term impact of this revolution may be, governments should try hard to assure a market of continued competition among network operators, as this competition is the source of a self propelled creation of welfare and new opportunities, motivated from within Africa.

Chapter 1 of this thesis highlights the positive impact of mobile telecommunication on the social and economic life in Sub Saharan Africa. **Chapter 2** builds on the static as well as the dynamic version of the Network Pricing Game, a model developed by Dr. Carolyn Gideon, to stress the immanent threat of network markets turning into a monopoly. This theses ends in **Chapter 3** with an brief outlook on further drivers of economic growth and opportunities awaiting Sub Saharan Africa in the coming decade.

Index of Variables

α_o	Market share of Firm 1 with $\alpha_{-o} = 1 - \alpha_o$ as market share of Firm 2 respectively.
c	Marginal cost of providing service to a single customer.
F	Fixed cost of providing service in the market per subscriber.
θ	Network subscribers' propensity to switch to a rival network for a given difference in prices.
P_{it}	The price chosen by Firm i in Period t, with $i, t \in (1, 2)$.
P^M	Monopoly price. The maximum price before customers start to disconnect
P_1^*	Price of Firm 1 that maximizes it's profits for the single period game.
P_2^*	Price of Firm 2 that maximizes it's profits for the single period game in response to Firm 1's price.
P_{11}^{Coex}	Price of Coexistence of Firm 1, set in period 1.
P_{11}^{EI}	Price set by Firm 1 in period 1, inducing exit of Firm 2.
π_1^T	Profit of Firm 1 in the dynamic Network[1] Pricing Game.
π_2^T	Profit of Firm 2 in the dynamic Network Pricing Game.
$\pi_2^{T\text{-}IN}$	Profit of Firm 2 in the dynamic Network Pricing Game, when Firm 2 is still in the market in the second period.
$\pi_2^{T\text{-}OUT}$	Profit of Firm 2 in the dynamic Network Pricing Game, when Firm 2 decides or is forced to exit the competition in the second period.
π_1^{Max}	Maximum profit of Firm 1.

[1]The dynamic Network Pricing Game consists of two period.

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1 Telecommunication: A Brief Overview

1.1 Developed World

In all societies of the developed world, telecommunication has long become a incremental part of life, in private and business use alike, although its costly usage at the beginning of the last decade favored business, innovation and subsequently economies of scale opened up the access to wireless telecommunication for private users.

In the turbulent years of the late 90's, when the .com bubble was gaining momentum, the privatization of state owned fixed-line telecommunication companies in the US and Europe made it regularly onto the front pages of the business press. Main challenges of a transition from state ownership to privately held companies and a subsequent competition in the telecommunication industry, are depicted by Joseph Farrell:

> *"The FCC and state regulators have been working hard since the 1996 passage of the Telecommunications Act to restructure regulation to make it more compatible with competition. Deregulation remains an especially complex problem for telecommunications, given such factors as its dependence on carrier-to-carrier cooperation, tendency toward a natural monopoly, the multidimensional aspects of competition, and the political constraints on deregulation."*[2]

Remarkable was the frenzy across Europe, at the turn of the millennium when the auctioning of third generation mobile telecommunication licenses for the 3G radio spectrum took place. Similar to a bank run the bidding mobile network operators raised their bids far beyond rational levels only to grab one of the much sought licenses, entitling it's holders to use a new predefined wave spectrum for their carrier signals to enable the delivery of next generation services. Services with high demands on data transfer going beyond the classic use of voice and text transfer. Subsequently the telecommunication industry was haunted by it's own economic crisis that followed after the bust of the .com bubble.

[2]Farrell, Joseph. *Prospects for Deregulation in Telecommunication*. Department of Economics, University of California, Berkeley, CA, USA . Industrial and Corporate Change, Volume 6, Number 4, 1997.

The above lines are meant to illustrate how challenging technological and market structure changes can be for economies and economic systems alike.

1.1 Sub-Saharan Africa

> "You can resist an invading army; you cannot resist an idea whose time has come."[3]

The idea addressed in the following paragraphs is that of a technological revolution across Sub-Saharan Africa (SSA). An idea on the brink to reality for an increasing part of Africa's population of currently 836 Million[4]. To give a better understanding of the actual state, I will discuss and show up the current development stages in various countries highlighting their individual particularities to create a better picture about leading and lagging countries. According to Ernest & Young's first African Study conducted in this field, the "*African markets are at differing stages of evolution, not just in the telecommunications field, but across the broader economic and social spectrum. From countries like South Africa [...], which have the largest economies, to countries like Somalia, which has a limited formal economy, the differences are significant.* [5]"

A direct consequence of these different stages is an equally scattered picture of mobile penetration rates. It allows to divide countries into three categories as shown in Table *1*. Low levels of mobile communication take up, combined with a robust economic growth averaging 2%[6] in the SSA region between 2000 and 2006, are contributing to emerging opportunities. This is especially the case in countries with penetration rates between 50 and 20%. Economies listed in this segment report the highest figures in subscriber growth. The interest of governments to profit from the telecommunication boom in their countries is big and the ways of doing so are numerous.

[3]Hugo, Victor. *Histoire d'un Crime*. 1852. English translation taken from: The Economist. *A special report on entrepreneurship* . March 12th 2009

[4]Haub, Carl. Kent, Mary Mederios. *2009 World Population Data Sheet.* Population Reference Bureau. Washington, USA.

[5]De la Bachelerie, Vincent. Global Telecommunications Leader, Ernest & Young. *Africa connected – A telecommunications growth story*. 2009.

[6]International Bank for Reconstruction and Development - The World Bank, *Africa Development Indicators*. 2008/09

Developed	Emerging	Virgin
Over 50% penetration • Lower mobile net additions • These include: Algeria Botswana Gabon Libya Mauritania Mauritius Morocco Namibia Seychelles South Africa Tunisia	**20 to 49% penetration** • Highest net additions per month • These include: Angola Benin Cameroon Congo Egypt Equator. Guinea Gambia Ghana Guinea Republic Guinea-Bissau Ivory Coast Kenya Lesotho Liberia Mali Nigeria Sao Tome & Principe Senegal Sierra Leone Sudan Swaziland Tanzania Togo Uganda Zambia	**Less than 20% penetration** • Highly regulated or politically Unstable markets • These include: Burkina Faso Burundi Central African Republic Chad Comoros Djibouti Democratic Republic of Congo (DRC) Eritrea Ethiopia Madagascar Malawi Mozambique Niger Rwanda Somalia Zimbabwe

Table 1: Sub categories of mobile penetration rates in Africa.

Source: International Telecommunications Union; Ernst & Young Analysis

1.2 The impact on welfare of increasing liberalization in African telecommunication markets

Emerging Telecommunication Companies. A fundamental change in policy, pursuing the process of local deregulation in telecommunications, from Senegal to Mauritius, marks the starting block for the race of technological revolution in Africa. Very soon after the successful establishment of an industry regulation body the first companies started to emerge, offering GSM mobile phone telecommunication services. The founding years of the early movers in this sector are going back to the mid 1990's. There we find the first big names incorporated in countries whose politics have levelled the playing field fast enough to attract investors. Most of these early days companies are still operating today. In their local markets as well as in neighbouring countries. Vodacom is South Africa's biggest player with a current customer base of 28.24[7] Million and a corresponding market share of 55%[6] was founded in 1994. MTN the second largest operator in South Africa dates back to 1994 as well.

[7]Vodacom - Financial Statements, *Interim results for the six months ending 30th of September 2009.* Company Website

Kenya. Going up north east the continent, companies such as Kenya's Safaricom were formed in 1997 as a fully owned subsidiary of Telkom Kenya, the countries fixed line operator, a 100% state owned monopolist. Safaricom, at the time this theses was written, owns a market share in Kenya of 77.5% according to the World Cellular Information Service[8]. Today the Government of Kenya holds a stake of 35% in the company. Vodafone PLC of England owns 40% whereas the remaining 25% are in free float on the Kenya Stock Exchange. During the time of the Sfaricom Initial Public Offering (IPO) in March 2008, the country had been in a stock market boom. Corporate and private sentiment towards stocks was subject to a broad hype, fueling a speculation wave that soon spread from telecommunications to other sectors and companies listed on the Kenyan Stock Exchage.

Ethiopia. Ethiopia is the bottom of development and comes last in any continent wide mobile telecommunication ranking. This fact cannot be blamed on its weak economic figures and GDP. It is more attributed to the lack of deregulating the market, allowing new entries. Politics in this regard have failed in both, the stimulus of a mobile telecommunication industry and the providing of services through the state owned operator the Ethiopian Telecommunications Corporation. Although Ethiopia's beginnings in fixed line telecommunication date back to "*1894, with the installation of 477 km long telephone and telegram lines from Harar to Addis Ababa*"[9] the mobile deployment and facilitation of wireless communication is a story of failure. From Ethiopia's population of currently 80.7[10] Million only 3.2%[11] have subscribed to a mobile phone service. From official source one can deduce, that during 2007 and 2008 the overall quality of services has further degraded, as the network capacity has not been upgraded while the number of subscribers grew from a small base. It is reported that most of the day the GSM network was overwhelmed by the traffic of calls and text messages. According to a reports by Cellular News, the state run operator has completed a network upgrade in the second half of 2009, notably assuring the supply of

[8]Safaricom - Unaudited Half year results for the period ended 30 September 2009. www.safaricom.co.ke

[9]Ethiopian Telecommunications Corporation. Historical Background. www.ethionet.et

[10]World Bank, World Development Indicators. 2008. www.worldbank.org

[11]Ethiopian Telecommunications Corporation. *ETC's Growth Perspectives in network coverage.* 2007/2008.

electricity with the installation of 150 diesel generators, to counter regular black outs related to power supply problems[12].

Democratic Republic of Congo. Returning to the review of the beginnings in African mobile telecommunications we turn to another underdeveloped country in Central Africa. The Democratic Republic of Congo (DRC) had seen it's first operators emerge in 2000 with OASIS SPRL followed by Vodacom and Celtel Congo in the same year. A year later Congo Chine Telecom entered the market. In 2002 Supercell SPRL joined the competition and 2008 has seen the latest entry by Africtell. With a current penetration rate of approximately 20% the market shares in subscribers range from slightly over 50%[13] for Vodacom, down to around 4% for TIGO.

Nigeria. From the Westafrica region Nigeria is the most interesting country for an analysis covering a shot introduction of its market structure and players. Nigeria has a special role in Africa as it is the most populous country with a population of over 150 Million. The average population age is only 19 years. These figures undermine the huge potential for mobile operators in this prospering country. Latest data show that Nigeria has a total of 67.84[14] million mobile phone subscribers translating into a penetration rate of 49.4%[12].

MTN Nigeria Communications Limited and Celtel Nigeria Ltd a subsidiary of ZAIN, who has introduced the first 3G network in December 2008, are both in operation since mid 2001. They have a market share of 46.19% and 24.47%, positioning them on first and third place by market share. The countries second largest operator is Globacom Ltd. who has started offering it's telecommunication services in 2003. It's market share is at 26.87% These three top players dominate the market with their cumulative share of 98% of all Nigerian mobile phone subscribers. Two remaining operators are competing for the 2% of the market not served by the big operators. Emerging Markets Telecommunications Services (EMTS) is leading this group with a market share

[12]Cellular News. *Ethiopian Operator Nears Completion of Network Upgrade*. July 3rd 2009. Accessed online the 13th January 2010 at http://www.cellular-news.com/story/38351.php

[13]Autorité de Regulation de la Poste et des Télécommunication au Congo – ARPTC. *Etat des Lieux Semestriel des Telecommunications en République Democratique du Congo*. 2007. www.arptc.cd

[14]Nigerian Communications Commission – NCC. *Subscriber Data At A Glance.* August 2009. www.ncc.gov.ng

of 1.76% translating into a customer base of approximately million. MTEL is a mobile telecommunications company 100% owned by the Nigerian State. It was created in 1996, when the government decided to split it's telecommunication operations into a fixed line (Nitel) and a GSM (MTEL) business. Despite MTEL's long existence and access to state funds, it has failed to delver competitive service qualities and prices. This is reflected by it's poor market share of 0.44%[14], in a strong growing market environment.

The following illustration visualizes the enormous growth Nigeria has experienced in mobile phone subscriptions and services.

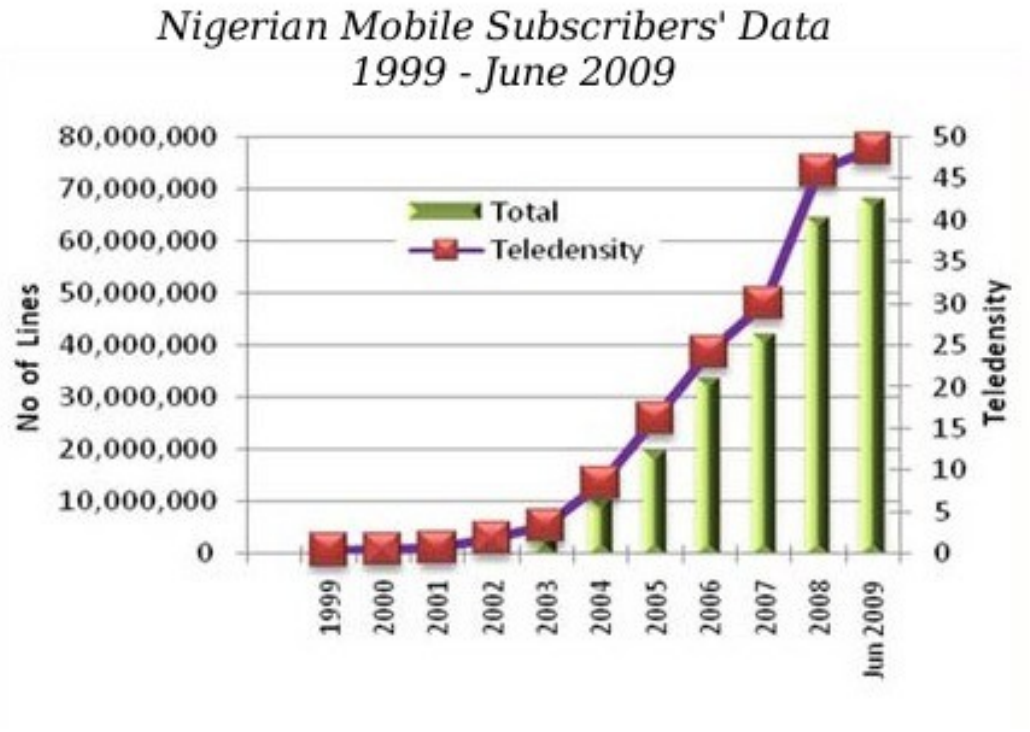

Illustration 1: Nigerian Mobile Subscriber's Data 1999 to 2009. Source: Nigerian Communications Commission, www.ncc.gov.ng

1.3 Competition creating welfare: four key elements

> "When the first mobile networks were launched in Africa two decades ago, few people imagined that mobile phones would become Africa's communications device of choice. In 1989, only South Africa had an operative mobile cellular network, and there were less than 4'000 subscriptions. It took seven years to surpass one million mobile subscriptions. The 100 million barrier was shattered in 2006, and by the end of 2008 there were 246 million mobile subscriptions in Africa "[15]

In 2001 the number of mobile phone subscriptions overtook the number of fixed lines, making Africa the first continent where this had happened[16]. This decent track record of growth is very likely to be continued on the continent in the coming years, according to the English thinktank Africa & Middle East Telecom Week. In a recent publication they present their estimates regarding the evolution of mobile phone penetration in Africa.

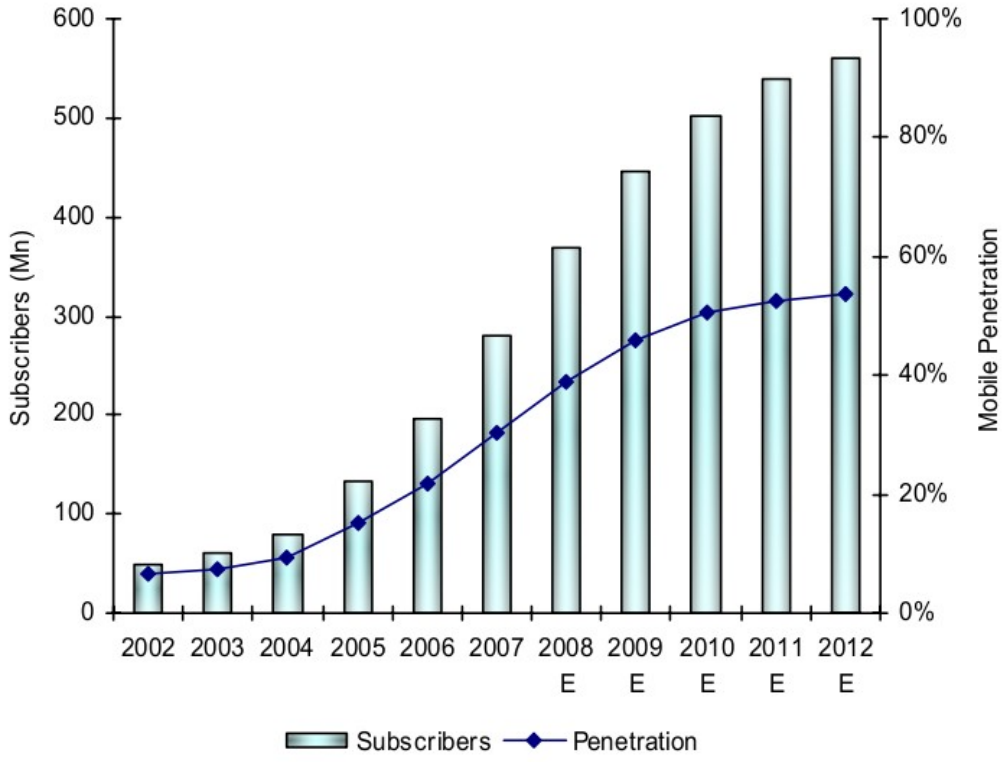

Illustration 2: Africa – Mobile Subscribers and Penetration (2002-2012).

Source: Africa & Middle East Telecom Week, African Mobile Factbook 2008

[15]ITU World Telecommunication. I*nformation Society Statistical Profiles 2009 : Africa . Chapter 2, Mobile growth: achievements and challenges .*

[16]Srivastava, Lara. *African Telecommunication Indicators,* ITU, 7th edition, May 2004. Geneva, Switzerland. www.itu.int/ti.

Several reasons characterize the growing acceptance and use of mobile phones and service.

First there is the absence of traditional fixed line telecommunication networks in most SSA countries. Apart from the capitals most rural and urban regions in Africa have been deprived from access to fixed lines. At the time they were in use, installed by colonial rulers, there was no interest in deploying these networks beyond purposes of colonial interests. Even if this have been the case, the price to pay would have locked out 99% of the indigenous population. As a result the average number of fixed telephone lines per 100 inhabitants in SSA stands at 1.5 in strong contrast to 31.6 mobile cellular telephone subscribers per 100 inhabitants[17] .

Second there is the benefit of technological research and development that led to the invention of the mobile phone. Since Dr. Martin Cooper of Motorola made the first mobile call to his counterpart at AT&T, Dr. Joel S. Engel on April 3rd 1973, a lot has changed. The first generation mobile handset he had developed was turned into a gadget available to the masses through the effects of scale in mass production of semiconductors and parts, resulting in a downward pressure on mobile handset prices. The Kenyan mobile operator Safaricom presented an interesting, cheap hand-held in August 2009. The *Simu ya Solar* has the benefit of being charged by solar power opening households with no electricity the door to mobile telecommunication for a price of 2,999 Kenyan Shiling – approximately 28 Euro[18]. These are the ingredients permitting Africa to leapfrog an older technology (fixed line telecommunication) and adopt the latest technology available, to the benefits of all involved.

Third there is the competition between operators on pricing. This is reducing the entry barriers for consumers to mobile services. A few years back the first owners of mobile phones in rural areas made a living by renting their phone and selling phone minutes to villagers who could not afford to own a phone but did want to call a friend or family member in a distant town. This

[17]Teltscher, Susan et al. International Telecommunications Union, Market Information and Statistics Division. I*nformation Society Statistical Profiles 2009: Africa.* Geneva, Switzerland. 2009.

[18]Safaricom. Press release. *Safaricom Goes Green With New Solar-Charged Phone.* Nairobi, Kenya*.* August 2009.

phone call saved them a long and costly journey. The approach was subsequently copied and adopted by most mobile operators in Africa. Their customers can recharge their own phones with calling time for as little as 0.05 Euro in thousands of little shops spread across the country. This method of payment enables people without bank accounts to have a phone. The costs of running a phone shop network can be almost neglected as many merchants offer phone credits as a side activity touching a fixed percentage of sales. Benefits on the other hand are huge. For example no unpaid invoices will ever occur with this prepaid system. A reason why 94,8%[19] of all African mobile phone contracts are prepaid.

Fourth are network externalities. Beyond the positive direct effects of communicating effortless over large distances the positive spillover of telecommunication networks is immense. A recent special report[20] from the Economist on telecoms in emerging markets mentioned that a 10% increase in mobile telecommunications penetration in emerging markets translates into a rise of 0.8 points in GDP. A result only toppled by access to the internet, especially to broadband connections. The boost in GDP growth is attributed to new possibilities for business ventures, resulting gains in the flow and circulation of important information and the access to knowledge and knowledge databases[21] for sectors spanning from education, agriculture and horticulture to medical aid and mobile banking, increasing the overall efficiency of the economy. In Uganda such an information database service enabled by mobile phone ownership is called

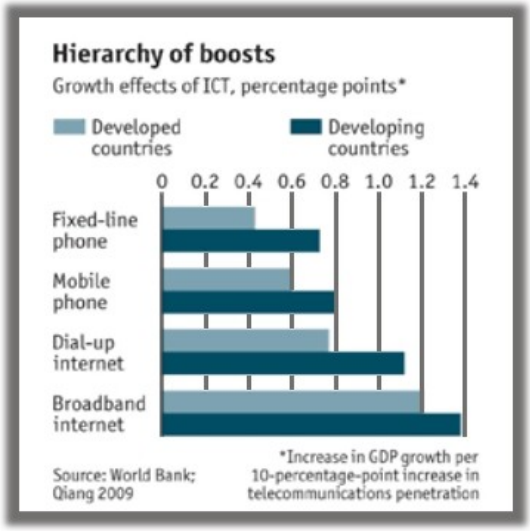

Illustration 3: Hierarchy of boosts. Source: The economist/World Bank/Qiang 2009

[19]Al Morshid, Sami Al Basheer. International Telecommunications Union. *Information Society Statistical Profiles 2009 : Africa.* 2009.

[20]Standage, Tom. *Special Report on telecoms in emerging markets: Eureka moments.* The Economist. September 26th to October 2nd 2009.

[21]Question Box. SMS service for questions from plant diseases to birth control. http://questionbox.org

Question Box. It has become an important channel of knowledge transfer for every day problems. As the founder of this initiative, Mrs. Rose Shuman explains: "*The premise behind Question Box is that many barriers keep most of the developing world from taking advantage of the wealth of knowledge available through internet search engines [..] could be a drag on economic development. In this way we are helping farmers make decisions regarding where to sell, what to plant and how to best take care for their crops. It's all about giving communities the ability to help themselves."*[22]

Across the African continent the economic benefits of telecommunication networks are now common knowledge, even among politicians, illustrated by a keen move from the government of Rwanda. *"..technology is the core of Rwanda's plan to transform its economy by 2020. The country seems ready to back its ambition with money and policies. By 2012, for instance, Rwanda wants every child in the country between the ages of nine and 12, 1.3 m children in all, to have a laptop, each with an internet or intranet connection to download free educational software and electronic books."*[23]

The Economist highlights a further revolutionary development regarding mobile phones in emerging markets: Enabling banking for the unbanked[24]. Already tested successfully are the mobile money service M-Pesa in Kenya, deployed by Safarikom the by far largest local operator. In Uganda the figures posted by MTN's mobile banking service are looking good as well. MTN Mobile Money as the service is called had signed up more than 80,000 subscribers within the first four months of it's operation. The awareness about MTN's Mobile Money among Ugandans is at 60% according to the special report. A fairly prosperous example of how the establishment of one network benefits the emerging of another kind of network. Whereby the second one can leverage on the existing network and increase the overall utility of it's consumers.

[22]Nixon, Ron. The New York Times. *Dialing for Answers Where Web Can't Reach.* September 27, 2009

[23]*Rwanda's laptop revolution: Upgrading the children. A pioneering scheme to computerise a whole people*. The Economist. December 3rd 2009

[24]Standage, Tom. *Special Report on telecoms in emerging markets: Beyond voice.* The Economist. September 26th to October 2nd 2009.

These positive network externalities are perceived very high in value as the following example illustrates[25]. In many SSA countries the expenditures for mobile telecommunication surpasses 50% of the disposable individual income. In Benin the monthly average mobile expenditure is 8.33US$ whereas the monthly disposable income is only 16.63US$. Botswana, Cameroon, Côte d'Ivoir, Ethiopia, Rwanda, Uganda and Zambia all surpass this 50% barrier. This is even more surprising when the high price sensitivity in Africa is taken into account. A impressive visualization of the impact of all of the above arguments is plotted into the following graph.

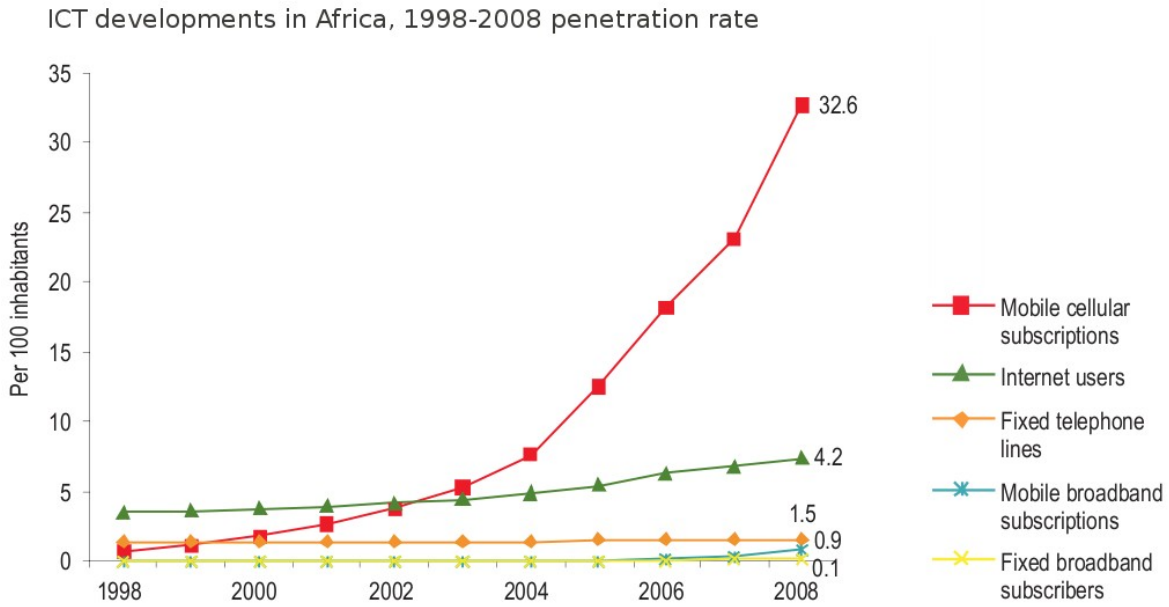

Illustration 4: ICT developments in Africa, 1998-2008 penetration rate. Source: ITU World Telecommunication/ICT Indicators database.

To witch extent this growth has leaped forward in Nigeria, has recently been expressed during the Nigerian Information Technology and Telecom Awards by Ernest Ndukwe, Executive Vice Chairman of the Nigeria Communications Commission:

[25]Gillwald, Alison. Stork, Christoph. *Towards Evidence-based ICT Policy and Regulation: ICT access and usage in Africa* . Volume One 2008 Policy Paper Two. Page 13.

> *"In Nigeria , an average growth of over 8.5 million lines per annum has been recorded from 2001 to 2009. Increase in teledensity from about 0.4 percent in 2000 to over 50 percent by October 2009. As in September, we crossed the 70 million mark in terms of connected lines. Internet connectivity is now in several cities across the country, computer and internet connectivity are in schools and colleges and tertiary institutions in the country."*[26]

1.3.1 Generic Foreign Direct Investment

The common perception of Africa as the least developed continent, home to political regimes with substantial political, economic and judicial uncertainty and instability has long kept foreign direct investment (FDI) in Africa at a low level. Although the absolute value of FDI increased *"from an annual average of almost $1.9 billion in 1983–1987 to $3.1 billion in 1988–1992 and $6.0 billion in 1993–1997 "*[27] Africa's global share of FDI has decreased steadily.

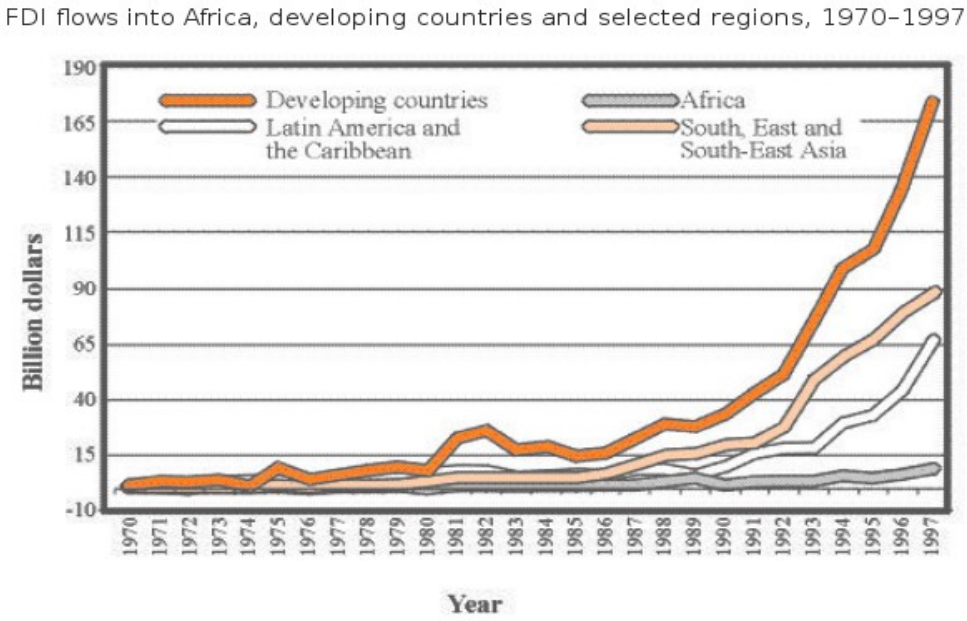

Illustration 5: FDI flows into Africa, developing countries and selected regions, 1970–1997 in Billions of US$ Source: World Investment Report 2008

[26]Ndukwe, Ernest. Executive Vice Chairman of the Nigeria Communications Commission. *Nigeria is leading destination for technology FDI.* Business Day Newspaper, November 24th 2009. Lagos. Nigeria.

[27]Odenthal, Ludger et al. *Foreign Direct Investment in Africa: Performance and Potential.* UNCTAD. 1999

This pattern has undergone a significant change since the turn of the millennium to hit a new high water mark for FDI in 2007 with 53 Billion US$ according to the World Investment Report 2008[28].

1.3.2 FDI in African Mobile Telecommunication

First, there is a continued amelioration in the conditions of doing business across Africa. Economic and political reforms have swept away many stumbling blocks, thereby favoring new ventures and fostering regional and interregional trade. The Mo Ibrahim Index, created in 2007 by Dr. Mohamed Ibrahim, a mobile communications entrepreneur and founder of Celtel, ranks and classifies the performance of all African countries according to their governance, security, corruption and respecting of human rights. For the best achievements the winning head of state is decorated by the Ibrahim Prize. It consists of a payment of 5 Million US$ over 10 years and 200,000 US$ annually for life thereafter, to the winning nations president. It is the largest annually awarded prize in the world and a thus a strong incentive for good governance.

Second, one can notice a strong rise in cross border investments in SSA by African, Arabic and international companies. Among the 15 largest foreign investors over the ten year period from 1996 to 2006, there are only two companies who did not spend their entire African related investment budget on the telecommunication sector. For Bouygues, a French industrial conglomerate, it is quite unusual to have not invested into the African telecommunication market, as this sector is among the cornerstones of its activities.

[28] *World Investment Report 2008: Transnational Corporations and the Infrastructure Challenge.* Geneva. United Nations. UNCTAD. September 2008

The 15 largest foreign investors in all infrastrucure industries in Africa, 1996–2006
(Millions of dollars)

Rank	Corporation	Home economy	Grand total	Energy	Telecom	Transport	Water
1	Vivendi	France	6 113	-	6 113	-	-
2	Mobile Telecommunications Co.	Kuwait	4 989	-	4 989	-	-
3	France Telecom	France	4 945	-	4 945	-	-
4	MTN Group	South Africa	4 555	-	4 555	-	-
5	Bouygues	France	4 550	-	-	4 485	65
6	Orascom	Egypt	3 777	-	3 777	-	-
7	Bombardier	Canada	3 483	-	-	3 483	-
8	Vodafone	United Kingdom	3 455	-	3 455	-	-
9	Emirates Telecommunications Corp.	United Arab Emirates	3 411	-	3 411	-	-
10	Suez	France	3 048	3 048	-	-	-
11	Portugal Telecom	Portugal	2 474	-	2 474	-	-
12	Veolia Environnement	France	2 368	2 353	-	-	15
13	Dubai Holding	United Arab Emirates	2 250	-	2 250	-	-
14	Wataniya Telecom	Kuwait	2 069	-	2 069	-	-
15	Telefónica	Spain	1 945	-	1 945	-	-

Illustration 6: The 15 largest foreign investors in all infrastructure industries in Africa, 1996–2006. Source: UNCTAD, World Investment Report 2008: Transnational

The African continent as such has huge deficits in infrastructure deployment. This is a major break on regional and interregional economic development, especially for landlocked countries. Following the price spike in global commodities, China has increased it's influence in Africa by signing many trade deals aimed at the vast and diverse natural resources many countries possess. Copper from Zambia, Oil from Nigeria, radioactive ores for the generation nuclear fuels from Namibia, bauxite, the most important ore for the production of aluminum from Guinea (Conakry). The list is endless. Many western nations have had a dislike of Chinas massive campaigning, may it be because they were too late or simply because they feared the risks involved in doing business in Africa. Chinese business practices aside, the trade deals with Africa have not only brought huge sums of cash into the financial systems of governments ranging on a scale form democracy (Ghana) to military dictatorship (Guinea), but they have brought new infrastructure into many countries. Roads, pipelines, mines and railways are durable investments that will help prosper a diverse mixture of other businesses. Somehow the largest chunk of FDI (excluding Sovereign investors notably Chinese) was aimed at the telecommunication sector of the mobile sort. So for some good reasons this sector must have offered a comparative advantage to its investors compared to other sectors investment opportunities. The quintessence derived form the

great amount of money that has flown, and still flows into mobile telecommunication in Africa, is that these decisions were driven by economic reasoning. Thus the investment decisions that were undertaken must have included precise expectations regarding medium to long term profits as well as a long term market vision. A vision that then resulted in the construction of a new network, which Africans were lacking.

With this brief overview of some key areas of the latest developments in the African telecommunication landscape we now enter the next part with a scientific model of game theory, dealing with a competition of two firms in a network industry such as the mobile telecommunication, just discussed.

2 The Network Pricing Game

The present chapter will introduce you to the theory of the Network Pricing Game, that will be encountered in its two different forms. One, the static Network Pricing Game and two, the dynamic Network Pricing Game, hereafter referred to by NPG. This specific model has been chosen for its many advantageous characteristics which enable its application to African Telecommunication markets and the competition between the major players in each country. Competition in a market requires that markets have been opened for competition by the local telecommunications authority in the first place. The NPG will formally explain the possible conditional outcomes of market structures from competition in network industries. We will see that in *"[...] some markets, intervention may be unnecessary for competition. It is likely that in the absence of regulation, some network markets will end in monopoly and others will sustain competition, based on their underlying characteristics."*[29]

[29]Gideon, Dr. Carolyn. *The Potential for Competition in Network Communication Industries*. The Fletcher School, Tufts University. Medford, Massachusetts, USA. 2004. Page 3.

2.1 Networks

A networks fundamental characteristic is its function in enabling the formation and existence of connections, referred to as links, too. Further a network may be built on a technology and consist, for example, of a telegraphic land line connected to electric telegraphs along the way. Operated by a person proficient in morse code, they enabled people in distant towns to communicate without taking the burden of a long travel. This cut town the risks of traveling several days by horse or by steam train.

Slightly older networks of a different sort were constituted by marriage. Jet networks based on technological evolution are only one of many examples. Certainly the predominant networks of our modern society are driven by technology. However social networks, connecting people, are the essence of all networks and are enabled by the combination of social and technology networks. A famous historical example of a social network in the 15th century is the one of Florentine Marriages[30]. Through strategic advantageous marriages the Medici family rose to a center position in both the economic and political Florentine networks of ruling families. A success built on an outstanding number of direct blood-line linkage to the powerful[31] and influential of their time. No other ruling family in the 15th century Florence had more direct links.

Networks come with numerous advantages. To the Medici their network increased their ruling power through the influence on political and trade decisions. A power they used to pursue the objectives of their time, notably in the development and sponsorship of artists, fine art and architecture.

[30]Jackson, Matthew O. *Social and Economic Networks.* Princeton University Press. Princeton and Oxford. 2008

[31]Padgett, J.F., Ansell, C.K.. *Robust Action on the Rise of the Medici, 1400 – 1434*. American Journal of Sociology. No 98. 1993.

2.1.1 Modeling the potential for competition in Network Communication Industries[32]

The prevention of monopolies in network based industries is among the top priorities of most global economies who have established appropriate bodies to watch sectors showing the characteristics of a market with a high potential of being monopolized. The key metrics include technological leadership, market share, pricing and pricing power as well as high price differences[33] for similar products or services in different markets, to which one refers to as marking to market. The logical interpretation of marking to market is characterized by a high monopolistic pricing policy in markets where a company owns a high market share, as opposed to a very aggressive pricing strategy in competitive environments. A regularly occurrence of this strategy can be seen, where products are sold below production costs to gain market share and hence distress or ruin competitors who may not be able to face a price war over a longer period[34]. The perused goal is to get rid of the competition, to subsequently reign in a specific product category or market[35].

We now approach the framework of the Network Pricing Game (NPG) to "*...develop a theoretical basis for understanding when network competition is sustainable, and when regulation will be beneficial to achieving sustainable network competition."*[36] A competition, needed for a continued increase in welfare, as discussed in the final part of this thesis.

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[32]Gideon, Dr. Carolyn. *The Potential for Competition in Network Communication Industries*. The Fletcher School, Tufts University. Medford, Massachusetts, USA. 2004.

[33]Price differences have to be determined with the Purchasing Power Parity (PPP), taking into account the long term exchange rate equilibrium between two economies. This equilibrium should in theory result in one price for a good, the "law of one price".

[34]*"306,85 US-Dollar Verlust pro Gerät hat Sony laut Medienberichten direkt nach dem Verkaufsstart der Playstation 3 gemacht..."* Steinlechner, Peter. *Bericht: Noch 37 US-Dollar Zuschuss pro Playstation 3.* Golem.de. Klaß & Ihlenfeld Verlag. 15.12.2009.

[35]A famous example is Microsoft Inc. who successfully imposed itself over the Mac and it's Operating System. The latter was the first to feature a graphical user interface in 1984, at a time when Microsoft's MS Dos running on an IBM computer was still based on a command line interface. Bill gates later copied and marketed this approach very successfully.

[36]Gideon, Dr. Carolyn. *The Potential for Competition in Network Communication Industries*. The Fletcher School, Tufts University. Medford, Massachusetts, USA. 2004. Page 4

This part is based on the dissertation "The Potential for Competition in Network Communication Industries" written by Dr. Carolyn Gideon[37] and builds on a model of competing networks, developed by Laffont, Rey and Tirole[38], whose model assumptions[39] are altered to question their conclusion of a symmetric equilibrium and a resulting symmetric duopoly. Their results appear questionable as companies involved in network industries start operating from very asymmetric positions. The likelihood of reaching an equilibrium from any possible market allocation is thus counterintuitive. Further critique on the model of Laffont, Rey and Tirole is addressed to the lack of a possible exit of one competitor neglecting one essential character of a competitive market as to when the bigger firm might attempt to induce the small firm to exit the market. How close in size must the firms be at the beginning of the game in order to reach the symmetric equilibrium? These issues are addressed by extending the model by Laffont, Rey and Tirole.

With every theory come different abstractions from reality for the ease of use. The key assumptions for the following discussion of the NPG are an unregulated price competition between asymmetric networks. Further Dr. Carolyn Gideon depicts six elements within her framework which she refers to as (1) exit decision, (2) market solutions without the intervention of regulation, (3) market maturity, (4) asymmetry in the sizes of the firms, (5) inter-connectedness and (6) subscribers innate hesitancy to switch networks.

To address the challenges arising from a sustainable competition, this model considers the market after entry to see when a small rival can survive and stay in the market, and when it will be forced to exit by its bigger rival. Therefore the importance of promoting competition through incentive policies should thus not only focus on inducing market entry, but assure that efficient entrants survive in the market, something that calls for regulation. The question here is what is the best form of regulation and when should it be used. To find an answer to this question the author proposes to *"...consider the market solution*

[37]Gideon, Dr. Carolyn. *The Potential for Competition in Network Communication Industries*. The Fletcher School, Tufts University. Medford, Massachusetts, USA. 2004

[38]Laffont,Jean-Jacques. Rey, Patrick. Tirole, Jean. *Network Competition: I. Overview and Nondiscriminatory Pricing.* RAND Journal of Economics, The RAND Corporation, vol. 29(1), pages 1-37, 1998.

[39]Price competition between two networks in the market, no regulation of retail prices, some fixed interconnection price and consumers choosing between networks.

if firms simply maximize their profits absent price regulation[40].” This shall allow to observe the firms strategic behavior and pricing in order to determine the natural outcome. In a second step the outcome is subjected to a backwards induction to understand when regulation is needed and what it should target to change the natural and unwanted course of unsustainable competition in a network industry. It may for example be necessary to regulate a market in a very early stage, even when competition is flourishing as *“...apparent competition in an immature industry may simply reflect growth in the market. Once the market matures and the growth has abated, consolidation becomes a more prominent issue.*[40]*”*

This argument is of special interest for Africa, as currently telecommunication markets grow at high rates with the first countries, notably South Africa, reaching the 100% saturation level. A level at which consolidation becomes very likely, as further growth in the customers base can best be achieved by acquiring a competitor and combining both companies. Gains are made through economies of scale, a better use of infrastructures and the possible use of new frequencies through the acquired companies mobile licenses.

To circumvent the difficulty of taking an apparent competition into account *“the model developed below assumes a mature market that no longer is experiencing growth in subscribers, leaving the firms to compete only for each other’s installed base of customers.*[40]*”* Further the model assumes asymmetry in the size of the firms competing against each other. Gideon mentions the findings of Laffont, Rey and Tirole[38] show that a symmetric competition is sustainable. Yet she complains *“[...] it is not clear how a market becomes symmetric, and if the symmetric case is always possible [40]”* and highlights research done by Sherpard[41] who discusses market dominance as a barrier to entry for network industries. Gabel[42] and Bernard, Ford and Spiwak[43] share this

[40]cp Gideon, p 5

[41]Shepherd, William G. *Problems in Creating Effective Competition. Opening Networks to Competition: The Regulation and Pricing of Access.* Edited by David Gabel and David F. Weiman. Boston, MA: Kluwer Academic Publishers. 1998.

[42]Gabel, David. *Why is there so little competition in the provision of local telecommunications services?* Paper Presented at The 30th Telecommunications Policy Research Conference, Alexandria, VA, September 2002.

[43]Beard, Ford and Spiwak.. *Why ADCo? Why now? An economic exploration into the future of industry structure for the ‘last mile’ in telecommunications markets*. Policy paper number 12, Phoenix Center for Advanced Legal and Economic Public Policy Studies. November 2001.

view in their findings from local telephone markets, where *"...entrants facing incumbent monopolies find it difficult to gain sufficient market share to realize scale economies quickly enough to compete.*[40]*"* Thus there must exist a certain level of market concentration, that if attained by one firm, prevents any other firm from competing successfully. Thus leaving no margin for the survival of an entrant, according to Gideon.

Her model assumes the networks of the competing firms to be interconnected, covering the entire country. Reciprocal compensation for access and proportional traffic are assumed, resulting in zero net payments between the firms. Network externalities are eliminated by this assumption, leaving the subscriber choice between networks to be based on price differences and the subscriber's innate propensity to switch networks for a given price difference. As Gideon mentions, this gives competition the full attention and makes it harder to prove competition is unsustainable. Otherwise existing network externalities would further dampen the expectations of the smaller competitor to survive in the market.

She assumes customers to be hesitant to switch providers, even when another network offers a lower price. Factors such as the reputation of the current provider as well as the inconvenience to change the current network provider are hereby taken into account. Yet it is important to note that customers are not locked in.

For the purposes of her paper, Gideon defines a network market as a geographic market where a network service is provided to customers. A network service is a service that, in order to be provided to a given end user, must be connected to the other end users, where an end user may be a content or application provider. In this paper, these markets are characterized by: (1) single subscribership, meaning customers will not subscribe to multiple providers; (2) large sunk costs of entry, severely limiting the number of competitors; and (3) a limited, defined geographic area.

2.2 The Static Network Pricing Game

For a clear view on the NPG's here it's key assumptions presented in a compact list:

(a) Model of price competition between two network firms

(b) Both firms cover the same, given geographic market

(c) Firm 1 is slightly larger[44] than Firm 2

(d) Firm 1 never exits while Firm 2 will exit if it can not earn positive profits

(e) The market is mature reflected in a fixed number of subscribers

(f) There is a monopoly price a firm can charge without alienating subscribers

(g) Demand is price inelastic below the monopoly price

(h) Before the game, subscribers are allocated between the firms by an exogenous process[45]

(i) Subscribers switch networks depending on price differences, yet show an initial hesitation of doing so

(j) Marginal costs of both firms are equal

(k) All sunk costs of entry are made prior to the beginning of the game

(l) Fix costs are equal for both firms, as they both have to maintain the same network size

(m) The fixed costs per market subscriber in each period are recurring costs of business and are not sensitive to traffic or the number of subscribers – eliminating efficiency gains

(n) The networks of the firms are fully interconnected – eliminating network externalities

[44]The term large is coined on the share of the total market it serves.

[45]To come with an African example, one may think of the allocation of frequencies. A procedure conducted openly through auction in some countries and through relations, bribes and misuse of political power in other countries.

(o) Interconnection between networks is mandatory an comes with a fixed symmetrical price with reciprocal compensation resulting in zero net payments between the firms[46]

Prices are set by the firms sequentially in a Stackelberg[47] game with Firm 1 as the first mover. The one period NPG consists of three stages. In Stage 1, the firms learn their initial market share allocations, and Firm 2 decides to exit or stay in the market based on this information and the characteristics of the market. In Stage 2, Firm 1 sets its price. In Stage 3, Firm 2 sets its price in response to Firm 1's price, if it is still in the market. Subscribers then choose to switch networks or stay with their current providers, and service is purchased, according to Gideon.

She characterizes markets by four parameters:

(1) $\theta \in [0,1)$ with θ as the subscribers' propensity to switch networks for a given difference in prices

(2) c as the marginal cost of providing service to a customer

(3) F as the fixed cost of providing service in the market per subscriber

(4) P^M as the monopoly price, the maximum price before customers start to disconnect

Following assumption (h) the initial market share is allocated by an exogenous process resulting in a slightly bigger share of the market for Firm 1. It's initial market share is denoted by $\alpha_0 \epsilon (0.5, 1)$ while Firm 2 has the remaining initial share of the market α_{-0}=$1-\alpha_0$. Both firms know that their initial market share will change according to their set price and the customers propensity to switch. The function describing this adjustment process is:

[46]Calling between the networks is assumed to be proportional, meaning that each customer is equally likely to call any other subscriber in the market.13 A network with 70% market share will find 70% of calls originating on its network terminate on its network, while 30% of the calls made by its customers are terminated on the rival's network. Likewise, this network will receive as incoming 70% of the calls made by its rival's subscribers.

[47]A Stackelberg

$$\alpha_1 = \alpha_0 - \theta(p_1 - p_2), \ for\ 0 < \theta \leqslant 1$$

As one would suggest, is the adjusted market share, after the subscribers have reacted to the pricing of the firms, taking into account their willingness to change. Intuitively one can see how a difference in prices translates into a change of market share.

Both firms maximize their profits. The profit functions are

$\pi_1 = (\alpha_0 - \theta(p_1 - p_2))(p_1 - c) - F$ for Firm 1 and

$\pi_2 = (1 - \alpha_0 + \theta(P_1 - P_2))(P_2 - c - F)$ for Firm 2.

To solve this maximization problem we need to find the optimal response of Firm 2 to the price set by Firm 1 and integrate this into the profit function of Firm 1. This is an advantage of the sequential nature of the Stackelberg game.

To do so we take the first partial derivation of the profit function of Firm 2 with respect to the price of Firm 2 and set it equal to zero $\frac{\partial \pi_2}{\partial p_2} = 0$. By rearranging the result we receive the best response function of Firm 2 on the price of Firm 1, given Firm 2 has chosen to stay in the market:

$$p_2 = \frac{1}{2}\left(c + \frac{(1-\alpha_0)}{\theta} + p_1\right).$$

In a second step this best response rule of Firm 2 is inserted into the profit equation of Firm 1. Thereafter we build the partial derivation to p_1 and set this equal to zero to receive, after a rearranging the terms, the price that maximizes the profits of Firm 1 for the single period game.

$$p_1^* = c + \frac{(\alpha_0 + 1)}{2\theta}$$

The same approach is used for Firm 2. This time we take the best price for Firm 1 and set it into the profit function of Firm 2. A partial derivation of this function to the price of Firm 2 yields after solving the maximization problem the best prise Firm 2 can achieve when Firm 1 maximizes its profit.

$$p_2^* = c + \frac{(3-\alpha_0)}{4\theta}$$

These results are all conditional on Firm 2 deciding to stay in the market. With the calculated prices it is now possible to compute the profits of both network operators. The profit of Firm 1, given Firm 2 stays in the market is

$\pi_1 = \frac{(\alpha_0 + 1)^2}{8\theta} - F$ and the profit of Firm 2 is $\pi_2 = \frac{(3 - \alpha_0)^2}{16\theta} - F$ given Firm 2 decides to stay in the market.

The above results assume Firm 2 decides in stage one of the single period game to stay in the market. Given Firm 2 would choose exit in stage one the trivial result would be a monopoly for Firm 1 with profits of $\pi_1 = P^M - c - F$ and $\pi_2^{Out} = 0$ for Firm 2.

Gideon mentions the existence of a positive correlation between the size of the initial market share and the firms profits. Starting from the profit functions of Firm 1 and Firm 2 we can show this by a partial derivation of these equations to their respective market share. These are strictly positive, hence a growth in market share results in an increase of profits.

As for Firm 1 $\frac{\partial \pi_1}{\partial \alpha_1} = \frac{\alpha_0 + 1}{4\theta} > 0$ and for Firm 2 $\frac{\partial \pi_2}{\partial \alpha_{-0}} = \frac{2 + \alpha_{-0}}{8\theta} > 0$.

With this lead at hand we want to find out more about the critical market share needed for Firm 2 to allow it survive the competition against the advantaged Firm 1. As noted before Firm 2 will drop out if it can not earn a positive profit and Firm 1 receives per default a larger share of the market than Firm2.

To find this market share threshold that Gideon denotes with α^*, we have to take the profit function of Firm 2 and set this equal to zero in order to solve it for α. A market share above this value allows a survival, a value at or below it will bring death to the network operator.

$$\pi_2 = \frac{(3-\alpha_0)^2}{16\theta} - F \quad \text{setting } \pi_2 = 0 \rightarrow \alpha_0 = 3 - 4\sqrt{\theta F}$$

Yet this denotes the market market share of Firm 1, so we need to make use of $\alpha_{-0} = 1 - \alpha_0$ to find the alpha of Firm 2:

$$\alpha_{-0} = 4\sqrt{\theta F} - 2 = \alpha^* .$$

As we can observe, the fate of Firm 2 does not depend on either its own not the price of its rival, but on the fixed costs of operating the network and the propensity of switching networks of the customers in the geographic market. One conclusion of this characteristic is that the firm, once it knows weather its market share is at or below the critical level, cannot change its destiny by increasing or decreasing its price. If it tightens the price for its service, customers will change to the rival network. Higher earnings per customer will not outbalance the losses in the total customer base resulting in less earnings. A decrease in price may not help either as the fall in earnings is not compensated by a growing customer base. The two main characteristics of the market are the fixed costs and the propensity to switch. Both exert direct and indirect changes of behavior. The needed initial market share increases in both, the rise of fixed costs and a growing propensity to switch, denoting a higher price sensitivity of the customers. An indirect effect of a growing propensity, is a drop in prices when the level of competition increases. Customers are more likely to switch for much smaller price differences, so both firms will adopt and compensate this effect by a drop in prices, resulting in lower earnings for the two companies, given Firm 2 is in the market. Hence knowing about these factors in a given market helps to determine how likely it is that the competition may end in a monopoly.

A much obvious measure is the critical market share α^*. Gideon continues with a categorization of markets into three different types according to the values of α^*.

- Sustainable Duopoly when $\alpha^* < 0$
- Inevitable Monopoly when $\alpha^* \geq 0.5$
- Indeterminate Markets when $0 \leq \alpha^* < 0.5$

For critical market shares below zero, Firm 2 will be able to survive. This is made possible through the right propensity to switch and the fix costs in the market. Even if Firm 2 starts with zero initial market share, it will be able to attract customers and earn enough to survive[48]. Monopoly will be the outcome for an alpha greater than or equal to 50% of the market. A zone of uncertainty about the outcome is located between zero and 50% market share.

A use of these findings could be applied to market regulation. When enough market data is available, notably about the propensity to switch and the fix costs of providing service, the computation of the above values should pose no problems. For Sub Saharan Africa one should assume a very high propensity to switch, when only taking the price of service into account. A marginal change in price gives a reason to substantial savings by switching between providers, as the income level is generally low. Due to these very low average income levels across Africa, the predominant way of paying for phone calls is in advance. Consumers purchase from single minutes to several hours of calling credit. With less to no money at their free disposal they exhibit a high price sensitivity. But the price is only one factor of the propensity to switch, as those willing to change their network may be confronted by other barriers such as a loss of their current mobile phone number and the purchase of a new phone card, making it much harder to get to an actual figure about the true propensity to switch within a market.

[48]Gideon explains in her foot note, a value of $F\theta < 0.25$ satisfies this outcome.

However, following Gideon, some general suggestions for can be given. In a market with a sustainable duopoly, no regulation is needed, as competition will prosper. A monopoly in a market will most likely call for action, although the existence of a natural monopoly may not. Most interesting for further analysis are indeterminate markets, as these may develop into either a monopoly or a sustained duopoly. With the latter being the preferred outcome, the indeterminate market calls for attention and a possible action from the regulatory body in charge. Any action considered by policy makers must target the markets underlying characteristics to decrease the critical market share and allow for a continuing competition among the network service providers. For example, a government could require subscribers to let switching customers take their mobile phone numbers with them to the new provider, hereby increasing the overall propensity to switch whereby the critical market share needed to stay in the market decreases.

As Gideon points out for the static Network Pricing Game, if Firm 2 has a market share lager than α^*, Firm 1 will take a higher price for its services. As the larger firm it can profit more from its larger customer base by taking a higher price compared to lowering the price to attract new customers. While affording to lose some customers seem to be bad idea, the short term result shows Firm 1 profits from this strategy as the partial derivation of the price difference with respect to the initial market share of Firm one is greater than zero:

$$p_1^* - p_2^* = \frac{(3\alpha_0 - 1)}{4\theta} \text{ and } \frac{\partial(p_1^* - p_2^*)}{\partial \alpha_0} = \frac{3}{4\theta} > 0 .$$

Even when the assumption (j) of symmetrical marginal costs is relaxed and the smaller firm would be given a cost advantage over Firm 1, this would not be of any big influence. It might help a little, but as long as the profound market structure persists this improvement may not be sufficient for Firm 2 to survive in the market, as Gideon highlights. These are the results of the static Single Period Network Pricing Game, showing the strong dominance of the market leader while the survival of the competitor depends on his initial size of market share and whether this is bigger than the critical share. However a game over

one period is a static approach. To see how robust these conclusions are we will put then to the test in a two period game. But before we do so, we take a short detour to Africa for a reality check on key assumptions of this model to underline the importance of efficient regulatory intervention to promote sustainable competition.

2.2.1 Detour: A comparison to reality in Africa I

A recent blog[49] entry by Steve Song[50], with the tittle "SMS Interconnect Fees" picked up the topic of overcharged fees by network operators for terminating SMS text messages on their networks subscribers phones, originating from competing networks. Mr. Song proclaims in range *"In at least 17 African countries, operators charge an interconnect fee for connecting with other operators nationally. In many cases they are doubling even tripling the cost of sending an SMS. The argument for levying an interconnect charge is based on the need of the operator to recover the costs of terminating a call or in this case an SMS on their network.*

Interconnection fees for text messages

Country	Dominant Operator	SMS Interconnect Markup
Niger	Zain	200%
Uganda	MTN	160%
Mauritania	Mauritel	150%
Nigeria	MTN	114%
Benin	MTN(Mascom)	100%
Botswana	MTN	100%
Congo	Zain	100%
Gabon	Zain	100%
Guinea	Areeba (MTN)	100%
Mali	Orange	100%
Rwanda	MTN	77%
Senegal	Orange	50%
Algeria	Djezzy (Orascom)	43%
Kenya	Safaricom	43%
Zambia	MTN	40%
Ghana	MTN	25%
Togo	Togocel	25%

Table 2: Interconnection fees for text messages in 17 African countries. Source: Steve Song, http://manypossibilities.net

[49]Song, Steve. *SMS Interconnect Fees.* 20th November 2009. Accessed online the 27th November 2009 at http://manypossibilities.net/2009/11/sms-interconnect-fees/

[50]Steve Song is a member of the Shuttleworth Foundation and currently work on telecommunications and access issues in South Africa. Prior to joining the Foundation he spent 10 years at the International Development Research Centre in Ottawa funding and engaging in research into Information and Communication Technology for Development (ICT4D) issues, mostly in Africa.

But let's face it, the incremental cost of terminating an SMS on an operator's network is effectively zero or near enough to zero, as to make no difference."

This of course highlights a need for regulatory intervention in order to correct this abuse of market dominance by the dominant operator in the market. Table 2 above reveals the urgency of dealing with these fees harming competition and fostering the positive network externalities of the local market leader.

A second observation, supporting the Network Pricing Game and the tendency of the dominant firm to reach a monopoly can be observed in Kenya. As East Africans most vibrant economy with a 2008 GDP per Capita figure of 896[51] US$ well ahead of its neighboring countries Uganda, Tanzania, Sudan, Ethiopia and Somalia, Kenya has also one of the most advanced mobile telecommunication industry in East Africa. But deregulation and privatization of public phone operators have not prevented the emergence of one very dominant operator: Safaricom. With a current market share in the Kenyan market of approximately 77% for the year 2009, down from a top at 84% in 2008, one can observe the tendency of the market leader to charge its customers a higher price, to capitalize on its large number of subscribers. A country comparison of local minimum wages per day and the amount of mobile phone minutes and text messages this minimum wage can buy gives a good insight. Illustration 7 on the next page is backed by a table of data, accessible in the annex A.2 under the topic "Cheap Talk?". There you can find further data such as the actual minimum wage in local currency as well as the number of text messages affordable for a days work.

[51]World Bank figures. 2008

A days work at the minimum wage in Kenya earns approximately 148.64 Kenyan Shillings. This amount of money would be completely consumed by only 9 minutes 50 seconds of mobile phone calls to rival networks or 30 SMS text messages terminating on handsets of rival network operators. This example presumes a subscription with Safaricom to originate calls and messages to other Kenyan networks.

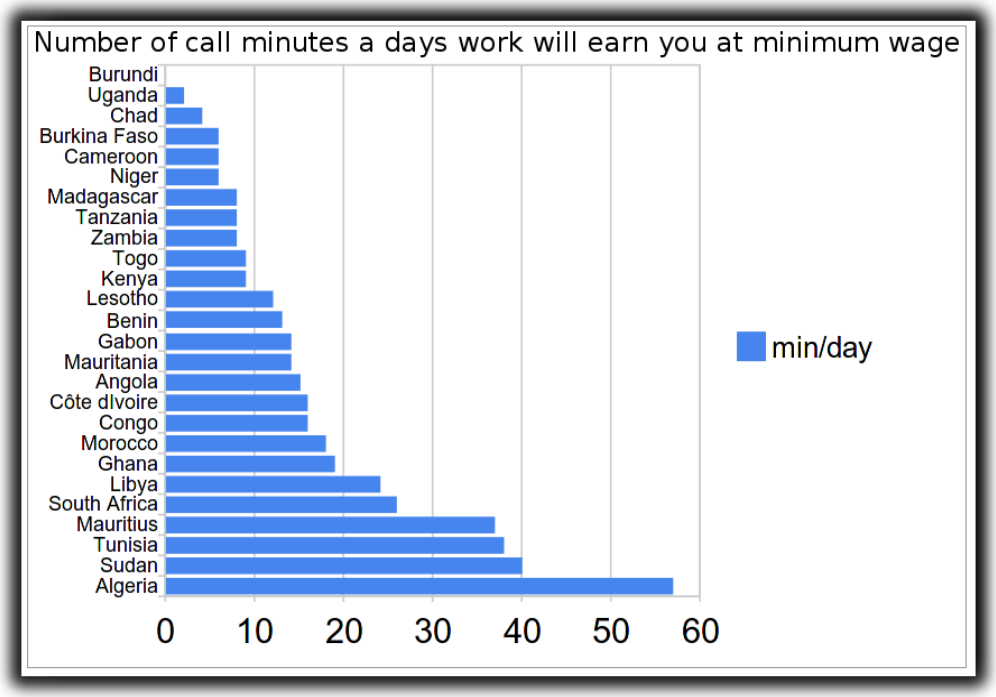

Illustration 7: Number of call minutes a days work will earn you at minimum wage. Source: Steve Song, http://manypossibilities.net

The Kenyan Government seems to have understood the urgency of maintaining competition in its local market by pushing reforms to modernize competition in telecommunication industries, as a Reuters press release can indirectly confirm: *"East Africa's biggest firm by market capitalization said in March 2009 that its market share had dropped to about 77 percent from 84 percent at the end of March 2008 as a result of aggressive competition from rivals Orange, controlled by France Telecom and Kuwaiti-listed Zain*[52]*"*

We now return to Gideons theory of the Network Pricing Game. This time the dynamic two period competition will be analyzed.

[52]Nyambura-Mwaura, Helen. S*afaricom investors eyeing market share, ARPU.* Reuters News Agency. Nairobi, Kenya. May 18th 2009.

2.3 The Dynamic Network Pricing Game

With the two period Network Pricing Game a new dynamic will enter into the equations, as both firms now have to consider their actions and strategies in period one with respect to period two. As before prior to period one the market shares will be attributed by a non-observable exogenous process. Both firms then have to decide if they want to grow their market share or even try to force the smaller firm out of the market in order to obtain a monopoly in period two. The sub-game in period two is then equivalent to the static NPG. To allow for a clearer picture of the dynamic game we first have a look at the stages and actions, in the two periods and their sequence.

Period	Stage	Action
1	1	Firms learn about their initial market share allocations
	2	Firm 1 sets its price
	3	Firm 2 sets its price. Thereafter subscribers stay or switch and purchase the services from their chosen service provider
2	1	Firm 2 chooses to stay IN the market or drop OUT
	2	Firm 1 sets its price
	3	Firm 2 sets its price. Thereafter subscribers stay or switch and purchase the services from their chosen service provider

Table 3: The Two Period Network Pricing Game. Source: Gideon, p.12.

As Gideon points out, both firms learn about their market share in stage one of period one. Then the by definition larger Firm 1 sets its price, where after Firm 2 sets its price and customers switch and purchase services from either of both firms, dependent on pricing and the markets fundamental characteristics. Arriving in period two of the game, Firm 2 has the choice to exit or stay in the market, hereafter Firm 1 sets its price. In the last stage Firm 2 sets its price and again customers chose their provider and purchase service. The game ends.

With the game in period two being contingent on the firms actions in period one, each competitor can now make use of strategic actions to maximize it's

profits. However the availability of strategies and their usefulness depend on the market conditions. These are determined by specific combinations of fixed costs and the propensity to switch.

If, for example, the critical market share threshold required Firm 2 to have a market share larger than 50% to earn positive profits, Firm 2 would never be able to survive and compete over two periods and thus always would exit in period two. This would make the market outcome an inevitable monopoly. If, for instance, the underlying market conditions allow Firm 2 to generate profits, even in the case when its initial market share is zero, then a duopoly will emerge no matter what action is taken by Firm 1. Thus firm 2 will always survive in period two and never drop out due to Firm 1's actions.

Thus, as Gideon concludes, the only interesting market is the intermediate one, where in period one it is not clear if the market outcome will be a monopoly or a duopoly. As in the one period game the resulting market structure will again depend on the market's underlying characteristics and the initial market share allocations. The decision of Firm 2 to stay in the market or exit is based on the price Firm 1 sets for the first period. This price then serves Firm 2 as an indication to whether it will have to exit in period two of the game. Hence Firm 2 will choose its price to either maximize profits over two periods, when Firm 1's price allows it to coexist, or maximize profits for only one period, if Firm 1 seeks the monopoly in period two and market conditions allow for this to happen.

With the price set by Firm 1 in period one being the critical parameter regarding the survival of Firm 2 in the second period, we seek to find the value this parameter needs to take, so that Firm 2 is indifferent between staying and exiting the competition. Reformulated we could ask, which price Firm 1 must choose in period one, so that the resulting shift in market share results in conditions, where Firm 2 in period two can earn a profit of zero at best.

Based on Firm 1's price in period one, denoted as P_{11}, Firm 2 can choose IN and stay in for both periods, or choose OUT and exit in the beginning of period 2. Thus Firm 2 must maximize its profit over two periods, given Firm 1's price. For reasons of simplification, there is no rate of interest nor inflation with the handy result that earnings in period one and period two must not be subjected

to a net present value calculus and can simply be added. Noted below is the simplified equation expressing the total profit for Firm 2 as a summation of its profits in period one and two. The index T-1 denotes the first period and T-0 the second period, just an infinite little moment before the game ends in T.

i. $\pi_2^T = \pi_2^{T-1} + \pi_2^{T-0}$

π_2^{T-1} is now replaced by the profit function we have been maximizing for Firm 2 in the single period game: $\pi_2^{T-1} = \pi_2 = (1-\alpha_0+\theta(p_1-p_2))(p_2-c)-F$, whereas the second term π_2^{T-0} is replaced by Firm 2's equilibrium duopoly profit[53]. It is derived from the duopoly market outcome of the single period game. Following is the illustrated of the above described steps.

ii. $\pi_2^T = (1-\alpha_0+\theta(P_{11}-P_{21}))(P_{21}-c)-F$

iii. $\pi_2^T = (1-\alpha_0+\theta(P_{11}-P_{21}))(P_{21}-c)-F+\frac{(3-\alpha_0)^2}{16\theta}-F$

However the static oligopoly game profit did not account for a second period adjustment of market shares as a result of the combined impact of customers propensity to switch and the actual price difference of both operators. Hence one has to add the market share adjustment $\theta(P_{11}-P_{21})$ to the equation, as highlighted in red below. Now the new profit function is ready for the optimization process.

iv. $\pi_2^T = (1-\alpha_0+\theta(P_{11}-P_{21}))(P_{21}-c)-F+\frac{1}{16\theta}(3-\alpha_0+\theta(P_{11}-P_{21}))^2-F$

The next step is to find the maximum of the profits over both periods depending on the price set by Firm 2 in period one, as expressed by the next equation.

v. $\underset{P_{21}}{Max}\ \pi_2^T = (1-\alpha_0+\theta(P_{11}-P_{21}))(P_{21}-c)-F+\frac{1}{16\theta}(3-\alpha_0+\theta(P_{11}-P_{21}))^2-F$

To solve this maximization its necessary to build the partial derivation of Firm 2's profit function with respect to the price of Firm 2, as this is the only levy it

[53]Duopoly Profit of Firm 2: $\pi_2 = \frac{(3-\alpha_0)^2}{16\theta} - F$

can tweak, while all other factors and characteristics are either given by the market conditions or induced by Firm 1.

vi. $$\frac{\partial \pi_2^T}{\partial P_{21}} = -\frac{15\theta P_{21}}{8} + \frac{5-7\alpha_0}{8} + \frac{7\theta P_{11}}{8} + \theta c = 0$$ [54]

It follows the best price Firm 2 can choose to maximize its profits over two periods of the game for any given price of Firm 1, given Firm 2 can stay in the market in period two.

vii. $$P_{21}^{\mathrm{IN}}(P_{11}) = -\frac{1}{15}(8\mathrm{c} + \frac{5-7\alpha_0}{\theta} + 7P_{11})$$

By inserting the price obtained above into Firm 2's profit equation (iv.) we obtain the total game profits of Firm 2 when this is choosing to stay IN, in the second period.

viii. $$\pi_{21}^{\mathrm{T\text{-}IN}}(P_{11}) = \frac{1}{225\theta}(10-8\alpha_o+8\theta(P_{11-c})) + \frac{1}{16\theta}(\frac{40-8\alpha_0}{15} + \frac{8\theta}{15}(P_{11}-c))^2 - 2\mathrm{F}$$

As there is just one other choice for Firm 2, of only competing in the first period of the game, one can return to the one period game and reuse the earlier obtained results. We recall Firm 2's single period profit function and rewrite the optimal price in equation xii. as the price Firm 2 will pick when it chooses to exit in period two:

ix. $$\pi_2 = (1-\alpha_0+\theta(P_1-P_2))(P_2-c-F)$$

x. $$\underset{P_{21}}{Max}\ \pi_2 = (1-\alpha_0+\theta(P_{11}-P_{21}))(P_{21}-c)-F$$

xi. $$\frac{\partial \pi_{21}}{\partial P_{21}} = -\theta(P_{21}-c) + 1 - \alpha_0+\theta(P_{11}-P_{21}) = 0$$

xii. $$P_{21}^{\mathrm{OUT}}(P_{11}) = \frac{1}{2}(c + \frac{1-\alpha_0}{\theta} + P_{11})$$

[54]Calculus involved to arrive from v. to vi. and vii. is extensive and has been done on paper in order to follow the reasoning of Gideon and her approach. To keep focused on the interesting figures, without blowing up the amount of mathematic calculus, the side line operations will not be shown here, but can be provided on request.

This is the best price Firm 2 can set if it knows it will exit at the beginning of period two. Inserting it once again into the known profit function yields us:

xiii. $\pi_2^{\text{T- OUT}}(P_{11}) = \frac{1}{4\theta}(1-\alpha_0+\theta(P_{11}-c))^2 - F$

As we seek to find the overall benefit Firm 2 enjoys form choosing to stay IN in the second period of the game, a subtraction of equation xiii. from equation viii. reveals this net benefit.

xiv.

$$\pi_2^{\text{T - IN}} - \pi_2^{\text{T - OUT}} = \frac{5}{12\theta} + \frac{4\alpha_0^2}{15\theta} - \frac{\alpha_0^2}{4} - \frac{\alpha_0}{60} + \frac{(5-\alpha_0)(P_{11}-c)}{30} + \frac{\theta c^2}{60} - \frac{\theta P_{11} c}{30} + \frac{\theta P_{11}^2}{60} - F$$

In a next step it is important to understand, when Firm 2 will rather choose to exit in period two of the game. With Firm 1 as the dominant player, we need to find the critical price $\hat{P_{11}}$ that Firm 1 has to choose, so that Firm 2 becomes indifferent between staying IN and getting OUT of the competition in the second period of the game. Hence the above equation must equal zero. Solving it for the price P_{11} set by Firm 1 in period we obtain

xv. $P_{11} = c + \frac{\alpha_0 - 5}{\theta} + 2\sqrt{15}\frac{\sqrt{F\theta}}{\theta}$.

At this price of Firm 1, Firm 2 will be indifferent between remaining in the game or exiting the game in period two. Still following Gideons footsteps, its now time to see if Firm 2 has a financial advantage from staying in the market. And if so how big this is.

For Firm 2, in order to have a benefit from choosing IN in period two, the first derivative of the differential equation $\pi_2^{\text{T - IN}} - \pi_2^{\text{T - OUT}}$ must be larger than or at least equal to zero.

xvi. $\frac{\partial(\pi_2^{\text{T - IN}} - \pi_2^{\text{T - OUT}})}{\partial P_{11}} \geq 0$

xvii. $\frac{\partial(\pi_2^{\text{T - IN}} - \pi_2^{\text{T - OUT}})}{\partial P_{11}} = \frac{5-\alpha_0}{30} - \frac{\theta c}{30} + \frac{\theta}{30} P_{11} \geq 0 \rightarrow$

Therefore Firm 2 will stay in the market in period two, if the price set by its bigger rival is larger than

xviii. $P_{11} \geq c + \frac{\alpha_0 - 5}{\theta}$

and from the second partial derivation of xiv. we can conclude that Firm 2's premium for choosing IN is increasing in P_{11} for all $P_{11} \geq c + \frac{\alpha_0 - 5}{\theta}$.

xix. $\frac{\partial^2(\pi_2^{\text{T - IN}} - \pi_2^{\text{T - OUT}})}{\partial P_{11}^2} = \frac{2\theta}{60} \geq 0$

We can now conclude Firm 2's actions accordingly. Firm 2 will choose to EXIT the competition when Firm 1 sets a price lower than or equal to $\hat{P}_{11}$ and remain IN if the price is larger than $\hat{P}_{11}$.

With these results it is now possible to formulate the best response rules for Firm 2 in period one of the dynamic NPG:

- ➔ If Firm 1 chooses $P_{11} > c + \frac{\alpha_0 - 5}{\theta} + 2\sqrt{15}\frac{\sqrt{F\theta}}{\theta}$, then Firm 2 chooses IN for Period two and set own price to

  $P_{21}^{\text{IN}}(P_{11}) = -\frac{1}{15}(8c + \frac{5 - 7\alpha_0}{\theta} + 7P_{11})$.

- ➔ If Firm 1 chooses $P_{11} \leq c + \frac{\alpha_0 - 5}{\theta} + 2\sqrt{15}\frac{\sqrt{F\theta}}{\theta}$, then Firm 2 chooses OUT in Period two and set own price to

  $P_{21}^{\text{OUT}}(P_{11}) = \frac{1}{2}(c + \frac{1 - \alpha_0}{\theta} + P_{11})$.

On the next side you find the graphical pendant of Firm 2's best response rules. With the red shaded area indicating Firm 2's exit in period two for given prices of Firm 1 and the green area marking prices of Firm 1 allowing Firm 2 to earn a positive return and stay in the market.

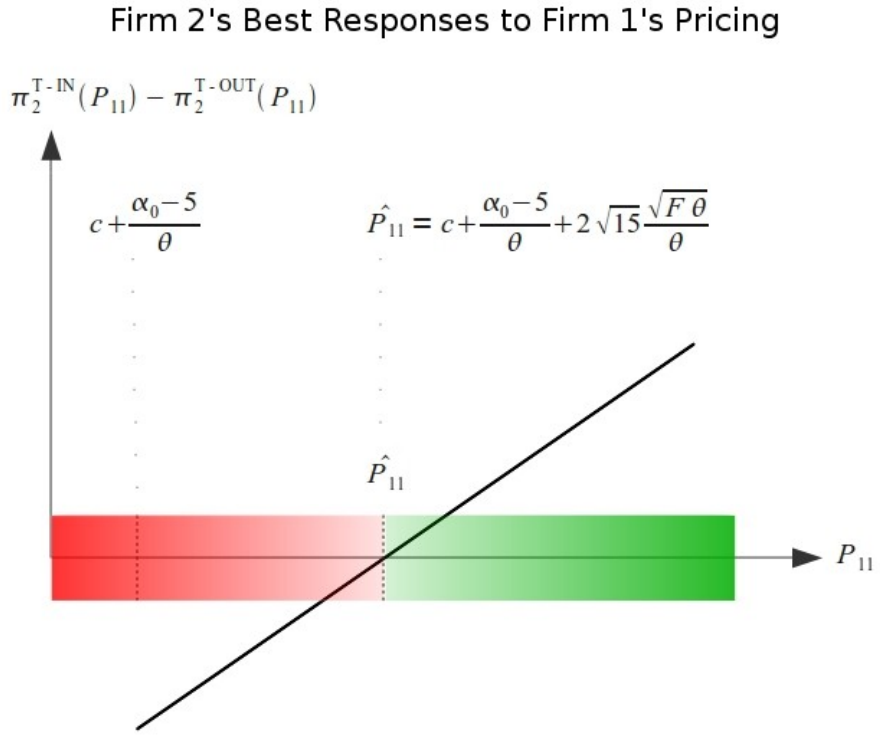

Illustration 8: Firm 2's Best Responses to Firm 1's Pricing

The first mover advantage of Firm 1 choosing its price first, combined with its advantage in initial market share allocation yields a clear result: Firm 1 can influence the market structure as it chooses its price. Further it can take into account Firm 2's response in strategy and price, depending on its own pricing.

Knowing all about Firm 2's strategies, we shall now find out more about Firm 1's strategies and the attempt to maximize its profits over two periods. Gideon formulates in her proposition 6 *"[...] that for high values of Firm 1's initial market share, such that* $\alpha_0 \geq 11 - 4\sqrt{15}\sqrt{F\theta}$*, Firm 1's optimal price in the static sequential game is a price that will induce Firm 2's exit in the dynamic sequential network pricing game. When this price induces Firm 2's exit in the dynamic sequential game, it is Firm 1's optimal exit-inducement price.*[55]*"* And an exit of Firm 2 is the best Firm 1 can achieve as it will be able to charge the maximum price from the market in period 2: the monopoly price. From the

[55]Gideon, p.14

best response rules of Firm 2 we already know that Firm 1 holds all aces on its hand. It now only needs to play them.

Assuming Firm 2 exits the competition in period two, the profit function of Firm 1 for two periods is

I. $\pi_1^T = (\alpha_0 - \theta(P_{11} - P_{21}^{OUT}(P_{11})))(P_{11} - c) - F + P^M - c - F$.

When inserting the price of Firm 2, when it has chosen to exit the game in period two (xii.), into the above equation (I.) we get

II. $\pi_1^T = \frac{1}{2}(\alpha_0 + 1 - \theta(P_{11} - c))(P_{11} - c) + P^M - c - 2\mathrm{F}$.

Firm 1's goal is to earn a maximum profit over the two periods of the competition. Assuming its strategy is to push Firm 2 out of the market in period two, its best price is obtained from in IV.

III. $\frac{\partial \pi_1^T}{\partial P_{11}} = -\theta P_{11} + \theta c + \frac{\alpha_0 + 1}{2} = 0$

IV. $P_{11} = c + \frac{\alpha_0 + 1}{2\theta}$. As P_{11} is Firm 1's best price we denote it

$P_1^* = c + \frac{\alpha_0 + 1}{2\theta}$.

For this price to qualify though[56], it must comply with the results derived from equation xv.

V. $P_{11} \leq c + \frac{\alpha_0 - 5}{\theta} + 2\sqrt{15}\frac{\sqrt{F\theta}}{\theta}$

Equation V. can be rewritten by applying equation IV:

VI. $c + \frac{\alpha_0 + 1}{2\theta} \leq c + \frac{\alpha_0 - 5}{\theta} + 2\sqrt{15}\frac{\sqrt{F\theta}}{\theta}$.

[56]The underlying market conditions like the initial market share and consumers propensity to switch must allow Firm 1 to price in period one in a way that maximizes it's own profit and despite consumers switching to Firm 2, leaves it with enough market share that Firm 2 will not be able to earn a profit in the second period and exit.

When rearranging VI. for α_o then we receive the necessary condition for the above static price IV., to maximize Firm 1's profits over two periods. It requires an initial market share of

VII. $\alpha_0 \geq 11 - 4\sqrt{15}\sqrt{F\theta}$.

The maximum profits that can be earned by Firm 1 in Period two are monopoly profits. Given that Firm 1's static price induces Firm 2 to exit in Period two, Firm 1 cannot do better as to earn this monopoly profit in the final period of the game.

VIII. $\pi_1^{MAX} = P^M - c - F$.

And since the equation IV. denotes Firm 1's profit maximizing price in the static game with competition, Firm 1 cannot do any better in the dynamic game, than by choosing IV. as its price. The best Firm 1 can obtain in the second period of the game is the monopoly price. It can only ask for this price, when competition has ceased. At this point it is important to keep in mind, that there is a required threshold α_o needs to exceed, in order to making a monopoly a possible market outcome.

With this result we now have a picture about Firm 1's strategy for a big initial market share. But what should Firm 1 do if this condition was not met and its attributed initial market share was situated at a lower level at the beginning of the two period game?

With $\alpha_0 \leq 11 - 4\sqrt{15}\sqrt{F\theta}$ Firm 1's price will not induce Firm 2's exit in period two and the price set by Firm 1 will be larger than $P_1^* = c + \frac{\alpha_0 + 1}{2\theta}$. We thus need to find the new best price response of Firm 1 for the changed market conditions. Gideon suggests the new price will be in a range between the optimal static price and the highest possible price that will induce Firm 2's exit in period 2. As market conditions have changed the price chosen by Firm 1 will by default result in coexistence with Firm 2. A less desired outcome, but inevitable under the above assumptions. Therefore the profit maximizing price for Firm 1 over the two periods is the closest it can get to V. and this is,

indexed by EI for Exit Inducing, as its primary goal remains inducing Firm 2 to leave the competition, even if this is not among the set of possible outcomes in this particular game set.

IX. $P_{11}^{EI} = c + \frac{\alpha_0 - 5}{\theta} + 2\sqrt{15}\frac{\sqrt{F\theta}}{\theta}$.

Any lower value of P_{11} would induce exit, and any higher value would come at a cost for Firm 1 whose total profits decrease in a rising of its own price[57] expressed by $\frac{\partial \pi_1^{T-Coex}}{\partial P_{11}} < 0$. In the next step Gideon derives Firm 1's price of coexistence by taking the first derivative of Firm 1's two period profit function and solving for P_{11}.

X. $\pi_1^{T-Coex} = \frac{1}{15}(8\alpha_0 + 5 - 8\theta(P_{11} - c))(P_{11} - c) + \frac{1}{8\theta}(\frac{8\alpha + 20}{15} - \frac{8}{15}\theta(P_{11} - c))^2 - 2F$

XI. $\frac{\partial \pi_1^{T-Coex}}{\partial P_{11}} = \frac{104\alpha_0 + 35}{225} - \frac{224\theta}{225}(P_{11} - c) > 0 \quad \text{for} \quad P_{11} < c + \frac{104\alpha_0 + 35}{224\theta}$

Therefore when

XII. $\alpha_0 < \frac{77}{8} - \frac{56}{15}\sqrt{15}\sqrt{F\theta}$, Firm 1's price of coexistence is

XIII. $P_{11}^{Coex} = c + \frac{104\alpha + 35}{224\theta}$.

We can thus conclude for Firm 1, when (XII.) holds, (XIII.) will not induce exit of Firm 2, and $\alpha_0 < 11 - 4\sqrt{15}\sqrt{F\theta}$, so P_1^* will not induce exit either, and $0 < \alpha^* \leq 0.5$, so both monopoly and competition are possible market outcomes, there is some value of Firm 1's initial market share allocation, $\hat{\alpha_0}$, such that Firm 1 will be indifferent between choosing among its pricing strategies of coexistence (Coex) and exit inducement (EI).

[57] Extensive proof is provided by Gideon, page 30 ff. A detailed treatment in this thesis seems beyond the constraint of the imposed time limit. Therefor the four remaining proofs are not deployed in all detail, yet its results are presented.

Based on these results, we can now formulate the best strategies and their according plan of action for Firm 1 for the dynamic NPG:

If $\alpha_0 \geq \hat{\alpha}_0$, then Firm 1 should choose $P_{11}^{EI} = c + \frac{\alpha_0 - 5}{\theta} + 2\sqrt{15}\frac{\sqrt{F\theta}}{\theta}$ as price and

if $\alpha_0 < \hat{\alpha}_0$, then Firm 1 should choose $P_{11}^{Coex} = c + \frac{104\alpha + 35}{224\theta}$ as its price.

For any other $\alpha_0 > \hat{\alpha}_0$ [58], the market outcome will be a monopoly.

The complexity involved in the above calculus may be a reason for difficulties in understanding the derived results. To counter these possible effects, a graph shall help in understanding the computed conclusions. According to Gideon, Firm 1 determines if it will earn higher profits from coexisting with Firm 2 (Coex) or from inducing Firm 2 to exit (EI). The difference between Firm 1's total profits for coexistence and total profits for inducing exit, is Firm 1's benefit of coexistence. It is shown in the illustration below as a function of Firm 1's initial market share. This benefit function is monotonic and decreasing in the relevant range of initial market shares. Thus Firm 1's profits from EI increase relative to its profits from coexistence when Firm 1 begins the game with a larger market share[59].

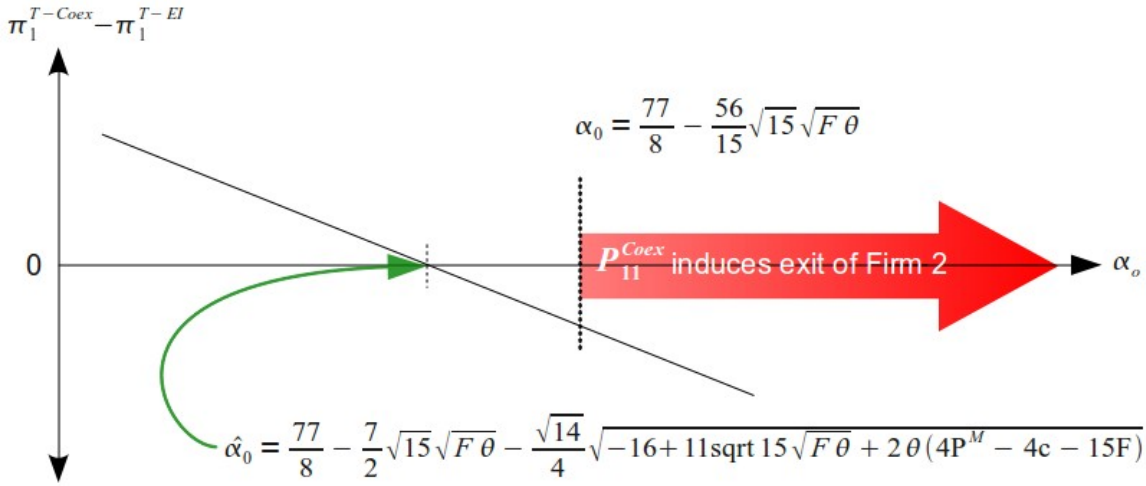

Illustration 9: Firm 1's benefit of coexistence with Firm 2

[58] For your information $\hat{\alpha}_0 = \frac{77}{8} - \frac{7}{2}\sqrt{15}\sqrt{F\theta} - \frac{\sqrt{14}}{4}\sqrt{-16+11\sqrt{15}\sqrt{F\theta}+2\theta(4P^M - 4c - 15F)}$

[59] Gideon, p. 15

On the way to the final conclusion of the discussed dynamic Network Pricing Game, we now have a look at the decision tree of dominant player Firm 1.

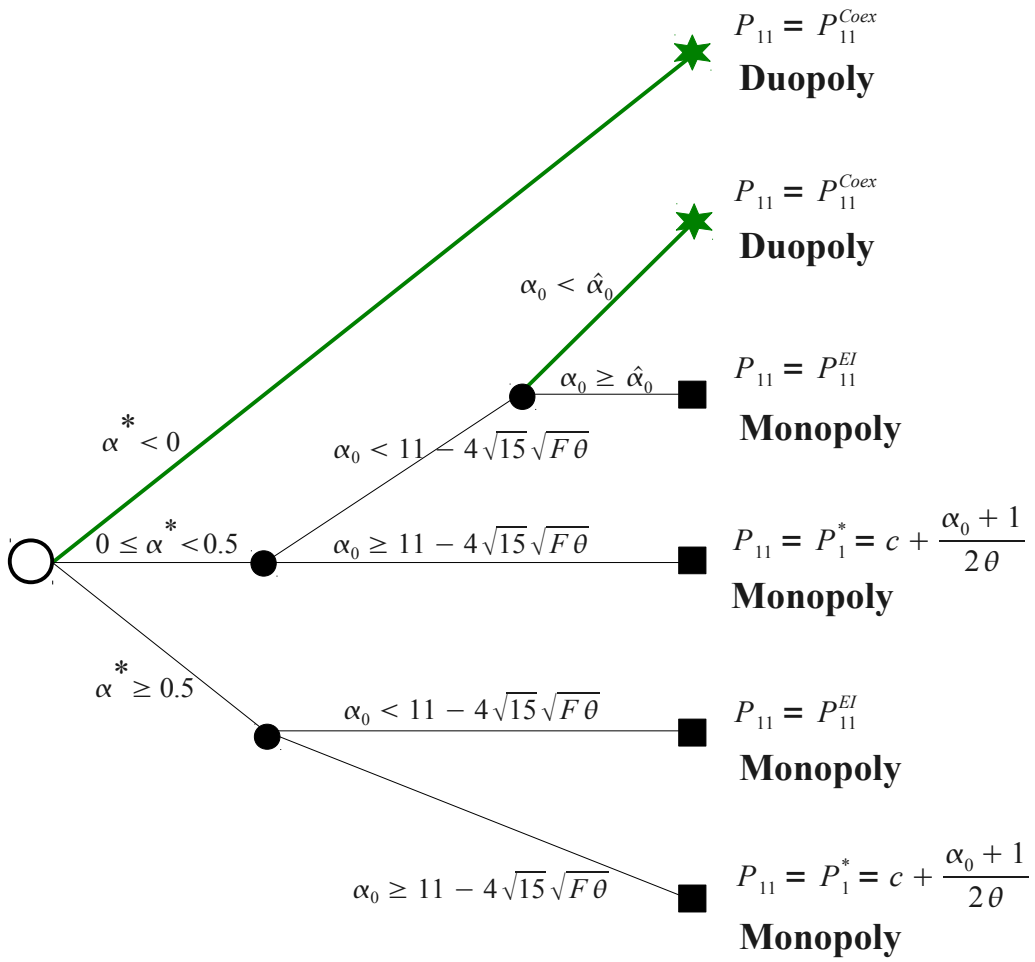

Illustration 10: Firm 1's solution to the dynamic Network Pricing Game

When inspecting the impressive game tree of the dominant Firm 1, a central question may emerge: What is the likelihood of a monopoly outcome in this Network Pricing Game? Gideon offers us a comprehensive answer to this question and undermines it with mathematical proof. It culminates in her final proposition, the probability of monopoly. According to her calculus, the probability of a monopoly increases with an increase of fixed costs F, increases with an increase in propensity to switch θ, increases with an increase in monopoly price P^M and decreases with an increase in marginal cost c.

These results are intuitive for any economist except the one for the propensity to switch. When consumers are assumed to change their operator very fast, expectations lead to thinking this may stronger benefit the weaker firm, Firm 2, as it may lure more customers from the dominant firm. However this is not the case, as mentioned earlier before, an increase in the propensity to switch results in more competition and lower prices for both firms. Thus there is no benefit for either firm from an increase in this metric and the beneficiaries on the other hand are the consumers. A further role of this metric, as described by Gideon, concerns monopoly markets. In these, competition may only come from new entrants and here the propensity of consumers switching is primordial. When it attains a sufficiently high level competition may find a prosperous ground to grow on. In markets with existing competition an increase in the propensity to switch can improve the outcome for a duopoly, unless the underlying market characteristics cause it to dip into a monopoly. The first best solution would require the propensity to switch to fluctuate and act as a catalyst, in order to balance the market for competition and against a monopoly.

2.4 Conclusion of the dynamic Network Pricing Game

The dynamic version of the NPG reveals that, based on the underlying characteristics, there are again three different possible market outcomes: Inevitable Monopoly, Sustainable Duopoly and undetermined Markets. For the latter, the final market structure is heavily determined by the firms initial market share allocation. An increase in the disparity of initial market share distribution will proportionately increase the likelihood of a monopoly as outcome. In the illustration on the next page, the green shaded areas indicate a duopoly as the market outcome, whereas the red ones signal a market of monopoly. In the centre element the colour gradient is weak in order to underline the uncertainty of the final state of the market.

On the vertical axis we find the initial market share allocations. By assumption (c), that was made at the beginning of the static NPG, Firm 1 is slightly larger than Firm 2. Therefore the range of α_o is from 0.5 to 1, with Firm 2 receiving the remaining share of $\alpha_{-0}=1-\alpha_0$.

On the horizontal axis we find the critical market share α^* in it's role of signaling how favorable market conditions (fixed cost, variable cost, prices and consumers propensity to switch) are to allow for competition in the market as well as market entry by new players.

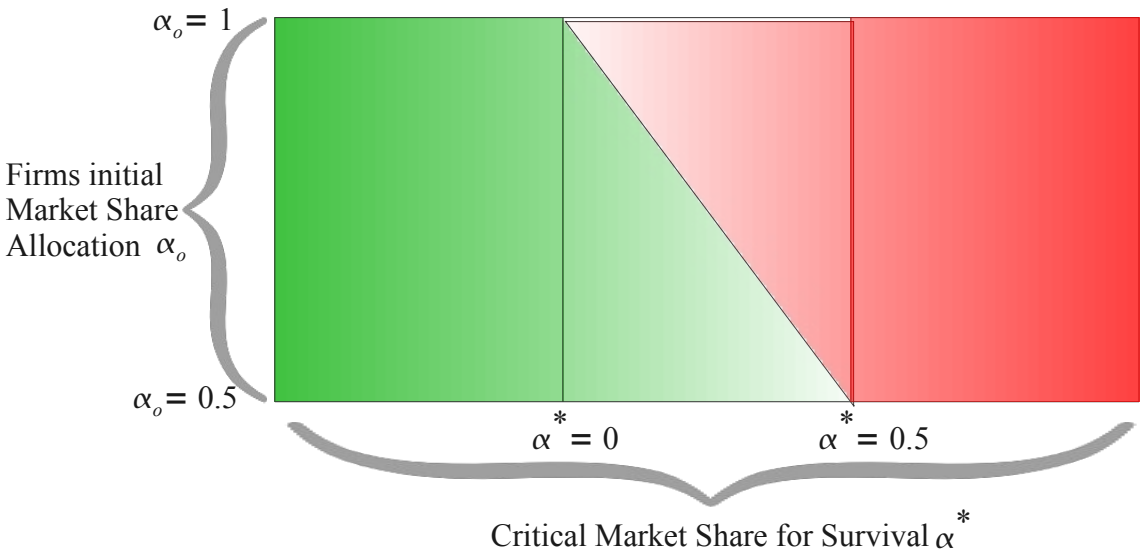

Illustration 11: α_o / α^* Market Structure Matrix

The next part will address some thoughts and ideas about how this model can be of use for policy makers for Sub Saharan African countries, to maintain a healthy competition in their young mobile telecommunications sector.

3 Dynamic Network Pricing Game: A comparison to reality in Africa II

Returning from the extensive discussion of the Network Pricing Game and its direct implications on the health of competition in a network market, this final part shall first draw a parallel between the NPG and some selected African Telecommunications Markets structures and then provide an outlook on further ground breaking changes on the continent, yet to come. Changes that will build upon the virtues of mobile telecommunications.

In the introduction of this theses the massive growth of the mobile telecommunication sector has been outlined with numerous examples. Yet we all should expect that this rapid growth will sooner or later abate, when levels of connectivity approach a density of 100% and the market is saturated. Then further growth will no longer be coming from new customer subscriptions, but from acquiring either the customers of rival operators, or even by acquiring the rival operators themselves. Hence by a process of consolidation in the local market. The current small numbers of competing firms and the eminent presence of a dominant operator in every African country will then give reasons for concern about a market concentration reaching into monopoly with all its negative implications for customers.

We shall now have a look at some market structures in a few representative countries. Nigeria has been selected for its position as Sub Saharan Africa's second biggest economy, behind South Africa and for its ranking as Africa's most populous country. Uganda and Mali have been chosen as they are both landlocked countries. Mauritius and Madagascar as island states, whereby Mauritius is further outstanding as its the winning African country of the Mo Ibrahim Index, an award for outstanding political governance, mentioned earlier. Senegal for its recent achievements of political reforms in view of facilitating business. *„Since 2004 various countries have brought in more than 1,000 reforms. Three of the top reformers in 2007-08 were African – Senegal, Burkina Faso and Botswana.*[60]*“* Kenya is mentioned due to its declining market

[60]The Economist March 12th 2009, Global Heros. A special report on entrepreneurship. Article: *An idea whose time has come.*

dominated by one operator still owning a significant market share. Though in mid[61] and late[62] 2008 two new competitors have opened operations in Kenya, raising the level of competition significantly as they price into the market with very low rates. South Africa is obligatory on the list, as it was the first country in Africa with a mobile telecommunication network deployment in 1998 and thus has the continents longest history within this industry.

Market Concentration Statistics for 2008-2009

Country	HHI-Index	No. of Operators
Nigeria	0.3	8
Uganda	0.31	5
Madagascar	0.36	3
South Africa	0.46	3
Mauritius	0.52	2
Senegal	0.54	3
Kenya	0.65	4
Mali	0.7	2
Namibia	0.77	2

Table 4: Market Concentration in Selected African Countries. Source: Local Telecom Comissions, ITU, Africa & Middle Easet Telecom Week et al.

The third row of the table displays the number of local operating firms in mobile telecommunication services – providing phone calls, text messages, data services and increasingly mobile internet access. Values in the second row reflect the Herfindahl-Hirschman Index (HHI) values for the mentioned countries.

Herfindahl-Hirschman Index: $H = \sum_{i=1}^{N} S_i^2$

The HHI is an indicator for the degree of competition within an industry expressed by its concentration. It is calculated by the total sum of the squared individual firms sizes. The index is used for example by the American Department of Justice and the Federal Trade Commission, to reduce large

[61]Waruru, Maina. AfricaNews. *Kenya telecom gets ready for third provider.* Nairobi, Kenya. 1st July 2008. The complete article can be found in the Annex.

[62]Kemibaro, Moses. YU Mobile Network Launches in Kenya. December 1st 2008, Nairobi, Kenya.

statistics into one meaningful number, with a HHI value above 0.18 indicating a high market concentration.

It is not surprising in this case, to see that across the board, African telecommunication markets are highly concentrated. This concentration is only partially attributed to the little number of competitors, as a market with three competitors, each owning a third of the market would translate into a HHI of 0.33, a result Nigeria just underbids with a total of eight operators. This reveals high values of HHI to be a result of market dominance by a single operator, as extreme asymmetries in size of market share reflect stronger into the result through the sums of squared shares.

These observations show, that the dynamic Network Pricing Game's assumptions are very close to reality and network industries tend to have a dominant player. From the above listed countries, only Madagascar, Nigeria and Uganda do not have a single firm with more than 50% market share, although the 47%, 41% and 47% market share respectively are not too fare away of the 50% mark. It can further be noted that African markets are clearly indeterminate markets, as to speak in terms of the NPG. They all exhibit high growth rates and thus are suspects for an apparent competition which may, when consolidation starts to gain ground, very likely end in a monopoly. Governments should thus take needed action, to change the markets underlying characteristics[63] to foster a competitive market on the long run.

Despite the strong to medium market imparity of operators across Africa there is one undeniable fact: Access to and use of mobile telecommunication has rocket-propelled Africa into the ICT-age and brought along the most significant impact on social and economic life. Putting a single value to the creation of welfare is a daunting task. There are endless positive effects that have to be taken into account. What is much better observable, are the indirect consequences of this impact on welfare.

[63]Characteristics including such features as the portability of mobile phone numbers across access providers, lowering of interconnection fees between network operators for terminating calls and text messages on rival networks, network sharing to cut fixed costs for new entrants and to counter over capacities being built up over time.

First, African markets have weathered the current economic crisis far better than anyone would have expected. Africa has not proved to be completely resistant to the global economic downturn, but its natural way in dealing with crises in day to day life has provided it with a comparative advantage in coping with economic and political shocks.

Second, Africa has seen its highest average growth rates in the past decade. Critics may argue that a great portion is attributed to exports of minerals. But despite many countries' strong dependency on exports of minerals, a great contribution to national growth rates is directly tied to the miracles of mobile telecommunication[64]. Mobile phones have enabled millions to exit unemployment and start a business venture with little investment needs. The strong growth of the industry has itself created a great number of jobs, sucking in well educated university graduates by large numbers.

Third there is the impact on governments earnings. The sale of broadcasting frequencies may just be a windfall profit, but long term tax income from service providers should be a welcome diversification for governments, even if they have to assure for competition within their local market[65].

Forth, In my humble opinion the mobile telecommunication boom has ignited a “self propelled” process of welfare generation. To illustrate this statement I have pictured the key elements in a star formation.

[64]The Economist. A special report on entrepreneurship. *An Idea who's time has come.* March 12th 2009

[65]Competition leads to lower prices and smaller profit margins among the involved players. This translates into smaller tax earnings by governments. This gives reason for concern when government interests merge with those of the operator(s).

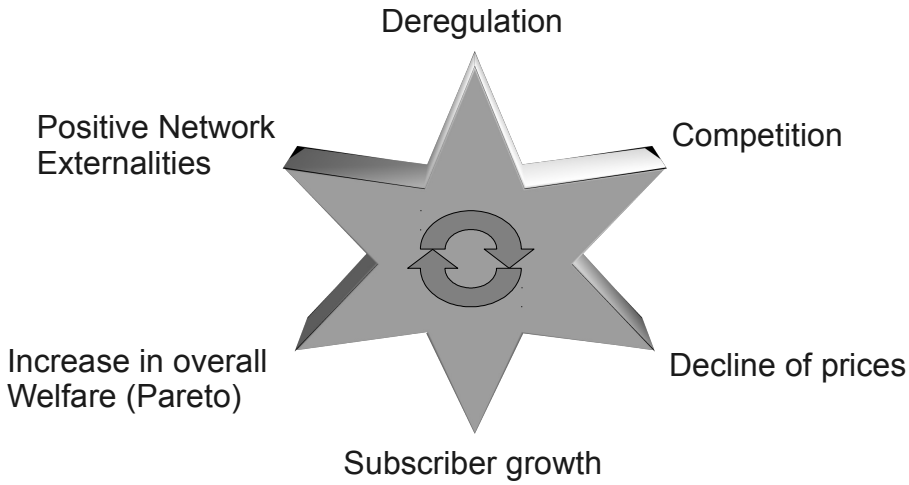

Illustration 12: Self Propelled Welfare Generation through Mobile Telecommunication

Reading the illustration clockwise, the welfare cycle was ignited by a process of deregulation in telecommunications markets across Africa. With early movers such as South Africa and laggards such as Ethiopia, whose only mobile operator up to date, the Ethiopian Telecommunications Corporation (ETC), is state owned and operated. Its characterized by poor signal coverage, low level of services and clogged networks throughout the day. This appalling state translates into a penetration level of just 3.2% of its current population of 80 Million. A deregulation of the Ethiopian Market would bring new investment and much needed competition into the country. With competition as the enabling factor for an increase in network coverage, availability of services and choice, it signifies the foundations of long term welfare creation. The transition form a monopoly to market of competition comes with a new price war between the operators, seeking to grow their customer base in the long run[66]. With declining prices for mobile services and sinking costs for handsets, entry barriers for consumers, even in the poorest countries, are lowered allowing a significant growth in subscribers. The joint consideration of the previous stages culminates in an overall increase in welfare which induces many other positive effects, called positive network externalities. Some of which will be mentioned hereafter. The expression “Pareto” in brackets shall signify the importance of the increase in welfare Africa is experiencing. Those profiting from an increase in utility, achieve this amelioration, without

[66]This may very well include a strategy of rent seeking.

deteriorating the welfare of others involved. A process that can be kept alive, but will need intervention, before market concentration leads to a monopoly.

3.1 Positive Network Externalities of Mobile Telecommunication

Beyond the positive effects discussed in the first chapter, notably mobile banking and the access to information and education, there is another hugely positive network effect making headway from 2010 onwards: mobile internet.

The internet revolution in Africa has not yet picked up steam, currently seen in mobile telecommunications. But predictions are good, that the mobile phone will be the device of choice for millions of Africans to access the internet in the coming years. An achievement building on the current boom and thus turning internet services delivered to handsets into another major externality to be attributed to mobile telecommunication.

There are three predominant facts supporting this hypothesis.

One, from the early to late 90's nobody in the telecommunication industry of developed economies was expecting the mobile phone to be a service affordable or needed by the African People. Time, as this theses shows, has proven them wrong and their views overly pessimistic. The internet is thus to be considered to accomplish a similar achievement in only a few years.

Two, with continued competition between operators, the price spiral will continue to fall and hence drive up subscriber levels till the market reaches saturation. In an attempt by operators, to create new revenue streams, they will start to offer further services to their existing customer base. These services may either be rolled out in the form of additional services offered, while maintaining prices fixed, to keep customers loyal, or by charging extra fees for their use.

Three, there are huge investments going on to link Africa's eastern and western shores to the optic fiber cable spanning the world. This fiber cable is serving as its center backbone of data exchange and Africa till 2009 was

deprived of access to this optic fiber cable. A very old cable running from southeast Asia to Mauritius and South Africa, before climbing up north on Africa's west coast, to reach Spain, has not been a real deal with its very low data throughput of just 360 gigabits per second. Thus data connections for international phone calls and internet access had to rely on expensive satellite links, to be connected to the world. Gladly this is a picture of the past. The future is depicted by the below illustration of fiber optic submarine cables. A line's thickness is an indication for its data throughput capacity.

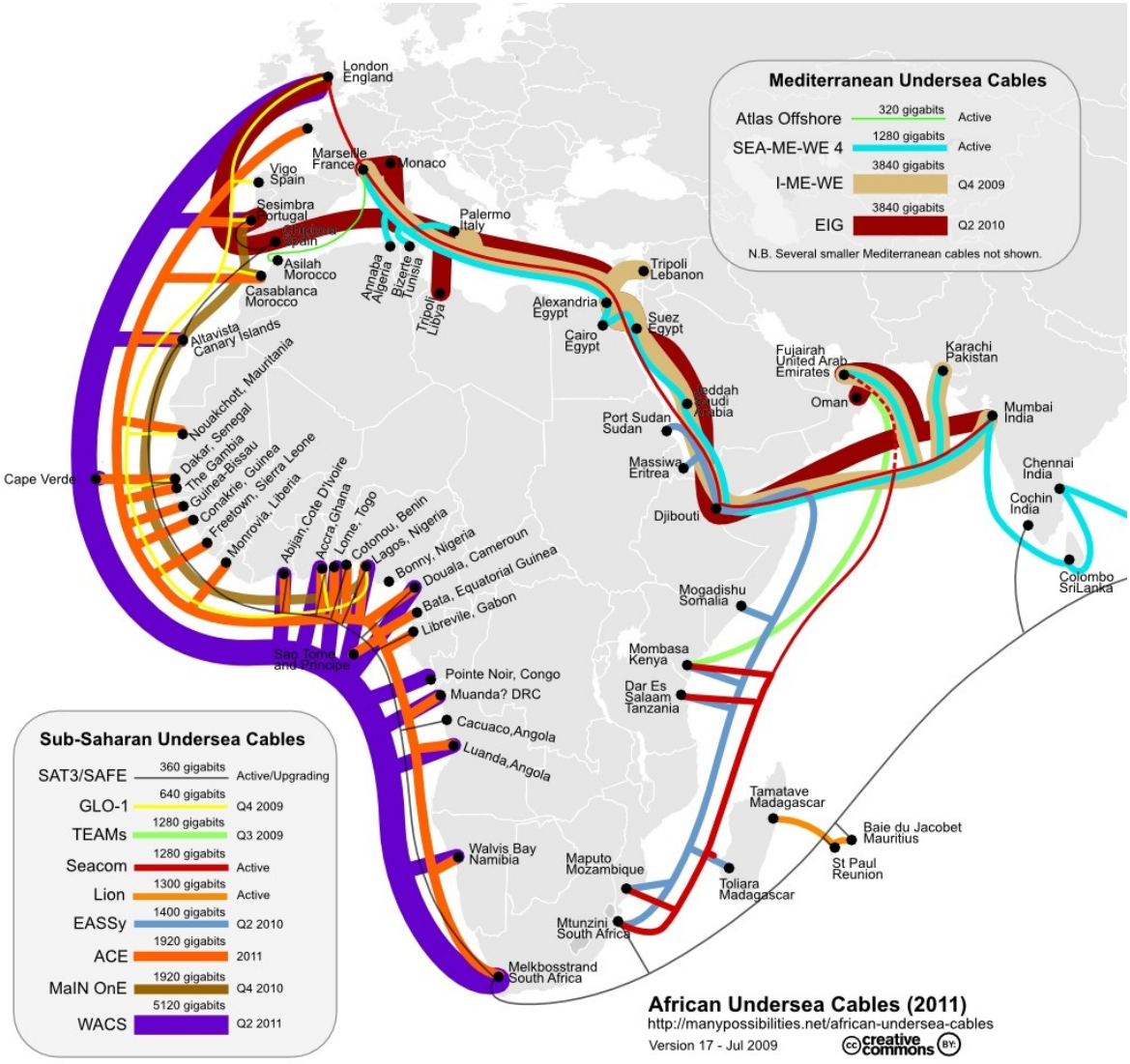

Illustration 13: Sub-Saharan Undersea Cables

With Table 4, further detailed statistics about these cables are provided. It is amazing to see how close the expected times of completion are. Considering the substantial amount of time and financial investment needed to build a new optic fiber connection, the original decisions by the investors have been taken during the last economic boom between 2004 and 2007. During this time low interest rates have dominated financial markets and motivated the global financial industry to seek ever new investment opportunities. With lesser options of making high returns in developed economies and an increasing demand for growing returns by investors, some funds origination in wealthy nations have found their way into submarine cables projects. Reasons why we can find sovereign funds from the Agha Kahn and a few American Special Purpose Vehicles among the majority of African investors for these projects.

	Seacom	EASSy	TEAMs	WACS	MainOne	GLO1	ACE
Cost (millions of USD)	650	265	130	600	240	150	???
Length (km)	13,700	10,000	4,500	14,000	7,000	9,500	14,000
Capacity	1.28 Tb/s	1.4 Tb/s	120 Gb/s – 1.28 Tb/s	3.84 Tb/s	1.92 Tb/s	640 Gb/s?	1.92 Tb/s
Completion	July 2009	June 2010	Sept 2009	Q2 2011	June 2010	Nov 2009	2011
Ownership	USA 25% SA 50% Kenya 25%	African Telecom Operators 90%	TEAMs (Kenya) 85% Etisalaat (UAE) 15%	Telkom Vodacom MTN Tata (Neotel) Infraco et al	US Nigeria, AFDB		France Telecom

Table 5: Sub-Saharan Undersea Cables Statistics

4 Conclusion

Africa in general, and Sub Saharan Africa in particular is experiencing a current boom in mobile telecommunication. This unprecedented and largely unexpected event has unlocked real growth potential on the microeconomic as well as the macroeconomic scale. With economic opportunities emerging from within Africa, the motivation and identification with the associated positive network effects on the greater economy possess a clear advantage on the motivation. A motivation that has since the turn of the millennium changed millions of lives for the better. With mobile telecommunications being such a young industry in Africa, the sector still has some leeway before it enters a large scale consolidation. A process which has an inherent risk of monopoly as a market outcome. Therefore governments with an active politic of monitoring competition and providing market conditions favoring a competitive local telecommunication market will have a leading edge in assuring prosperity for the future of their nations. An African future.

A Annex

A.1 Kenya telecom gets ready for third provider

By Maina Waruru, AfricaNews reporter in Nairobi, Kenya. Tuseday, 1st July 2008

Kenya is set to have a third mobile phone operator this August, bring an end to a duopoly enjoyed by Safaricom Limited and Celtel Kenya for years.

Kenya is set to have a third mobile phone operator this August , bring an end to a duopoly enjoyed by Safaricom Limited and Celtel Kenya for years.

The dominance of the two will come when the latest entrant into the market Econet Wireless International (ECI) enters the rolls out its network in the country bringing to three the number of operators and ushering in much needed competition .

The entry of ECI into market will also bring in new products experts say, away from the normal voice and data services offered by the pair who have dominated local seen over the past 8 years.

Indications that the firm was ready to take the plunge became clear on Monday this week when it announced senior staff appointments for Kenya operations , with Michael Foley formerly of Celtel Tanzania being named CEO .

Others named include Anna Othoro formerly working for Celtel Kenya and who was appointed marketing director , a pointer to the fact ECI poached heavily from the pan African mobile phone operator.

ECI making its first step into the region made the move months ahead of Telkom Kenya which later in the year is set to enter the GSM market , making the field even more crowded but more competitive.

The entry of ECI marks an end to 5 years of conflict between the Southern African firm and Kenya government over a host of issues ranging from its ownership structure to its financial and technical capacity to offer GSM service.

The company has been in Kenya since 2003 when it won a bid to commence services in the country but its Kenyan partners the Kenya National Federation of Cooperatives (KNFC) failed to raise part of its financial commitment forcing ECI to take up 41% reserved for the Kenyan firm.

This resulted in a 2 year long legal battle that ended in 2005, but the firm again was unable to raise the money on its own forcing then information minister Raphael Tuju to cancel. The move was contested by the company which the courts ruled in its favor in 2006.

The company payed $100 million license to the government this year allowing it to commence business in the country .

That was not before roping in Indian telecoms firm Essar communications holdings which bought a 49% stake in ECI and injecting in much needed capital , to enable the firm pay for the license.

The company started recruiting senior staff in April this sending jitters across the 2 Kenyan operators who feared losing top and qualified staff to the new entrant.

As it turned only Celtel the lesser of the pair turned victim with Safaricom the most profitable firm in East and Central Africa retaining its senior personnel.

ECI will to fight hard to a get its own market segment in a market of an estimated 13 million subscribers with Safaricom having 10.5 million of those, an equivalent of 85% leaving Celtel with a meager 15%.

The anticipated entry of ECI is eagerly awaited by subscribers who are hoping for new products and lower calling tariffs.

Entrenched operators Safaricom and Celtel have been offering reviewing tariffs and carrying out promotions to keep subscribers hooked, a number of whom only used to the pair may be tempted to jump ship.

A.2 Cheap Talk?

How far does a day's minimum wage brings you in phone minutes and text messages to rival operators?

Country / Currency / Dominant Operator	Minimum Wage -Daily	Mobile call to other network cost/min	SMS to other network cost/SMS	Minutes per day affordable at min wage	Number of SMS affordable per day
Algeria Algerian Dinar Djezzy (Orascom)	545.45	9.5	5	57.42	109
Angola kwanzas Unitel	390.91	25.92	9	15.08	43
Benin CFA MTN(Mascom)	1363.64	100	50	13.64	27
Burkina Faso CFA Zain	1394.73	230	30	6.06	46
Burundi francs U-Comm (Orascom)	157.58	300	20	0.53	8
Cameroon CFA MTN	1283.91	200	50	6.42	26
Chad CFA Zain	1272.73	260	25	4.9	51
Congo CFA Zain	2454.55	145	50	16.93	49
Côte d'Ivoire CFA Orange	1663.95	99	50	16.81	33
Gabon CFA Zain	3636.36	250	50	14.55	73
Ghana ghana cedi MTN	2.76	0.14	0.05	19.72	55
Kenya kenyan shilling Safaricom	148.64	15	5	9.91	30
Lesotho maloti Vodacom	36.91	2.9	0.75	12.73	49
Libya dinar Libyana	5.91	0.24	0.05	24.62	118
Madagascar ariary Orange	3182.95	390	120	8.16	27
Malawi kwacha Zain	167.82	47.71	13.16	3.52	13
Mauritania ouguiya Mauritel	961.36	65	8	14.79	120
Mauritius rand Orange	144.58	3.9	0.6	37.07	241
Morocco dirhams Maroc Telecom	87.88	4.8	0.8	18.31	110
Niger CFA Zain	1272.73	195	75	6.53	17
Nigeria naira MTN	250	37	15	6.76	17
South Africa rand	78.96	2.99	0.8	26.41	99

Illustration 14: Number of call minutes a days work will earn you at minimum wage.

Source: Song, Steve, http://manypossibilities.net

A.3 Visualized GSM and 3G coverage in Africa

Illustration 15: GSM and 3G coverage in Africa. Latest available visualized data from end of 2007. Source: GSM Association. 2008

A.4 African Undersea Cables Investor details

Seacom (http://www.seacom.mu)

Industrial Promotion Services (25%), an arm of the Aga Khan Fund for Economic Development (USD 75 million)

(Kenya – founded by Prince Karim Aga Khan IV of Pakistan)

VenFin Limited (25%) – USD 75 million)

Herakles Telecom LLC (backed by Blackstone) (25%), New York-based lead company, no website (USD 75 million)

Convergence Partners (12,5%) – USD 37.5 million

Shanduka Group (12.5%) – USD 37.5 million

EASSy (http://www.eassy.org/)

EASSy is 90% African owned although that ownership is underwritten by a substantial investment by Development Financial Institutions (DFIs) including World Bank/IFC, EIB, AfDB, AFD, and DfW. Total DFI investment is apparently $70.7 million, with $18.2 million coming from IFC, 14.5 million from AfDB. This is a smaller amount than the originally advertised $120 million investment from DFIs.

South African investors in EASSY include Telkom South Africa ($18.9 million) , Neotel, and MTN.

There are 26 telco operators in total invested in EASSy.

An SPV created to facilitate. open access will be the biggest shareholder, with 46%.

In Jan 2008, VSNL announced an investment in EASSy

TEAMs

85 per cent of the cable is owned by TEAMs (Kenya) Ltd and the rest by Etisalaat of the United Arab Emirates (UAE). The TEAMS (Kenya) Ltd holding breaks down as follows:

20% – Government of Kenya (through Min. of Finance)

20% – Safaricom Ltd

20% – Telkom Kenya Ltd

10% – Kenya Data Networks Ltd

10% – Econet/Essar Telecom Ltd

5% – Wananchi Group

3.75% – Jamii Telecom Ltd

1.25% – Broadband Access/AccessKenya Ltd

1.25% – Africa Fibrenet (Uganda) Ltd

1.25% – InHand Ltd

1.25% – iQuip Ltd

1.25% – Flashcom Ltd

West African Cable System (WACS)

Telkom

Vodacom

MTN

Tata Communications (Neotel)

Infraco

Cable & Wireless

Portugal Telecoms

Telecom Namibia

Togo Telecom

Angola Telecom

Sotelco (U.S.)

MaIN OnE

Privately owned. On June 1, 2009, the African Development Bank confirmed USD 66 million financing for the project.

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Abbreviations & Expressions

SSA. Sub-Saharan Africa. All countries of Africa except the northern African countries of Algeria, Egypt, Libya, Morocco, Tunisia, and Western Sahara.

FDI. Foreign Direct Investment. Foreign direct investment is defined as an investment involving a long-term relationship and reflecting a lasting interest in and control by a resident entity in one economy (foreign direct investor or parent enterprise) of an enterprise resident in a different economy (FDI enterprise or affiliate enterprise or foreign affiliate). Such investment involves both the initial transaction between the two entities and all subsequent transactions between them and among foreign affiliates. Source of definition: UNCTAD, World Investment Report 2009.

Innate. Innate is a synonym for inherent, or a natural tendency.

Propensity Propensity is derived from the Latin word propendere, "to incline to, to hang forward, to weigh over"; from pro-, "forward" + pendere, "to hang".

ICT. Information and communication technologies. allow users to participate in a rapidly changing world in which work and other activities are increasingly transformed by access to varied and developing technologies. By this definition, you could almost say ICT is technology's version of economic growth, to satisfy the needs and wants of the community over time. ICT tools can be used to find, explore, analyze, exchange and present information responsibly and without discrimination. ICT can be employed to give users quick access to ideas and experiences from a wide range of people, communities and cultures.[67]

[67]Definition taken from wikipedia.org

GSM. Global System for Mobile Communications. It is the most popular standard for mobile telephone systems in the world. The GSM Association, its promoting industry trade organization of mobile phone carriers and manufactures, estimates that 80% of the global mobile market uses the standard.[68]

3G. The 3rd Generation of standards for mobile telecommunications defined by the International Telecommunication Union. Services include wide-area wireless voice telephone, video calls, and wireless data, all in a mobile environment. Compared to GSM (2G) services, 3G allows simultaneous use of speech and data services and higher data transmission and reception rates. Thus, 3G networks enable network operators to offer users a wider range of more advanced services while achieving greater network capacity through improved spectral efficiency.

NPG. Network Pricing Game

.com bubble. The .com bubble was a speculative bubble in stock markets in Europe and the United States, which ended in the first quarter of 2000. The bubble was fueled by technology firms covering sectors from telecommunications to internet based services and businesses. The latter were characterized by big visions, high market valuations and steep losses, as turning simple ideas into earnings proved more troublesome than many had expected.

[68]Definition taken from wikipedia.org

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Declaration

Hereby I declare that I wrote this thesis myself with the help of no more than the mentioned literature and auxiliary means.

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Bad Camberg, 25th of Febrauary 2010

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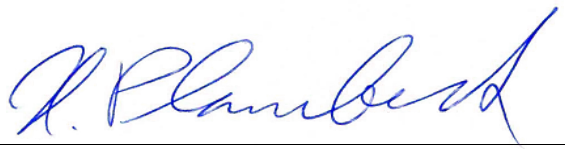

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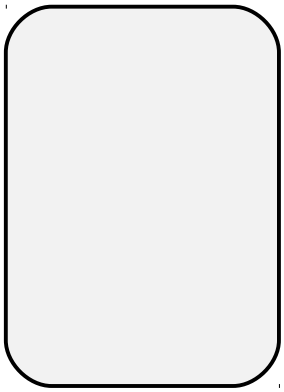

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