“Reforms, sector outcomes and economic growth in Telecommunications in Africa :

Revisiting empirical evidence”

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SUMMARY

1. Introduction

In this paper I would like to put forward certain issues that were not taken into account to a large extent by the academic literature on telecommunications in Africa. In particular, the literature I would like to revisit relates to the relationship between telecom outcomes and economic growth and between telecom outcomes and telecom reforms.

I would like to raise questions over certain methodologies, data and focus followed by the empirical literature when analyzing these matters. I would also like to propose different ways in which these caveats can be bypassed.

In section 2, I will explain what we know from the theoretical and empirical literature relating telecommunications outcomes and growth at the macroeconomic level. I will also explain the divergence between the methodologies used for developed countries as those employed for developing countries, when analyzing the link between telecommunications outcomes and economic growth at the macroeconomic level.

I will explain why the methodologies (as well as the data available) often fail to capture the real macroeconomic impact of telecommunications outcomes in economic growth with samples from developing countries. I will argue that for countries worldwide, but particularly so for African countries, it is much more reliable to use microeconomic data to derive estimates on the impact of telecommunications on economic development.

In section 3, I will explain what we have learned from the empirical literature on the impact of telecommunications reforms on telecommunications outcomes in Africa. I will focus in particular, on the privatization and competition reforms. I will then argue that little has been done however, to understand the determinants of these telecommunications reforms.

I will revisit then the small literature on the theoretical and theoretical determinants of telecommunications reforms in Africa. I will propose ways in which these analyses could be extended by making case-by-case qualitative and quantitative assessments.

In section 4, I will conclude by suggesting that many improvements can be done to the research analyzing the links between reforms, outcomes and economic growth in the

telecommunications sector in Africa. With respect to the relationship between telecommunications outcomes and economic growth, the use of structural models as well as detailed data to estimate macroeconomic equations is fundamental.

Whenever this is not possible, microeconomic analysis should be more reliable and hence preferable. With respect to the relationship between reforms and outcomes, while much has been done on the impact of reforms on outcomes, very little work can be found on the determinants of reforms. Detailed country analyses of the determinants of reforms would be extremely valuable to get a better understanding of the functioning of markets.

2. Telecommunications outcomes and economic growth in Africa

In this section, I will first explain what we know from the theoretical and empirical literature relating telecommunications outcomes and growth at the macroeconomic level. Secondly, I will explain the divergence between the methodologies used for developed countries as those employed for developing countries, when analyzing the link between telecommunications outcomes and economic growth at the macroeconomic level.
Thirdly, I will argue that for countries worldwide, but particularly so for African countries, it is much more reliable to use microeconomic data to derive estimates on the impact of telecommunications on economic development.

2.1 Theoretical framework

"Theory and empirical research on the impact of telecommunications in economic growth: What have we learned?"

2.1.1 Neoclassical Models

The prior interest on capital accumulation as a major driver of growth in the early 1950s was soon outweighed in the research arena by the role played by technological progress.
The growth rate of technology, population and savings rate are treated has exogenous variables.
In the neoclassical growth model proposed by Solow (1956), we take the hypothesis of diminishing returns to each input and assume constant returns of scale.

Since the capital-labour ratio is subject to diminishing returns, capital accumulation only affects output per worker during a transitory period.[1]
As the capital-labour ratio reaches some constant ratio, long run output per worker stagnates on a steady state where the capital stock, the labour force and the output per worker grow at the

[1] See Solow (1970) for an overview of neoclassical growth theory.

same rate. In this setting therefore, investment on capital and, more particularly, on infrastructure does not lead to long term growth, but instead affects the rate of convergence towards a steady state.

Solow steady state demonstration[2]:

There are two inputs, capital K(t) and labor L(t), we assume a Cobb-Douglas production function, so production at time t is given by (**1)**:

$$(1)\ Y(t) = K(t)^{\alpha} (A(t)L(t))^{1-\alpha} \qquad 0 < \alpha < 1$$

The notation is standard: Y is output, K capital, L labor, and A the level of technology.
L and A are assumed to grow exogenously at rates n and g:

$$(2)\ L(t) = L(0)e^{nt}$$

$$(3)\ A(t) = A(0)e^{gt}$$

The number of effective units of labor, A (t)L(t), grows at rate n + g.

The model assumes that a constant fraction of output, s, is invested. Defining k as the stock of capital per effective unit of labor, k = K/AL, and y as the level of output per effective unit of labor, y = Y/AL, the evolution of k is governed by :

$$(4)\ \acute{k}(t) = sy(t) - (n + g + \delta)k(t)$$
$$= sk(t)^{\alpha} - (n + g + \delta)k(t)$$

where δ is the rate of depreciation. Equation (4) implies that k converges to a steady-state value k* defined by :

$$sk^* = (n + g + \delta)k^*$$

or,

[2] « A contribution to the empirics of economic growth » N; Gregory Mankiw, David Romer, David N. Weil, p410-411.

$$(5)\ k^* = [s/(n + g + \delta)]^{1/(1-\delta)}$$

Since stagnation of long run output per worker seemed not consistent with the observed growth rates of developed economies, Solow (1956) pointed out the existence of an exogenous factor, the so-called technological progress that would allow for long-term growth.

The intuition is that technology can make the combination of production factors more effective and therefore the same quantities of capital and labour can increase output beyond the existent levels through, for example, improved infrastructure and education.

Empirical evidence based on this conceptual framework and derived from data on developed economies reveals that the bulk of productivity had to be explained through what was an unidentified technological factor that was embodied in the residual, the so-called total factor productivity (TFP) component (see, for example, Abramovitz, 1956, and Solow, 1957).

One of our main concerns in the Solow model will be the conditional convergence in which we consider two countries with different initial levels of technology (growing at the same rate) and the same other exogenous exogenous factors .

Each one of the considered countries will reach a steady state, with the same levels of capital per effective unit of labor (k*) and same levels of output per effective unit of work (y*), but in the long run we will find different levels of income per capita, this unexplained gap in the model is then due to the technology factor. We could then refer to developed countries as technologically developed and developing countries as countries that needs to introduce ICT technologies in order to catch up with developed countries steady states. After saying this, we have to note that the assumptions made in this model, diminishing returns and constant returns of scale, may be not fully compatible with all the ICT expected effects.

2.1.2 Endogenous growth models

Endogenous growth theory emerged in the 1980s when Griliches (1979) and Romer (1986) among other authors, concerned with identifying the underpinning factors of technological

progress, modelled this residual as an economically determined factor. Under this approach the authors understood by capital accumulation not only physical capital but also knowledge capital.

In Griliches (1979) each firm possesses a knowledge capital, which spills across firms; in Romer (1986) firms learn by investing to produce more efficiently and this knowledge spills between firms. These arguments bring to the forefront the notion of externalities or spill over effects where decisions can impact third parties.

Due to the presence of externalities in capital accumulation, the social return to capital investment should exceed the private return and subsequently investment in capital need not be subject to diminishing marginal productivity nor the production function limited to constant returns to scale. Under the neoclassical view, the impact of infrastructure investment exceeds its mere contribution to output per worker, and is partly captured through the contribution of the TFP.

One remarkable difference between neoclassical and endogenous growth theories regarding technological progress is that the former regards this feature as a public good which is non rival and non excludable whereas the latter analyses technology as a non rival partly excludable good. According to the endogenous growth theory then, some individuals could be excluded from using the good, which would enable economic incentives to develop production.

Inspired by Schumpeter (1943), a stream of literature has been developed under the belief that intellectual property rights provide incentives for investment in knowledge creation at the cost of allowing temporal monopolies. In contrast, under neoclassical theory there is perfect competition and the market makes the best allocation including investment in technology.

Even if bearing on mind the (very) different assumptions underlying neoclassical and endogenous growth theories, researchers have yet not reached a consensus on empirical grounds over which shall be the prevailing theory. And this remains applicable for the particular case of infrastructure investment as (potential) determinant of output and for the context of developing economies.

At first one could easily turn to be at odds with neoclassical growth theory when thinking about developing economies. Indeed, when Solow (1956) developed his model he was trying to explain the patterns of economic growth in the US and never applied this framework to the context of developing countries.

According to neoclassical growth theory output per worker will converge around the world, with areas under low capital-labour ratios having higher rates of return to capital and attracting capital until they would eventually catch-up with more advanced economies. As T tends to infinity the importance of this catch up terms goes to zero and so the initial value of output per worker has no implications on the long run (initial condition).

However, evidence highlights that rapid productivity growth was never sustained in the poorer regions of the world. Indeed, there has been little unconditional convergence in output around the world and that most capital investment has gone to developed countries. Neoclassical analyst rectified then the convergence proposition to that of conditional convergence, where output per worker would not converge to a common level unless other institutional and market factors coincide.

Relying on the little explanatory power of the neoclassical growth models to show how growth rates differ across time and countries, new factors were introduced on the associated empirical models to address the unexplained part of growth. The new items that are relevant for infrastructure markets are economies of scale, spill over effects, government policies and technological catch up.

Interestingly, there is vast empirical evidence in favour of conditional convergence where less favoured countries would growth at faster rates until they have reached a steady state under the assumption of decreasing returns to scale which is clearly an argument against endogenous growth models which have been rarely backed up by robust econometric studies.

Another fundamental issue that can be criticized in growth accounting empirical models derived from neoclassical growth theory is the problem of the interdependence between the contribution of capital accumulation and technological progress on output, which is particularly relevant when analyzing infrastructure investment. The neoclassical assumption of neutral

technology where technological progress affects equally other factors, though appropriate in order to define long run equilibrium, should be questionable.

Since the new technologies lead to learning effects, the contribution of capital accumulation and technological progress must be interdependent. Moreover, technological progress is embodied in new capital investments, where these two factors should reinforce each other. What steams from this issue, is that contributions from capital accumulation and technological progress may quite easily turn out to be empirically indistinguishable which though more lightly also applies endogenous growth theory.

Let us recall that in endogenous growth theory technological progress is endogenously determined as a function of economic incentives and behaviour, and it arises as individuals respond to market incentives. This brings about one of the major differences between the two-presented streams of literature: in endogenous growth theory, since technological progress depends on economic decisions, government policies can affect output per worker in the long term.

However, in neoclassical growth theory policies can only have an impact during the transitory period. In practice, however, it is not possible to discriminate theories relying on this topic. Since the long run can be a quarter of a century and onwards while the data availability is at most 140 years, it is difficult to distinguish policies that bring growth closer to its steady state.

Whatever approach used, both neoclassical and endogenous associated empirical works are subject to constraining pitfalls when addressing the relationship between infrastructure and growth. The implausibly high rates of return on infrastructure investment are attributed to econometric failures in macro econometric studies. Models can be mispecified if there is omitted bias, that is, there are variables that explain growth and still they are not included in the regression.

Non-stationarity in time series induces a spurious correlation between infrastructure investment and output. Even though this can be easily corrected by first differencing, this solution destroys the long-term relationships in the data. Moreover, it is difficult to disentangle in which sense(s) is (are) running the causal relationship(s) between infrastructure and output.

To conclude, our standpoint is that there is not a need to make a clear cutting decision upon the prevailing model, and that the results would gain in robustness if both models were empirically tested and presented. Even if infrastructure analysis tends to more closer to endogenous growth theory, both theories remain nevertheless potential explanatory frameworks on economic behaviour.

2.1.3 Table 1: Theoretical framework for telecommunications & growth

1. Theoretical analyses : Telecom outcomes and economic growth			
Theory	**Author**	**Main assumptions**	**Implications for economic Growth (focused on infrastructure)**
Neoclassical growth theory : exogenous growth model	Harrod–Domar (1946)	See Harrod–Domar model. BASIC ASSUMPTIONS: 1. Output is a function of capital stock where Y=output ; K= capital stock ; S= total savings ; s= savings rate ; I= Investment ; δ=rate of depreciation of the capital stock 2. The marginal product of capital is constant; the production function exhibits constant returns to scale. This implies capital's marginal and average products are equal. 3. Capital is necessary for output. 4. The product of the savings rate and output equals saving, which equals investment 5. The change in the capital stock equals investment less the depreciation of the capital stock	Long-run rate of growth is exogenously determined by assuming a savings rate (capital accumulation). Its implications were that growth depends on the quantity of labour and capital; more investment leads to capital accumulation, which generates economic growth. The model also had implications for less economically developed countries; they have plenty of labour but less physical capital this, slows down their economic progress. Because they don't have enough saving capacities, their accumulation of the capital stock through investment is low. These implies that economic growth depends on policies to increase investment, by increasing savings.
	SOLOW-SWAM (1956) SOLOW (1957) SOLOW (1970) SOLOW (1988)	See Solow-Swan growth model. BASIC ASSUMTIONS : 1. population grows exogenously at the rate n, assuming a Cobb-Douglas form for a constant returns to scale production function: $Y = Ka (AL)^{1-a}$ $0 < a < 1$, [1] where Y is output, K is capital stock, L is labour input and A is the level of domestic technology. Let the rate of growth of labour-augmenting technology equal g (i.e.At=A0egt) and the growth of labour equal n (i.e. Lt=L0ent).	These models implies : 1. capital accumulation as a major driver of growth. 2. existence of an exogenous factor, the so-called technological progress that would allow for long term growth. The intuition is that technology can make the combination of production factors more effective and therefore the same quantities of capital and labor can increase output beyond the existent levels through, for example, improved infrastructure and education.
Endogenous growth theory	Schumpeter (1943)	See Schumpeterian model of Innovation. BASIC ASSUMPTIONS : The Walrasian steady state (equilibrium) can be "pertubed" by innovation. Schumpeter describes a model in which the four main cycles (business cycles) , 1. Kondratiev (54 years),2. Kuznets (18 years), 3. Juglar (9 years), 4. Kitchin (about 4 years)	investment in knowledge creation at the cost of allowing temporal monopolies (incentive for investment in reseach applied)
	Griliches (1979)	See model of the knowledge production function. BASIC ASSUMPTIONS : 1. Firms exist exogenously Firms 2. Firms pursuit knowledge as an input into the process of generating endogenous innovative activity	These arguments bring to the forefront the notion of externalities or spillover effects where decisions can impact third parties. In Griliches (1979) each firm possesses a knowledge capital which spills across firms
	Romer (1986)	See Romer Model of Growth. BASIC ASSUMPTIONS: 1. Output of representative firms is the vendor's level of knowledge, other physical inputs (such as physical capital and raw labor, etc.) and the total stock of knowledge K, function. 2. The production function of a firm has constant returns to scale, but the whole economy exhibits increasing returns to scale. Knowledge can generate spill over effects. 3. The growth rate depends on the level of investment in a learning by doing model	Firms learn by investing to produce more efficiently and this knowledge spills between firms.

2.2 Empirical Analysis

Empirical Analysis applied to : "Telecom outcomes & economic growth"

2.2.1 Empirical: Microeconomics

« Empirical findings in the impact of ICTs in economic growth in developing countries: Microeconomic analysis"

Under these premises, micro econometric studies have been able to circumvent these constraints much more convincingly than macro econometric studies whose results remain questionable. Some micro econometric studies find that R& D raise firms' productivity with coefficients that imply significant spill over effects (Jones and Williams, 1998). Though this result advocates for endogenous growth theory, it does not rule out neoclassical growth theory (Durlauf et al., 2005).

To understand at the microeconomic level, process changes enabled by the extensive use of ICT, there are two theoretical perspectives, transaction cost economics (Williamson 1981) and coordination theory (Malone and Crowston, 1994). Coordination theory extends this perspective by describing alternative coordination mechanisms and the trade-offs between them more explicitly.

In these views, ICT has an impact by changing the relative desirability of different ways of working by making different activities and processes more or less attractive. These theories also describe implications for industry structure. For example, these perspectives lead to a common prediction of disintermediation, since the reduced cost of communication allows buyers and sellers to find each other without requiring the services of an intermediary.

Transaction cost economics focuses on changes in the costs of various transactions due to factors such as changes in access to information. In particular, the theory of transaction cost economics defines transaction costs as the costs of human coordination and cooperation (North,

1996). Transaction cost economics argues that individuals choose that particular organisation form for their transaction that minimizes transaction costs (Coase, 1937; Williamson, 1975).

Coase (1996, reprint from 1937) stated that there are obviously costs involved in using the price mechanism otherwise the market would channel all economic transactions. Coase discerns four types of transaction costs: searching costs; costs of contracting; monitoring costs; and costs of enforcement. Searching costs stand for costs of discovering the relevant prices; costs of contracting stand for costs of negotiating and concluding; monitoring costs happens when a contract is concluded, and both parties check that the opposite party fulfils the commitment.

Williamson (1975, 1985) has renewed the transaction costs theory by defining several factors that influence this optimum and thereby, the choice for an economic organizational mode. According to him three specific characteristics of transactions that refer to the nature of the exchanged commodities, affect transaction costs and thus the choice for market or hierarchy: asset specificity, frequency and uncertainty.

Asset specificity refers to the degree to which an asset can be redeployed to alternative uses and by alternative users without sacrifice of productive value (Williamson, 1991). An asset is very specific if the use of it is limited and therefore hard to resell. Asset specificity relates amongst others to location (site specificity), for example a natural resource that cannot be removed; physical factors (physical asset specificity), for example a specialized machine or tool required to produce a single component; human factors (human asset specificity) for example specified knowledge. According to Williamson, these forms of asset specificity lead to vertical integration.

Next to asset specificity, frequency and uncertainty were also named as a specific characteristic that affects the transaction costs. The higher the frequency of the transaction, the more plausible this transaction will take place in a hierarchical relation. Uncertainty relates to the unexpected behaviour of the contracted parties. If the uncertainties accompanying transactions are high, the choice for hierarchy is more likely (Williamson, 1985). Within uncertainty, time specificity is important to this paper, because depending on the time prices will vary in intraregional and international trade of commodities.

I note that earlier modes of ICT, such as the telegraph, have promoted integration between firms in several industries. Current mass production and distribution depend on the speed, volume and regularity in the movement of goods and communications possible by railroad and telegraph in the nineteenth century in the United States (Chandler, 1977).

This caused an overall increase in the volume of output, which in turn increased the number of transactions. Almost the same conclusion comes concerning the rise of multinational enterprises in the nineteenth and twentieth centuries. Markets enlarged as a result of improvements in transport and communication, which increased the frequency of transactions between firms (Jones, 1996).

I would like now to illustrate the relevance of this literature to the context of mobile phones in Africa. With 5 out of 10 Africans having a mobile phone by 2010, this technology has a large leeway to circumvent traditional market bottlenecks. Examples of services that are reducing transaction costs are mobile payments which are and e-agriculture.

Kenya´s mobile payment system has already attracted over 5 million consumers in less than two years in a country where only 26 per cent of the population has a bank account (OECD, 2009). The service is reducing transaction costs sharply and more so in the transfer of small amounts of money, which is the common practice between urban and rural areas.

To illustrate, if someone wants to send 1,000 Kenyan shillings (Ksh) (about 9 €) to a partner is another area in the country, money transfer operators typically request a fee of 500Ksh. For the same amount, the mobile payment operator asks 30Ksh if the money is sent to a mobile phone

user in the same mobile phone network and 75Ksh if it is sent to a mobile phone user in another network.

In Ghana, mobile phones have brought together farmers and consumers by enabling access to production information timely and affordably. As grain markets typically occur once per week, traders and farmers have historically travelled long distances to markets to obtain production information. This not only requires the cost of travel, but also the opportunity costs of traders‟ time (Aker, 2008).

The arrival of mobile phones in Ghana, provides an alternative and cheaper search technology to grain traders, farmers and consumers. Users can sign up to receive weekly text messages alerts on commodities for a fee and the cost of the message. Users can also upload offers to buy and sell products via mobile phone and make precise price requests on products.

As outcome, grain traders operating with mobile phones search over a greater number of markets, have more market contacts and sell in more markets as compared to their non-mobile phone counterparts. This suggests that traders with mobile phones are better able to respond to surpluses and shortages, thereby allocating grains more efficiently across markets and dampening the price differences.

2.2.2 Empirical: Macroeconomics

« Empirical findings on the impact of telecommunications in economic growth in developing countries: Macroeconomic analyses"

There is a relatively large empirical stream of literature addressing the research question on how important is a good communications system for economic growth in developing countries. The early investigations are concerned with the relationship between fixed-line deployment and economic growth, where they mostly find evidence of a positive link (see Röller and Waverman, 1999, Chakraborty and Nandi, 2003, Lee et al, 2009, Fuss et al, 2005 and Sridhar and Sridhar, 2009).

However, these studies suffer from important caveats. Firstly, certain authors do not address the endogeneity of telecommunications infrastructure, which may bias the measure of infrastructure on growth. Indeed, at a household level an increase in income can impact the purchasing power for telecommunication services, and therefore, the associated demand. In addition, increases in economic growth may demand greater telecommunications infrastructure to comply with growing business transactions.

Secondly, other authors do not take into account country specific effects, which might explain the abnormally large returns to investment found in some studies. This second problem of

spurious correlation may arise because regional specific infrastructure investments might be correlated with other growth promoting measures.

Some authors have engaged in more performing econometric methodologies based on multiple equation models that account for endogeneity and fixed effects (Röller and Waverman, 1999, Sridhar and Sridhar, 2004, and Fuss et al., 2005, Maiorano & Stern 2007). Although these studies report a positive link between telecommunications infrastructure and economic growth, none of these have addressed the issue of causality between the two variables. Chakraborty and Nandi (2003) are the first to my knowledge to examine Granger causality between fixed-line deployment and economic growth in a TSCS data set on developing countries.

In addition, they are also the first to explore in this context; the unit root characteristics typically associated to the economic growth series, which can induce spurious correlation in results. Their analysis suggests that there exists a long run co integrated relationship between telecommunication infrastructure and economic growth.

By analyzing the role of fixed-line privatization, they find that in the absence of this reform, there is no income effect, but only a causal relationship running from telecommunications to growth. In line with this last stream of literature that addresses causality, this research aims at deriving a structural model consistent with the endogenous growth theory and that accounts for the presence of country-specific effects and unit roots in the series.

2.2.3 Empirical caveats

2.2.3.1 Data & Methodology

Notwithstanding the research efforts just highlighted, the stream of literature on telecommunications and economic growth in developing countries suffers from several important caveats.

Firstly, the methodology used for mobile phones can be questioned. Recent literature is not following closely the lengthy and accurate empirical literature on telecom impact in US and other advanced economies in the 80s and after (see for example, van Art et al, 2002, for the European Union and Mulder, 2006, for Latin America). Models used are not very fine or elaborated.

For example, early investigations concerned with the relationship between fixed-line deployment and economic growth, mostly find evidence of a positive link.[3] However, these studies suffer from important caveats. Firstly, certain authors do not address the endogeneity of telecommunications infrastructure, which may bias the measure of infrastructure on growth. Indeed, at a household level an increase in income can impact the purchasing power for telecommunication services, and therefore, the associated demand. In addition, increases in economic growth may demand greater telecommunications infrastructure to comply with growing business transactions. Secondly, other authors do not account for country specific effects which might explain the abnormally large returns to investment found in some studies. This second problem of spurious correlation may arise because regional specific infrastructure investments might be correlated with other growth promoting measures.

Some authors have engaged in more performing econometric methodologies based on multiple equation models, that account for endogeneity and fixed-effects (Röller and Waverman, 1999, Sridhar and Sridhar, 2004, and Fuss et al., 2005). Although these studies report a positive link between telecommunications infrastructure and economic growth, none of these have addressed directly the issue of two-way causality between the two variables. Chakraborty and Nandi (2003), are the first to my knowledge to examine Granger causality between fixed-line

[3] See Röller and Waverman (1999) and Chakraborty and Nandi (2003) for an overview of this literature.

deployment and economic growth in a TSCS data set on developing countries. In addition, they are also the first to explore in this context, the unit root characteristics typically associated to the economic growth series, which can induce spurious correlation in results. Their analysis suggests that there exists a long run co-integrated relationship between telecommunication infrastructure and economic growth. By analyzing the role of fixed-line privatization, they find that in the absence of this reform, there is no income effect, but only a causal relationship running from telecommunications to growth.

Second, in terms of caveats in literature on telecommunications and economic growth in developing countries, in standard growth theory, it is GDP averages over 5 or better over 10 years, that are relevant (Durlauf et al, 2005). Otherwise, the regression would be capturing the business cycle, instead of long term growth. However, in the stream of literature we are referring to, GDP is captured through time series.

Third, while developed countries have recently achieved a consensual definition of the scope of ICTs through the OECD (2002) report where they are identified as information technology manufacturing industries and information services, developing countries have not yet reached such an agreement even though the World Bank (2006) has engaged on pervasive efforts towards creating a detailed comprehensible framework to which countries could adhere.

Reaching an agreement on the definition of ICTs, which are typically reported on basis of national accounts, is fundamental in other to allow cross country comparisons and obviously, studies of their economic impact. As a result most studies on the economic impact of ICT focus on developed countries, where in developing countries international comparisons are constrained to a specific ICT sector or country.

Indeed, the models in the 80s used large volumes of precise data that accounted for human and capital accumulation as well as ICTs (see OECD 2003, Colecchia and Schreyer, 2002, for data classification).

Current literature in Africa instead, often uses mobile penetration as proxy for capital accumulation in a country, forgetting of the full range of other physical capital investments in the country but also of the wider nature of ICTs – ICTs are not only mobile phones.

Obviously the recent adoption of certain technologies and their fast evolution and convergence around ICTs sectors is making the task difficult. For example, in some business investments ICTs are used as intermediate goods in manufacturing processes and are not reported as ICT investments on national accounts, undermining the size and therefore economic impact of ICTs.

Finally, the data on Africa should be taken into account cautiously. Measures of GDP in African countries are often suffering from mis-measurement, for example Ethiopia.[4] In another example, in the government in Ghana is currently revising its GDP estimates which are announced to impact the value between 1/3 and 1/2 (rise). The country is delaying these official figures because it would imply that the country would go above 1000 USD per capita and hence they would no longer be eligible for World Bank concessional loans. Measures of telecom variables are sometimes very questionable as well in their construction.

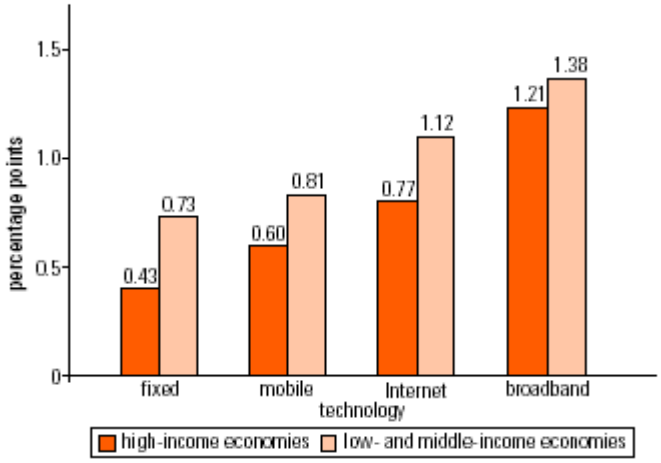
2.2.3.2 Debatable assumptions

Current literature in developing countries attributes an instant impact of mobile phones on growth. A positive impact between GDP and mobile phones is found, and hence this impact is instantaneous. However, the likelihood that a raise in 10 per cent in mobile phones one year, causes a raise in 2 per cent of GDP that same year, does not seem plausible.

See figure from the IC4D 2009[5] :

[4] OECD (2009).
[5] "Information and communication for development 2009 : Extending reach and increasing impact" World Bank Report.

Figure 1.1 Growth Effects of ICT



Source: Qiang 2009.

Note: The y axis represents the percentage-point increase in economic growth per 10-percentage-point increase in telecommunications penetration. All results are statistically significant at the 1 percent level except for those for broadband in developing countries, which are significant at the 10 percent level.

Even less, with the history on telecommunications back on the nineties, where computers could be found everywhere except in the statistics". That is, it took an important lag in time, for economies to capture the impact of communication technologies at the macroeconomic level. In the literature in advanced economies, it took some time to find the impact of ICTs in growth, recognizing that the impact happens with a certain lag (Pilat, 2006).

Another strong reason why this stream of literature is debatable, is that spillover effects of the use of mobile phones and other technologies are not modelised. However, it stands out that the largest impact of mobile phones in the economy does not come through the direct effect, but rather through the impact on other sectors such as agriculture, banking, payments whereby transaction costs are strongly reduced.

Since the supply chain is also affected, it is not clear the impact of mobile phones on employment. And then, if this is not specifically modelised then this effect goes onto the error term and is not taken into account when measuring the impact of mobile phones on economic growth.

2.2.3.3 Causalities

One way relationship establishment :

In this chapter I would like to explain shortly the different methodologies encountered in this literature revue and listed all along this paper.
The most basic and well-known regressions and models used in these literature are :

- Ordinary Least Square model or "OLS model"
- Fixed Effects
- Random effects
- Generalized Method of moments or "GMM model"

The different types of regressions could be approached in a more academic way by presenting Bayesian models, parametric and non parametric regressions but or objective is to stick to the models most frequently applied for resolving our matters.

We will concentrate on quantitative analysis, for these the most appropriate basic model to start with is the OLS model, it s the simplest model used in econometrics, it is based on a linear regression, the remarks made here after over the OLS model can be extended to the rest of the presented models.

The establishment of correlations through regression estimations have to be carefully treated and analysed, that is why I would like to remind some basic issues, before doing this kind of analyses, the most important basics are :

- To be sure that the independent variables used to explain the dependent variable are linearly independent and
- at least that the sample analyzed is sufficiently representative for the inference prediction. If not, results may be biased and inconsistent.
- To carry a regression analysis it is important to define correctly the form of the function. This defined function has to be based on knowledge that if possible does not rely on data.
- And last but not least, the regressions have to be conducted in an interval of known values, if not we will make extrapolations that will conduce us the extremely dangerous and potentially wrong conclusions.

Once we have said this, these evidences are reinforced by the fact that when we make tests of goodness of fit of the applied models, one of the assumptions is that the error is normally distributed. In probability theory, the normal (or Gaussian) distribution, is a continuous probability distribution that is often used as a first approximation to describe real-valued random variables that tend to cluster around a single mean value.

The normal distribution is considered the most prominent probability distribution in statistics. There are several reasons for this: First, the normal distribution is very tractable analytically, that is, a large number of results involving this distribution can be derived in explicit form. Second, the normal distribution arises as the outcome of the central limit theorem, which states that under mild conditions the sum of a large number of random variables is distributed approximately normally. Finally, the "bell" shape of the normal distribution make it a convenient choice for modelling a large variety of random variables encountered in practice.

However, a normally-distributed variable has a symmetric distribution around its mean. Quantities that grow exponentially, such as prices, incomes or populations, are often skewed to the right, and hence may be better described by other distributions, such as the log-normal distribution or Pareto distribution. In addition, the probability of seeing a normally-distributed value that is far (i.e. more than a few standard deviations) from the mean drops off extremely rapidly. As a result, statistical inference using a normal distribution is not robust to the presence of outliers (data that is unexpectedly far from the mean, due to exceptional circumstances, observational error, etc.). When outliers are expected, data may be better described using a heavy-tailed distribution such as the Student's t-distribution. In this way, the coefficient of determination indicating goodness-of-fit of the regression, R-square, will follow a t- distribution. More in detail, the most well-known tests are the :

- R Square (R Square adjusted)
- Student Test commonly named "T-Test"
- Fisher Test commonly named "F-Test".

The R square test is used to analyse the errors dispersion rate.
Adjusted R-squared is a slightly modified version of R square, designed to penalize for the excess number of regressors which do not add to the explanatory power of the regression. The

T test and the F Test are fitting tests. To test the fitting of individual parameters and averall fits. Those tests are used to define if the time series “X” brings a significant quantity of proofs to determine the future values of the time series “Y”. For example the F-Test can be roughly simplified as the explained variance divided by the unexplained variance, always taking into account the liberty degrees.

Through these tests, statisticians can define is the model is well fitted or not, and add significant values through the “t-statistics” or “p-values”. These are basics statistics that allow us to establish one way relationships, after presenting different econometric models used in the current literature, all of them based on this basic assumptions we have just presented, we will come back, to the causalities tests, via the reserve the presentation of the reverse causality tests, that are one of the key points of this paper.

Different econometric models used in the literature :

The choice of econometric models in the literature depends on the nature of the data and on the type of relationships the authors are seeking to explore. Most authors start with the choice between random and fixed effect models to analyze equations where the dependent variable is continuous. These models are run over ordinary least squares (OLS).

In statistics and econometrics, OLS is a method for estimating the unknown parameters in a linear regression model. This method minimizes the sum of squared vertical distances between the observed responses in the dataset, and the responses predicted by the linear approximation. The resulting estimator can be expressed by a simple formula, especially in the case of a single regressor on the right-hand side.

The OLS estimator is consistent when the regressors are exogenous and there is no multicollinearity, and optimal in the class of linear unbiased estimators when the errors are homoscedastic and serially uncorrelated. OLS can be derived as a maximum likelihood estimator under the assumption that the errors are normally distributed, however the method has good statistical properties for a much broader class of distributions (except for efficiency).

Fixed effects are typically kept because they eliminate unobserved fixed heterogeneity and hence are more adapted to measuring causal links. With dynamic models and models with

endogenous variables, typically variations to the fixed model are used such as the Generalized Method of Moments (GMM).

Fixed and random effects :

A fixed-effects analysis assumes that the subjects you're drawing measurements from are fixed, and that the differences between them are therefore not of interest. So you can assume that your subjects (and their variances) are identical. By contrast, a random-effects analysis assumes that your measurements are some kind of random sample drawn from a larger population, and that therefore the variance between them is interesting and can provide information about the larger population.

The most fundamental difference between random and fixed effects is thus that of inference. A fixed-effects analysis can only support inference about the group of measurements (for example, countries) actually present in the sample. A random-effects analysis, by contrast, allows inferring information about the population from which you drew the sample.

Fixed effects

Typically fixed-effect models are used to analyze causality relationships since they eliminate (fixed) unobserved heterogeneity. Indeed, we hope that our independent variables have explained much of what is different about an observation, but there is probably some un-modeled heterogeneity located in the error term ei,t. There is a need to remove this shared and thus systematic heterogeneity from the error term.

One way to do estimate a "fixed effects" model is to gives every unit in our study its own intercept. The most intuitive way to do this would be by including a dummy variable for N-1 units. We still assume that the β pools across units, so we have N parallel regression lines. Note that any substantive explanatory variables that do not vary across time in each unit will be perfectly collinear with the fixed effects, and so we cannot include them in the model or estimate their effects. The typical equation would be:

$$y_{i,t} = \alpha_i + x_{i,t}\beta_1 + e_{i,t}$$

where yi,t is the dependent variable observed for individual i at time t, xi,t is the time-variant regressor, αi is the unobserved individual effect, and ei,t is the error term. αi could represent motivation, ability in micro data or historical factors and institutional factors in country-level data.

The hypothesis for fixed effects model being appropriate is that all of the units share the same intercept. The alternative is that they vary across units, so the way to test this is by running both models and then comparing their sum of squares in a joint F-test.

Random effects

In the random effects model instead of thinking of each unit as having its own systematic baseline, we think of each intercept as the result of a random deviation from some mean intercept. The intercept is a draw from some distribution for each unit, and it is independent of the error for a particular observation. Instead of trying to estimate N parameters as in fixed effects, we just need to estimate parameters describing the distribution from which each unit's intercept is drawn. If we have a large N (panel data) random effects will be more efficient than fixed effects. Another property is that you can still have explanatory variables that don't change over time for a unit. The typical equation would be:

$$y_{i,t} = \alpha_i + x_{i,t}\beta_1 + z_i\beta_2 + e_{i,t}$$

where zi is the observed time-invariant regressor. In fixed-effects zi is included in αi. since it is possible to have correlation between αi and xi,t.. A huge assumption in random effects is that Cov(αi , xi) = 0, which means that the things that make a unit's intercept different are unrelated to the country's xs. A small assumption is that Cov(αi , ei) = 0.

Generalized Method of Moments

We have a dynamic nature in our data when the present value of the dependent variable depends on past values on this variable. We can confirm this by Lagrange multiplier tests. When we do confirm dynamics, we can use the Generalized Method of Moments (GMM) developed by Arellano and Bover (1995) for analyzing panel data and applied by Beck and Katz (2004) to TSCS data.

We specify the following dynamic autoregressive in first differences which enables to suppress the unobserved fixed heterogeneity. This equation also enables us to handle the potential endogeneity of the lagged dependent variable yi,t-1.

$$\Delta yi,t = \Delta yi,t-1 + \Delta xi,t\beta 1 + \Delta ei,t$$

To take care of endogeneity problems which can arise in the estimation of the equation because of yi,t-1, we set a procedure to find appropriate instruments. When exploiting the information in first differences associated with this equation, we follow the standard approach that consists in taking lagged variables in levels as a set of potential instruments. Indeed, these lagged variables in levels have explanatory value over the differenced xi,t and yet are not correlated with the error term in first differences, $\Delta ei,t$. The same procedure can be applied to any other endogenous regressor in xi,t by building over the differentiated equation and by using lagged variables of xi,t in levels as instruments.

Reverse Causality :

Sometimes, research also serves to justify reforms that were already engaged following the Washington consensus. In turn, the empirical literature on telecommunications, only takes into account the link running from telecommunications outcomes to reforms indirectly, by controlling for the potential endogeneity or reverse causality when measuring the impact of reforms on outcomes.

One of the most well known and used test of causality is the granger test of causalities.

This test is mainly based on linear regression modelling of stochastic processes.

Once we have said this, it is evident that most of the papers that applies logarithms or exponential functions to adapt their data sets, needs to adapt this causality test before applying it. If this adaptation is not correctly done, the results will be incorrect. Taking logs allows to minimize heteroskedasticity and influential outliers problems. Another technical issue that needs to be addressed is that of stationarity of the dependent variable. Lack of stationarity can have as consequence that any estimation method applied to such a dynamic system is likely to be inaccurate. For example, Beck and Katz (2004) show that with a non stationary dependent variable, the dispersion of the value of the coefficient in an autoregressive process of order one found with different asymptotically equivalent methods often exceeds its standard errors.

Another thing to be studied closely is the granger definition of causality and its implications.

Granger-causality tests can be done by combining the DIF-GMM estimation technique with a causality testing procedure developed in Holtz-Eakin et al. (1988) for panel data. These tests are based on the estimation of the equation:

$$\Delta(y_{it}) = \sum_{k=1}^{m} \alpha_k \Delta(y_{it-k}) + \sum_{k=1}^{m} \delta_k \Delta x_{it-k} + \Delta x'_{it}\beta + \Delta\varepsilon_{it}$$

which we use to see whether the variable x, 'Granger-causes' the variable y. Following Holtz-Eakin et al. (1988), we initially set the lag length m equal to 3 and check whether this lag length is 'acceptable' by means of a Wald test of the significance of $\delta 3$ and $\alpha 3$. If such a lag length is accepted, we test the joint significance of $\delta 1$, $\delta 2$, and $\delta 3$ and conclude on whether x does not cause the variable y. If the lag length is not accepted, we repeat the procedure using the next smaller lag length. In the case where no lag length is accepted, we conclude that no causality running from x to y exists.

2.2.4 Table 2 : "Empirical findings for telecommunications & growth"

2. Empirical analyses : Telecom outcomes and economic growth

Author	Data and period	Main results	Methodology	Deve-loped	Deve-loping
Lee et al, 2009	44 Sub-Saharan African countries; 1975-2006	They find that mobile cellular phone expansion is an important determinant of the rate of economic growth in Sub-Saharan Africa.	linear generalized method of moments (GMM)		X
Sridhar and Sridhar, 2009	63 developing countries; 1990 - 2001	They find significant impacts of cellular services on national output, when they control for the effects of capital and labour. The impact of telecom penetration on total output is, however, significantly lower for developing countries than that reported for OECD countries, dispelling the convergence hypothesis.	3 stage least squares		X
Röller and Waverman, 1999	20 OECD countries; 1970-1990	Allowing for nonlinear effects they find evidence of a positive and significant link between telecommunications and economic growth, provided that a critical mass in a countries telecommunication infrastructure has been achieved.	Annual Production Function (APF) approach, micromodel for telecommunication investment with a macro production function; econometric methodologies based on multiple equation models that account for endogeneity and fixed effects; none of these have addressed the issue of causality between the two variables	X	
Fuss et al., 2005	92 developing countries; 1980-2003	We find that mobile telephony has a positive and significant impact on economic growth, and this impact may be twice as large in developing countries compared to developed countries.	Annual Production Function (APF) approach, Endogenous Technical Change (ETC)		X
van Art etal, 2002	European Union; 1995-2000	The study shows large variations in terms of ICT and TFP contributions to labour productivity growth between European countries, but no EU country (except Ireland) is ahead of the U.S. in terms of the total contribution from ICT.	Growth accounting framework	X	
Mulder, 2006	6 Latin American countries; 1990-2004	There is an apparent decline in ICT contributions to growth after the 2000 fall in IT stock prices. As yet, no clear indication of TFP exploitation from using ICT goods and services	Growth accounting framework		X
Aker, 2008	Niger; 2005-2007	In Ghana, mobile phones have brought together farmers and consumers by enabling access to production information timely and affordably. As grain markets typically occur once per week, traders and farmers have historically travelled long distances to markets to obtain production information. This not only requires the cost of travel, but also the opportunity costs of traders‟ time	Generalised method of moments and treatment models		X

3. Telecommunications reforms and outcomes in Africa

"Empirical Analysis applied to telecommunications reforms and outcomes in Africa"

In this section, I will firstly explain what we have learned from the empirical literature on the impact of telecommunications reforms on telecommunications outcomes in Africa. I will focus in particular, on the privatization and competition reforms where very much has been written from an empirical standpoint.[6]

Secondly, I will argue that little has been done however, to understand the determinants of these telecommunications reforms. I will revisit then the small literature on the theoretical and empirical determinants of telecommunications reforms in Africa. Lastly, I will propose that these analyses could be extended by making case by case qualitative and quantitative assessments.

The impact of telecommunications reforms on outcomes: What research tells us so far

When analyzing the two-way relationship between telecommunications reforms and telecommunications outcomes, the academic literature focuses on the impact of reforms on outcomes. Because of technological progress, a questioning on increasing returns to scale nature of the sector, and, in the case of Africa, strongly conditioned by the liberalization wave following the Washington consensus, the telecommunications sector gradually opened to competition and privatization.

[6] See Banerjee and Ros (2000), Djiofack-Zebaze and Keck (2008), Fink et al (2002), Gutierrez (2003), Henisz (2002), Li et al (2005), Li and Xu (2004), Mc Nary (2001), Ros (1999), Ros (2003), Wallsten (2001), Wallsten (2000), Gasmi et al (2006).

3.1 Reforms : "Competition"

"The impact of competition on network deployment and labour efficiency : Consensus on the benefits of competition worldwide"

In the academic literature there is preliminary evidence of a worldwide positive impact of an aggregated measure of competition on network deployment and labour efficiency. For example, Fink et al. (2002) provide an analysis of the impact of competition on deployment and labour
efficiency in data on 86 developing countries across African, Asian, Middle Eastern, Latin American, and Caribbean countries for the period 1985-1999.

Ros (1999) uses data on countries with GDP per capita less than USD 10,000, McNary (2001) and Li and Xu (2004) use worldwide data and Wallsten (2001), Gutierrez (2003) and Ros (2003) analyze Latin American and Africa data sets. Several authors such as McNary (2001), Fink et al (2002) and Li and Xu (2004), consider separately competition in the fixed line and mobile networks.

In another study, Gasmi and Recuero Virto (2009) analyze through a large data set on developing countries from 1985-1999 the divergent impact of competition in analog and digital mobile networks. They find that while digital mobile phone competition and fixed-line deployment are complements, analogue mobile phone competition and fixed-line deployment are instead substitutes.

3.1.1 Table 3 : Impact of competition reforms on outcomes"

3. Empirical analyses : Telecom reforms and telecom outcomes (competition)					
Author	**Data and peri**	**Methodology**	**Main Results**	**Developed**	**Developing**
Djiofack-Zebaze and Keck (2008)	177 countries, 45 in Sub-Saharan Africa; 1997-2003	fixed effects, fixed effects corrected for heteroscedasticity, random effects and Hausman-Taylor	In Africa, multilateral commitments do not reflect recent reforms. However, globally, adherence to the GATS Reference Paper is associated	X	X
Fink et al (2002)	86 developing countries across Africa, Asia, the Middle East, and Latin America and	Kmenta's cross-sectionally heteroscedastic and time-wise autocorrelated (CHTA) approach.	The authors find that competition leads to significant improvements in performance. The sequence of reform matters: mainline penetration is lower if competition is introduced after privatization, rather than at the		X
Gutierrez (2003)	22 Latin American countries; 1980-1997	static panel (fixed-effects, 2SLS) and dynamic panel (exogenous variables and endogenous	Openness of markets to competition contributed positively to better sector performance.		X
Ros (1999)	worldwide; 1986-1995	fixed-effects, instrumental variables approacg	While competition does not affect network expansion, it positively affects efficiency as measured by mainlines per	X	X
Ros (2003)	20 Latin American countries;1990-	Ordinary least squares, instrumental	Competition and price cap regulation are strongly positively associated with teledensity.		X
Wallsten (2001)	30 Latin American and African countries; 1984-1997	fixed-effects	competition is correlated with increases in the per capita number of mainlines, payphones, and connection capacity and with decreases in the price of		X
Gasmi et al (2006)	29 developing countries and 23 developed countries ; 1985–99	fixed-effects, instrumental variables approacg	The impact of political accountability on the performance of regulation is stronger in developing countries. An important policy implication is that future reforms in these countries should give due attention to the development of	Yes	Yes
Gasmi and	86 developing	fixed-effects,	While digital mobile phone		X
Gebreab (2002)	41 African	fixed-effects	Competition with at least two		X

3.2 Reforms : "Privatization"

"The impact of privatization remains an open question"

3.2.1 Impact of privatization on deployment and prices

The introduction of competition was typically associated with a privatization of the fixed line network. In turn, the privatization of the fixed line network was almost systematically preceded by tariff re-balancing. Indeed, prices were traditionally below cost since consumers were subsidized. This subsidization was done by imposing high tariffs to those consumers making long distance and international calls. In turn, consumers making local calls, were paying below cost prizes.

Some preliminary evidence in the literature leads to conclude that tariff re-balancing happened before and during early stages of privatization. Unexpectedly, the increase in local tariffs was followed by an increase in the number of people having access to telecommunications (Banerjee and Ros, 2000). This was because there was a large unmet demand due to constrained supply. Indeed, prices were too low to allow the fixed-line operator to invest in the network and therefore, answer to increasing demands.

Due as well to constrained supply, privatization of fixed-line operators could be expected to be associated with a larger number of the population having access to telecommunications services (Bortolotti et al, 2004). Private investors had both the capital and the technical know-how to implement improvements in analogue networks.

Once having explored the impact of privatization on deployment and prices, we will now analyze the impact on efficiency.

3.2.2 Impact of privatization on efficiency

Due to data constraints, efficiency in telecommunications is typically analyzed through labour efficiency as compared to other measures, such as technical efficiency, which are more difficult to obtain.

Holding this limitation on mind, again we find an ambiguous impact of privatization on labour efficiency in the economic literature. For instance, for data sets in Latin-American countries, the correlation is positive (Banerjee and Ros, 2000 and Gutierrez, 2003), while for a data set in 30 countries in Latin-America and in Africa the correlation is instead negative. Furthermore, as before the impact of the institutional endowments is important in efficiency (Baudrier, 2001).

So far the insights we have given in this section reveal that there is large misunderstanding of the real effect of privatization of the fixed-line operator. This remains particularly applicable when mentioning the impact on deployment and on efficiency.

3.2.3 Table 4 : “Impact of Privatization reforms on outcomes”

4. Empirical analyses : Telecom reforms and telecom outcomes (Privatization)

Author	Data and period	Methodology	Main Results	Developed	Developing
Wallsten (2000)	28 countries worldwide; 1987-2000	fixed-effects	Exclusivity periods are correlated with a significant decrease in the incumbent's investment in the telecommunications network, payphones, mobile telephone penetration, and international calling.	X	X
Banerjee and Ros (2000)	23 Latin American countries; 1986-1995	feasible generalised least squares	positive and statistically significant relationship between privatization and network expansion and efficiency in the Latin American region.		X
Gutierrez (2003)	22 Latin American countries; 1980-1997	static panel (fixed-effects, 2SLS) and dynamic panel (exogenous variables and endogenous variables via GMM)	Divestment of former state-owned telco operators contributed positively to better sector performance.		X
Wallsten (2001)	30 Latin American and	fixed-effects	Privatizing an incumbent is negatively		X
Fink et al (2002)	86 developing countries across Africa, Asia, the Middle East, and Latin America and the Caribbean; 1985-1999	Kmenta's cross-sectionally heteroscedastic and time-wise autocorrelated (CHTA) approach.	The authors find that privatization leads to significant improvements in performance. The sequence of reform matters: mainline penetration is lower if competition is introduced after privatization, rather than at the same time.		X
Li and Xu (2004)	worldwide; 1981-1998	fixed-effects	Full privatization, which gave private owners control rights, contributed substantially to improving the allocation of labor and capital, expanding service output and network penetration, and improving labor and total factor productivities. But partial privatization, in which the state retained control rights, showed no significant impact. The increase in competitive pressure contributed substantially to growth in the sector by raising both factor inputs and total factor productivity.		X
Ros (1999)	worldwide; 1986-1995	fixed-effects, instrumental variables approacg	When 50 % of the assets of the fixed-line operator are in the private sector, there is significantly higher penetration.	X	X
Gasmi and Recuero	86 developing	fixed-effects, instrumental	Privatization enhances fixed-line		X
Gebreab (2002)	41 African countries; 1987-2000	fixed-effects	The presence of an incumbent-owned cellular in mobile markets has a negative impact on the diffusion of mobiles, suggesting again an abuse of a dominant position by the incumbent fixed-line operator. However,privatization of the incumbent fixed-line operator that is involved in cellular accelerates mobile growth, and mitigates the negative effect of the presence of an incumbent-owned cellular.		X
Ros (2003)	20 Latin American countries;1990-1998	Ordinary least squares, instrumental variables	Privatisation are positively associated with teledensity and operating efficiency		X

3.3 Africa's specificities

The empirical evidence on the impact of competition is much smaller for Africa than for other regions such as Latin America, since the former continent engaged latter on this reform. Preliminary evidence nevertheless supports a positive impact of competition on outcomes in the telecommunications sector.

Gebreab (2002) finds that competition with at least two mobile phone operators and digital technology are key drivers of mobile subscription. Indeed, in practice only one mobile phone license was granted often in the analogue segment and usually to the fixed-line incumbent. Hence, there was no effective competition between mobile phones and fixed-line at early stages. Afterwards, with the arrival of digital technology more licenses were granted which did enable competition with fixed-line.

In addition, there is empirical evidence that market competition in Africa needs to be followed by state oversight in order to obtain equal access and avoid favouritism. The capacity to promote effective competition depends on the ability of the regulator to design solutions and enforce them. In Haggarty et al (2002), it is explained how the fixed line operator Ghana Telecom (GT) obstructed the interconnection with other operators.

This fact resulted on major dysfunctional telecommunications markets with Westel, the second network operator having only 2,600 subscribers three years after being operational, and with Mobitel, the mobile operator claiming that it could provide have to close its operations. Another example is the one of Senegal. When a new government came into power in the 2000, the state decided that the prize that have been paid for Sentela in the nineties, was too low and they withdrew the licence (Azam et al, 2002). For a more exhaustive exploration of the link between institutions and telecommunications deployment in Africa, see Horrall (2002).

However, there is no consensus on the impact of privatization of the fixed-line network. Some empirical work (Ros, 1999 and McNary, 2001) find that privatization of these networks had either a non significant or negative impact on deployment. On the other hand, Banerjee and

Ros (2000), Ros (2003) and Gutierrez (2003) find instead a positive correlation between privatization and access to telecommunication services with data sets on Latin-American countries. It is therefore an open question the real effect of privatization of African operators on deployment.

Of course, just like in the case of competition the capacity of regulators to enforce an efficient functioning in the market is fundamental (Wallsten, 2001 for a combined data set of African and Latin-American countries and Gutierrez 2003, only for Latin-American countries). Nevertheless, the risk of expropriation and interference in the market has remained high in the context of privatization in Africa. For example, the government in Ghana, prevented Telecom Malaysia from having a majority in the governing board. They did so, by breaking the management contract over Ghana Telecom (Haggarty et al, 2002).

In addition, while empirical results so far take into account OECD and Latin-American countries, Africa remains largely unexplored. At the same time, we could expect privatization to have a different impact on outcomes in different regions in the world.

For example, we could expect privatization to be more positively correlated with deployment in Africa and in other developing countries than in OECD countries, since the former are traditionally constrained in supply. On the other hand, the ability of governments to attract private investment to the extremely small networks in Africa at a time when mobile competition is prominent, remains an open question.

4. Determinants of Reforms

"Telecommunications outcomes before engaging on reforms: What research leaves aside"

When analyzing the two-way relationship between telecommunications reforms and telecommunications outcomes, the link running from telecommunications outcomes to reforms is usually neglected. This is explained through the fact that international implementation agencies, policy makers and applied researchers are mostly interested of learning the impact of reforms on outcomes. Indeed, in order to select a certain type of telecommunications reform, it is useful to have some evidence on its impact.

In contrast, in this article we claim that the link running from outcomes to reforms deserves more attention and is essential to understand the functioning and impact of the reform once engaged. We propose in the remainder of this section to discuss a few exceptions where the theoretical and empirical literature addresses the determinants of telecommunications reforms in developing countries. The analysis leads us to conclude that detailed country analyses could enrich and complement largely to provide strong support to perform new empirical work of this type.

4.1 Theoretical Framework

4.1.1 Determinants for privatization

"Few theoretical literature on the determinants of reforms in developing countries"

The theoretical literature on the features that influence the decision to reform the telecommunications sector by introducing competition or privatization has emphasized the role of corruption, the cost of public funds and aid.
Determinants of privatization reforms

Among the determinants of privatization in infrastructure, Laffont (2005) develops a positive theory of privatization. For sufficiently low levels of corruption, as corruption increases the

private gains of politicians from privatization are larger than those obtained with a public firm and dominate the social costs of privatization.

For large levels of corruption, it is necessary to leave the control of the firm to private shareholders, and in these circumstances, the private gains of politicians cannot compensate for the rents appropriated by private investors. An implication of this theory is then that with low (high) levels, increasing corruption levels should influence positively (negatively) the decision to privatize.

Returning to the normative approach, Auriol and Picard (2004) find that when the government does not fully capture the expected profit of the privatization transaction, privatization improves social welfare for intermediate values of the cost of public funds, but state ownership is preferred for low or high values.

Since developing countries have typically medium to large levels of the cost of public funds, the latter should negatively influence the privatization decision. The implication then is that when public firms in the infrastructure sector are sold at a discount because of a high country risk rating, a government in need for cash should keep the profitable ones. Hence, countries with a relatively high cost of public funds and a high risk will tend to privatize less. Warlters (2004) finds similar results to Auriol and Picard (2004).

Ghosh et al (2005), in an analysis of factors influencing the decision to privatize in 35 developing countries, find that foreign aid has no systematic impact on the privatization process. Aid, especially technical assistance, can positively affect the pace and intensity of privatization.

They find strong evidence of foreign aid being a facilitating factor in privatization in the presence of complementary institutional capacity. Ultimately, privatization is driven by domestic political and economic factors, and foreign aid can facilitate implementation only when developing countries have, or are able to create, market-supporting institutions.

4.1.2 Determinants for competition

In terms of the competition reform, Emerson (2004) develops a model where rent seeking firms agree to pay bribes to policy makers to limit market entry. The author obtains equilibriums characterized by low (high) levels of corruption combined with high (low) levels of competition.

In terms of regulatory pricing, Evans et al (2005) suggest two possible ways in which price regulation encourages socially optimal investment: first, there is less than total electoral transparency in which voters receive an optimal amount of information and second, the decisions on price are delegated to a su ciently, but not excessively, pro-industry regulator. Note that this is not specific to developing countries.

However, few empirical work has been done on the situation of the telecom sector in Africa (telecom outcomes) previously to engaging on telecom reforms (some exceptions with worldwide datasets are Gual and Trillas, 2006, Li and Xu, 2002, Gasmi and Recuero Virto, 2009).

4.1.3 Table 5 :Theoretical framework defining determinants of reforms

5. Theoretical analyses : Telecom Reforms and telecom outcomes

Author	Main assumptions	Main results
Emerson (2006) (2004)	It is hypothesized that a government agent that controls access to a formal market has a self-interest in demanding a bribe payment that serves to limit the number of firms. This corrupt official will also be subject to a detection technology that is a function of the amount of the bribe payment and the number of firms that pay it.	Develops a model where rent seeking firms agree to pay bribes to policy makers to limit market entry. The author obtains equilibriums characterized by low (high) levels of corruption combined with high (low) levels of competition.
Laffont (2005)	Positive analysis	For sufficiently low levels of corruption, as corruption increases the private gains of politicians from privatization are larger than those obtained with a public firm and dominate the social costs of privatization.For large levels of corruption, it is necessary to leave the control of the firm to private shareholders, and in these circumstances, the private gains of politicians cannot compensate for the rents appropriated by private investors. An implication of this theory is then that with low (high) levels, increasing corruption levels should influence positively (negatively) the decision to privatize.
Auriol and Picard (2004)	1. countries maximise profits; 2. countries characterized by a large are also countries that get low privatization proceeds; 3. the government must design the contracts such that the regulated rm reveals its private information.	when the government does not fully capture the expected profit of the privatization transaction, privatization improves social welfare for intermediate values of the cost of public funds, but state ownership is preferred for low or high values.
Warlters (2004)	the detection technology is a function of the amount of the bribe payment and the number of	State ownership is preferred for high values of the cost of public funds
Evans et al (2005)	The regulated company is the only organized interest group or lobby in this economy.It may spend resources with the aim of capturing the will of the public decision-makers, although it does not have a prior preference for any of the parties.	Suggests two possible ways in which price regulation encourages socially optimal investment: first, there is less than total electoral transparency in which voters receive an optimal amount of information and second, the decisions on price are delegated to a sufficiently, but not excessively, pro-industry regulator. Note that this is not specific to developing countries
Ghosh et al (2005)	International assistance organizations use foreign aid to encourage governments in developing countries to enact market reform and privatization policies aimed at accelerating economic growth. Recent research findings, however, question the assumption that foreign aid has a positive impact on governments' decisions to adopt economic reforms or that it accelerates economic growth.	They find that foreign aid has no systematic impact on the privatization process. Aid, especially technical assistance, can positively affect the pace and intensity of privatization.They find strong evidence of foreign aid being a facilitating factor in privatization in the presence of complementary institutional capacity. Ultimately, privatization is driven by domestic political and economic factors, and foreign aid can facilitate implementation only when developing countries have, or are able to create, market-supporting institutions.

4.2 Empirical Framework

"Few empirical literature on the determinants of reforms in developing countries"

There is an emerging yet limited empirical literature focusing on the determinants of sectoral reforms in infrastructure industries and this literature has been so far mainly concerned with

4.2.1 Political factors

Using telecommunications data for the period 1990-1998 on a panel of countries chosen worldwide, Li and Xu (2002) and Li et al. (2005) explore the political economy of liberalization, privatization, and regulatory reforms.

In both studies, countries with stronger pro-reform interest groups, namely, financial actors and urban consumers, are more likely to implement reforms in more democratic environments.
Li and Xu (2002) find that less democratic countries are more likely to maintain the public sector monopoly when the fiscal deficit is high.

Gual and Trillas (2006) are the first to consider both the determinants of the reforms, in particular, to highlight the role of entry and regulatory policies, and the impact of the reforms on network deployment with 1998 cross-sectional data on 37 countries. With regard to the determinants of reforms, they find that countries with interventionist traditions have fewer liberalization policies and that the larger the size of the incumbent and the lower the protection of investors, the more prone a country is to create an independent regulator.

4.2.2 Financial Factors

In addition, Li et al. (2005) find that reforms are less likely to be implemented in countries where incumbent operators have already sunk large investments since these operators have strong incentives to oppose the reforms.

Gasmi and Recuero Virto (2009) perform a similar study on the determinants and impact of reforms, with data set on 86 developing countries for the period 1985-1999. Sectoral as well as institutional and financial factors are found to be important determinants of the actual reforms implemented. In particular, they find that countries facing increasing institutional risk and financial constraints are more likely to introduce competition in the digital cellular segment and to privatize the fixed-line incumbent, these policies being economically attractive to both investors and government. In contrast, competition in the analogue cellular segment and the creation of a separate regulator seem to be relatively less attractive policies as they are found to be less likely to be introduced in countries facing increasing institutional risk and budget constraints.

In terms of sectoral factors, Gasmi and Recuero Virto (2009) find that reforms such as competition in the fixed local segment and in mobile digital phone segment are associated with past increases in fixed line deployment.
In contrast, competition in the mobile analogue segment and privatization, are associated with no previous significant changes in the fixed-line network in terms of deployment. One issue is whether the authors are looking at the right variable, only fixed-line deployment.

Another issue that is common to previous empirical articles as well is to which extent it is possible to extrapolate results on an aggregate of countries from different regions, to explain the functioning of markets in Africa.

I propose hence that the next step forward is to do a country analysis in the African context to achieve a better understanding on the determinants of reforms, in particular the privatization of the fixed-line incumbent which has had a non consensual impact on market outcomes. I would also propose to analyze to which extent the theoretical literature on the topic addressed above, explains behavior in Africa.

4.2.3 Table 6 : Empirical findings for reforms determinants

6. Empirical analyses : Determinants of telecom reforms					
Author	**Data and period**	**Methodology**	**Main results**	**Developed**	**Developing**
Li and Xu (2002)	on privatization (1981-98 for 167 countries) and competition policies (1990-98 for roughly 50 countries)	ordinary least squares, random effects	Countries with stronger pro-reform interest groups (the financial services and the urban consumers) are more likely to reform.	X	X
Gual and Trillas (2006)	37 countries worldwide ; 1998	ordinary least squares, intrumental variables. First to consider both the determinants of the reforms, in particular, to highlight the role of entry and regulatory policies, and the impact of the reforms on network deployment	With regard to the determinants of reforms, countries with interventionist traditions have fewer liberalization policies and that the larger the size of the incumbent and the lower the protection of investors, the more prone a country is to create an independent regulator.	X	X
Gasmi and Recuero Virto (2009)	86 developing countries; 1985-1999	fixed-effects, instrumental variables approach	Sectoral as well as institutional and financial factors are found to be important determinants of the actual reforms implemented. In particular, countries facing increasing institutional risk and financial constraints are more likely to introduce competition in the digital cellular segment and to privatize the fixed-line incumbent,these policies being economically attractive to both investors and government. In contrast, competition in the analogue cellular segment and the creation of a separate regulator seem to be relatively less attractive policies as they are found to be less likely to be introduced in countries facing increasing institutional risk and budget constraints. Reforms such as competition in the fixed local segment and in mobile digital phone segment are associated with past increases in fixed line deployment. In contrast, competition in the mobile analogue segment and privatization, are associated with no previous significant changes in the fixed-line network in terms of deployment. One issue is whether the authors are looking at the right variable, only fixed-line deployment.		X
Li et al (2005)	50 developing countries; 1990-1998	ordinary least squares	Regulatory reforms are more likely in countries with strong proreform interest groups (a larger ?nancial sector and a greater proportion of urban consumers) and less likely in countries where incumbent operators have already made large investments and hence have strong incentives to oppose the reforms.		X
Bortolotti et al (2004)	worldwide; 1977-1999	fixed and random effects	Privatization has taken place often under the pressure of economic and budgetary constraints.	X	X

5. Conclusion

The main conclusion of this paper is that much can be still done in the academic literature to improve the understanding of the relationship between telecommunications reforms, telecommunications outcomes and economic growth in Africa.

In terms of the relationship between telecommunications outcomes and economic growth in Africa, the academic literature should benefit from leveraging more closely from past models developed for ICTs from the 1980s for advanced economies. Surprisingly, the models that have been used have been rather loose.[7]

A future research is to do analysis with microeconomic data related for example to transaction costs which is easier to interpret and does not suffer from the caveats linked to macro models.[8]

In terms of the relationship between telecommunications reforms and telecommunications outcomes, we can conclude that one size does not fit all, and that it is important do to a per country descriptive analysis before doing any estimation in order to have a clear understanding of the context in which we are using the data. In addition, the use of non parametric models (unlike OLS and other parametric models typically used in this academic literature) can help to allow flexibility in results.[9]

[7] These models are largely based on Roller and Waverman (1999).
[8] For example, Aker (2008) on e-agriculture in Africa, Recuero Virto (2009) on mobile payments in Africa and Latin America.
[9] See Repkine (2009), for example.

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