ASSESSMENT OF THE ECONOMIC IMPACT OF TELECOMMUNICATIONS IN SENEGAL (2010-2013)

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Telecom Advisory Services, LLC

Authors

- **Raul Katz** (Ph.D., Management Science and Political Science, Massachusetts Institute of Technology) is currently Director of Business Strategy Research at the Columbia Institute for Tele-Information, Adjunct Professor in the Division of Economics and Finance at Columbia Business School (New York), and President of Telecom Advisory Services, LLC. Before founding Telecom Advisory Services, he worked for twenty years at Booz Allen Hamilton, where he was the Head of the Telecommunications Practice in North and Latin America and member of its Leadership Team.

- **Pantelis Koutroumpis** (Ph.D., Economics, Imperial College) is currently a Fellow at the Innovation and Entrepreneurship Group of Imperial College Business School (London) and a Fellow at the Columbia Institute for Tele-Information (New York). He is also an Expert Affiliate at Telecom Advisory Services LLC. He has previously worked with the European Investment Bank, LECG, the ICAP Group and other major telecommunications' equipment vendors.

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Summary of Findings

The direct positive relationship between information and communication technologies (ICT) and economic development is largely accepted. For decades, economists, social scientists, and policy makers have examined ICT's link to such measures of economic well being as GDP growth, job creation, and productivity. In the past, primarily due to limited data availability, studies examined cross-sectional samples of countries at the aggregate level. More recently, however, due to increased information at their disposal, researchers have added a new dimension to the field, focusing on the economic impact of telephony and broadband within a single country.

The following study contributes to this new line of research. In 2010, the authors conducted an assessment of the economic impact of telecommunications in Senegal, focusing on the relative impact of wireless and broadband communications. This new study, which expands the time series to include data up to 2013, attempts to answer three questions raised as hypotheses two years ago:

- How sustainable has the direct economic contribution of telecommunications been to the Senegalese economy? Does economic volatility mirror changes in telecommunications' contribution to GDP or is the sector continuing to grow in anticipation of a structural shift in output composition?

- Could we, in light of market developments, test the hypothesis of "diminishing returns" to wireless penetration? Or, alternetively, are we witnessing a "return to scale" whereby impact increases with penetration?

- Since mobile broadband has continued to grow exponentially in Senegal, reaching 631,000 subscriptions by mid-2013, could we actually start to witness the emergence of broadband's economic impact as a result of the dramatic growth in mobile broadband?

Two years following the 2010 study, the total revenues of the Senegalese telecommunications industry increased by US$ 100 milion, reaching US$ 1,503 million (slightly dropping as a percent of the GDP from 10.8% in 2010 to 10.3% in 2011, and increasing to 10.8% in 2012)[1]. This ratio has been relatively stable since 2009, and its consistent growth since 2003 demonstrates the increasing importance of the sector. However, it does not signify that telecommunications' relative importance has remained constant. Unit prices have declined significantly as a result of competition, which primarily explains this stabilization. In fact, the decline in prices correlates with the increase in wireless sector competitive intensity.

Despite the relative stability of telecommunications' direct contribution, the indirect effects have greatly expanded. First, the contribution of mobile telephony to GDP growth has increased significantly since 2010. It could be the result of wireless

[1] National Accounts are still not published for 2012. Data for 2012 sector revenues is estimated by Hot Telecom Services.

moving to the next level of impact, beyond the voice and mobility contributions. Second, as a result of the acceleration of mobile broadband adoption, this technology has started to have an economic impact, albeit not at the level achieved in more developed environments.

In terms of annual GDP contribution in 2012, total telecommunications effects amount to US$ 1,852 million - US$ 1.5 billion in direct effects and US$ 349 million in indirect effects - a 15% increase from 2010. This is a contribution of 13.08% (2012 GDP: US$ 14,160 million).

Annual contribution to GDP	2010	2012
Direct effects of telecommunications	US$ 1,400	US$ 1,503
Indirect effects of mobile telephony	US$ 210	US$ 176
Indirect effects of broadband	Not statistically significant	US$ 173
Total	US$ 1,610	US$ 1,852

Table A. Cumulative Economic effects of telecommunications (in US$ millions)
Source: Telecom Advisory Services analysis

The comparison of both study results is particularly interesting. First, as mentioned above, direct effects do not increase substantially between 2010 and 2012. Second, assuming that the lack of statistical significance in the indirect effects of mobile broadband in 2010 has no economic impact whatsoever, the total indirect impact of telecommunications at this point in time was US$ 210 million. Thus, the increase in indirect effects from 2010 to 2012 is primarily the result of mobile broadband becoming a key platform that yields economic spillover. Third, the emergence of mobile broadband as a key driver of indirect contribution, and the decline in voice telephony indirect effects, signals a gradual transition from voice telephony to data communications.

The policy implications of these findings are manifold. It is critical that emerging markets first implement policies that facilitate infrastructure investment growth in order to achieve critical mass in terms of network deployment and device adoption. Once achieved, policy focus needs to shift to the areas that maximize spillovers, focusing on the promotion of intense usage and stimulating technology innovation. Along those lines, while the direct contribution of the telecommunications sector is initially a relevant metric to monitor infrastructure deployment and adoption, over time, policies should focus on maximizing indirect effects.

1. Introduction

Since the launch of the Internet, and particularly over the last ten years, researchers have attempted to measure the economic contribution of communications. Originally the approach focused on the study of cross-sectional samples of countries. Due to data availability limitations, this examination primarily focused on OECD countries (facilitated by the extensive Eurostat data sets) or worldwide analysis (based on ITU statistical indicators). While this approach has continued,[2] researchers have gradually shifted their focus towards country-level quantitative assessments. For example, in an attempt to understand better the economic impact of broadband, we have conducted studies in Europe (Katz et al., 2010a), the United States (Katz and Suter, 2009a; Katz et al, 2011a), and Latin America (Katz, 2011c; Katz, 2010b; Katz et al., 2011d; Katz and Callorda, 2013).

Increased data availability and lengthier time series now allows researchers to extend single country analyses by developing tracking models. Adding to cross-country comparisons and single country studies, research can finally shed light on how technology contributes to the economy within a single country over time. Policy makers could greatly benefit from this expanded view as it would allow them to change course or fine-tune policies without relying only on a "rear view mirror" or an analysis of "expected" impact.

The following study represents a contribution to this new line of research. In 2010, the authors conducted an assessment of the economic impact of telecommunications in Senegal (Katz and Koutroumpis, 2012a), focusing on the relative impact of wireless and broadband communications. This new study, which enhances the time series with data up to 2013, attempts to answer three questions raised as hypotheses two years ago.

First, the 2010 study concluded that telecommunications had a sizable **direct** economic impact, accounting for over 10% of Senegal's GDP. In fact, Senegal's National Accounts indicated that between 2002 and 2010, the rate of growth of telecommunications' contribution to Senegal's GDP was three times that of the construction and financial services, generating as much as the two other sectors combined (Francs CFA 419 billion). Since 2010, Senegal's economic growth slowed to 2.6% in 2011 (from 4.2% the year before), but increased again in 2012, reaching 3.7%. While inflation, driven by high-energy prices, reached 3.38%, it dropped to 1.42% in 2012. Finally, the GDP percentage of Gross Capital Formation increased from 28.93% in 2010 to 30.33% in 2011, partly due to slower economic growth. In this context of changing economic conditions, it is relevant to research how the sustainability of telecommunications' direct economic contribution to the Senegalese economy. Is volatility in the economy as a whole mirrored by changes in telecommunications' contribution to the GDP, or is the sector continuing to grow in anticipation of a structural shift in the composition of output?

[2] See Koutroumpis (2009), Waverman (2009) and Katz (2012).

Second, the econometric modelling from the 2010 study generated evidence of a substantial **indirect** contribution of wireless telephony. According to the study, the annual contribution to GDP growth from mobile phones was approximately 0.044% for every 1% of increase in wireless penetration. Given that the economy grew – on average – 4.1% annually between 2003 and 2010, this figure suggested that wireless alone was responsible for 13.6% of all economic growth in Senegal during this period. The study also concluded that, given the projected future growth in wireless penetration, the impact of the technology on GDP would continue to increase, albeit at a slower rate due to a saturation effect. As expected, wireless telephony in Senegal has continued to grow rapidly, averaging 18% annually. Wireless penetration (in connections) has increased from 66.22% by the end of 2010 to 92.68% two and a half years later. Could we, in light of market developments, test the hypothesis of "diminishing returns" to wireless penetration? Or, alternetively, are we witnessing a "return to scale," whereby impact increases with penetration? We cannot discard this last counter-hypothesis as universal adoption of the technology could lead to the creation of new markets and the acceleration of innovation.

Third, the study did not find any econometric evidence of an economic contribution from broadband in Senegal for the period 2004-2011. This result was not inconsistent with the findings of other studies; in many emerging countries, broadband penetration yields almost no economic impact due to very low network coverage, a concentrated market structure, the consequent higher prices, and limited consumer interest due to minimal local content and applications. However, the study also anticipated that the future of broadband in Senegal, particularly in regards to mobile broadband, could change this situation. Wireless broadband has, indeed, undergone a substantial growth in the past two years. By the end of 2010, mobile broadband represented 24,000 subscriptions and fixed broadband amounted to 78,000 lines, but just two years later, mobile broadband subscriptions reached 491,000, compared to 95,000 fixed lines. Indeed, mobile broadband has continued to grow exponentially, reaching 631,000 by mid-2013. Could we actually start to witness the emergence of broadband's economic impact as a result of the dramatic growth in mobile broadband?

In sum, a study that revisits the impact equation two years later is pertinent for several reasons. First, how sustainable has the direct economic contribution of telecommunications been? Furthermore, even if the direct contribution did not change substantially, could the indirect impact increase? Second, is there a condition of "diminishing returns" to wireless telephony, whereby it would be imprudent to extrapolate economic effects from mid-penetration levels to saturation points? Or, alternatively, is there a growing "return to scale" where economic effects tend to increase exponentially with penetration? Third, can we find evidence of economic effects of mobile broadband that would lead governments in emerging countries to formulate policies that stimulate its growth to the detriment, perhaps, of fixed broadband?

Along these lines, a caveat should be made. The measureable economic impact of ICT infrastructure depends heavily on the timing of its introduction, existing adoption conditions, and market maturity. As studies of the lagged impact of ICT have demonstrated (Hardy, 1980; Jorgenson et al., 2006; Karner and Onyeji, 2007), significant economic effects of ICT do not materialize immediately after the introduction of a new technology. This study is predicated on the assumption that two years (or potentially even less) could be sufficient enough to start detecting economic effects. An underlying premise of the research is that 1) given the speed with which technology is developing around the world, multi-year lags in assessing social and economic impact may not be necessary, and 2) measurement techniques notwithstanding, policy makers are better served by conducting multiple, frequent tracking assessments that allow them to monitor the emergence of new effects and accelerate, slow-down, or correct policies.

This study begins by providing a brief review of the results of last year's study (Section 2). It then presents the changes that have taken place in both the Senegalese economy and in the telecommunications industry since last year (Section 3). This provides a context for conducting a new iteration of econometric modelling with the additional observations (Section 4). The implications from a public policy standpoint are drawn in Section 5.

2. Summary of 2010 study results

The impact of telecommunications on the Senegalese economy in the period ending in 2010 was assessed first in terms of the sector's direct impact resulting from its GDP contribution, the employment generated by telecom operators and local suppliers, and taxes paid. It was then examined in terms of its indirect "spill-over" impact on the economy as a whole through its contribution to GDP growth across sectors.

2.1. Direct economic contribution of telecommunications until 2010

Total revenues of the Senegalese telecommunications industry equaled US$ 1.4 billion USD (10.8% of national GDP) in 2010. This ratio had grown consistently since 2002, indicating the sector's increasing importance (see Figure 1).

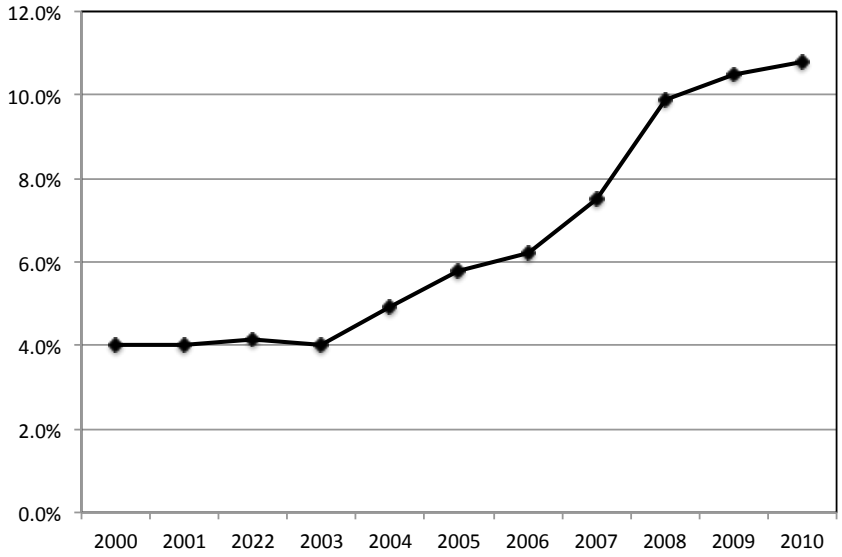

Figure 1. Percentage of GDP
Sources: IMF; World Bank (2011)

Furthermore, the value-added of the telecommunications and postal services sectors reached US$ 850 million while its contribution to GDP growth was US$ 104 million (8.5%), the highest across industrial sectors.[3,4] When comparing it against other sectors, the the telecommunications and postal services sectors' direct contribution to GDP growth was higher than energy, construction, and finance (approximately US$ 26 million each sector) and had been consistently growing faster since 2002 (see Figure 2).

[3] When considering it with transportation (Source: National Accounts)
[4] GDP of Senegal in 2010 was $12,954 m (current)

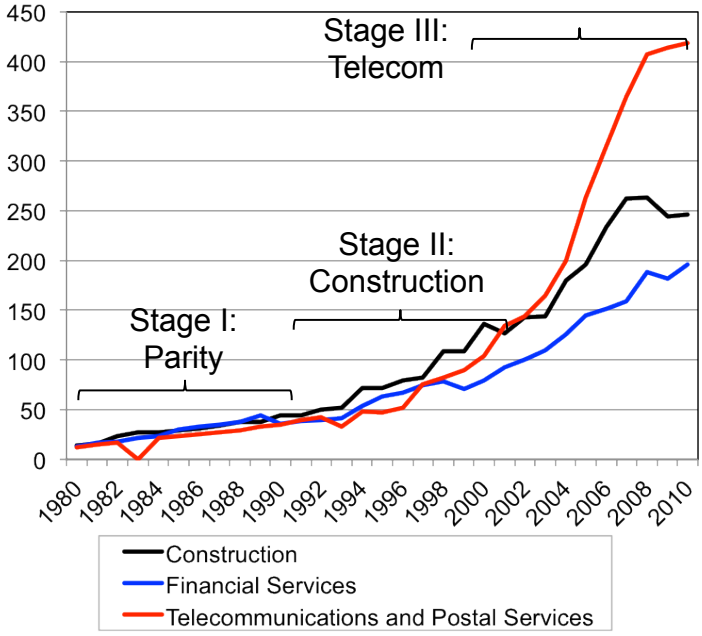

Figure 2. Senegal: GDP by industry (1980-2010) (in CFA billion)
Source: Senegal National Accounts

In parallel to its direct economic contribution, the telecommunications industry had an important impact in the creation of direct jobs (i.e. telecommunications employment). The total number of direct jobs in the telecommunications sector reached 3,000, while the indirect employment reached 55,000. Combined, total direct and indirect employment in 2010 represented 1.11% of the total employment in Senegal, and 10.6% of the service sector[5]. Finally, the Senegalese telecommunications sector contributed 12.6% to the public treasury through paid taxes in 2010. For example, Orange Sonatel, the incumbent operator, contributed 10.4% of the total fiscal revenues of the country[6].

2.2. Indirect economic contribution of telecommunications until 2010

As indicated above, beyond the direct economic contribution, telecommunications can have a positive indirect impact on economic growth. Given the differing penetration rates of mobile telephony and broadband, this study conducted separate economic impact analysis of each technology.

Based on structural econometric models, mobile telephony was found to have a significant effect on the Senegalese economy between 2003 and 2010. The annualized average contribution to the Gross Domestic Product was estimated to be equal to

[5] Total population employment reached 5,194,107 in 2010; according to the Youth Employment Network study on Ghana and Senegal, 10.5% of the labor force is employed in the service sector
[6] Source: Sonatel: Un Groupe Integre, 2010.

0.044% of GDP growth for every 1% increase in mobile telephony penetration (see Table 1).

Variables	Mobile Model
Growth (GDP_{it})	
Labour force (L_{it})	0.416***
Fixed Capital Stock (K_{it})	0.615***
Mob Penetration (Mob_Pen_{it})	0.044*
Constant	-
Demand (Mob_Pen_{it})	
GDPC ($GDPC_{it}$)	0.165
Mob. Price ($MobPr_{it}$)	-5.238***
Market Conc (HHI_{it})	-3.590***
Constant	10.588***
Supply (Mob_Rev_{it})	
Mob Price ($MobPr_{it}$)	-3.122***
GDPC ($GDPC_{it}$)	0.929***
Market Conc (HHI_{it})	0.123
Constant	-3.360***
Output (ΔMob_Pen_{it})	
Mob Revenue (Mob_Rev_{it})	0.867***
Constant	7.150***
Year Effects	YES
Quarter Effects	YES
R^2	(1)
Growth	0.99
Demand	0.98
Supply	0.98
Output	0.30

Table 1. Results of 2010 Mobile Telephony Model
Source: Telecom Advisory Services analysis

These results fit well with the logarithmic growth impact curve developed by Gruber and Koutroumpis (2011). With a median mobile penetration of approximately 35% between 2004 and 2010, the aforementioned 0.044% increase in GDP was only 3% lower than the estimate derived from Gruber and Koutroumpis' exponential model[7] (see Figure 3).

[7] Estimated value: (0.0074 * ln (0.35)) + 0.0533 = 0.0455, Actual estimate: 0.44

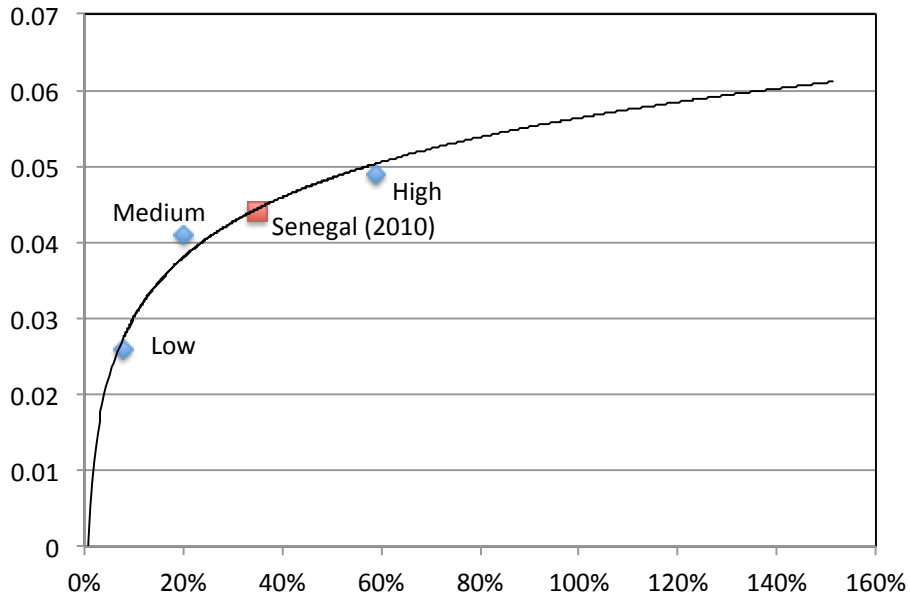

Figure 3: Estimate based on fitted line of previous studies
(median mobile penetration ~35%); Sources: Gruber and Koutroumpis (2009)
Source: Telecom Advisory Services analysis

Based on the prior model and using industry forecasts, the expected impact of the sector was also calculated. Based on the estimated mobile penetration rate of 115% by the end of 2016, which suggests a saturation stage, the median mobile penetration for the period of study (2004-2016) would increase to 61.4% and the annual impact from each 1% increment of mobile penetration would contribute slightly more than 0.05% on GDP. In fact, we hypothesized at the time that the wireless market saturation would lead to a stagnation of the economic effect of mobile adoption over time and that while the growth effects would be preserved, they would be transferred to broadband.

For the analysis of the impact of fixed[8] broadband on the economy, a model similar to the mobile telephony structural model was utilized. According to the model, no significant effects were found from the adoption of broadband for the period 2004-2010 (see Table 2).

[8] Mobile broadband adoption was embryonic at the time.

Variables	Broadband Model
Growth (GDP_{it})	
Labour force (L_{it})	0.402***
Fixed Capital Stock (K_{it})	0.552***
Broadband Penetration (BB_Pen_{it})	-0.003
Constant	-
Demand (BB_Pen_{it})	
GDPC ($GDPC_{it}$)	0.832**
BB. Price ($BBPr_{it}$)	-0.794***
Education (Edu_{it})	0.082
Urbanization (URB_{it})	25.402***
Constant	-87.929***
Supply (BB_Rev_{it})	
BB Price ($BBPr_{it}$)	0.161
GDPC ($GDPC_{it}$)	3.273***
Constant	-7.223***
Output (ΔBB_Pen_{it})	
BB Revenue (BB_Rev_{it})	0.572
Constant	7.554
Year Effects	YES
Quarter Effects	YES
R^2	(1)
Growth	0.99
Demand	0.99
Supply	0.35
Output	0.16

Table 2. Results of 2010 Broadband Impact Model
Source: Telecom Advisory Services analysis

This result was not inconsistent with the findings yielded by other studies, including the author's own examination of Colombia (Katz et al., 2011d), where broadband penetration of 4.83% yielded an economic contribution of 0.003% to GDP growth for every 1% increase in penetration. We hypothesized, however, that the real growth potential of broadband would come from the adoption of mobile broadband in the country.

3. Changes in the Senegalese economy and the telecommunications sector since 2010

3.1. Changes in the Senegalese Economy since 2010

The 2010 study was conducted shortly following the 2009 global recession and the 2008 Senegalese food and energy crisis, both of which significantly affected the country's economy. Recovery began in 2010 after a combination of domestic structural reforms and the improved results of the global economy. Gross domestic product (GDP) growth increased from 2.2% in 2009 to 4.2% in 2010, although it fell back to 2.6%[9] in 2011 before recovering in 2012 to reach 3.7%. Projections based on future implementation of the government's socio-economic program and compliance with the IMF's Policy Support Instrument,[10] predict GDP growth to equal 4.3% and 5.1% in 2013 and 2014, respectively.

Changes in inflation also signal the start of the recovery. After a sharp rise during 2005-2008, inflation turned negative, reaching -0.98% in 2009 and 1.37% in 2010. In 2011, mainly as a result of higher energy prices, inflation reached 3.38%, but dropped down to 1.42% in 2012[11] and hovered at 1.1% until July 2013[12] (see Figure 4).

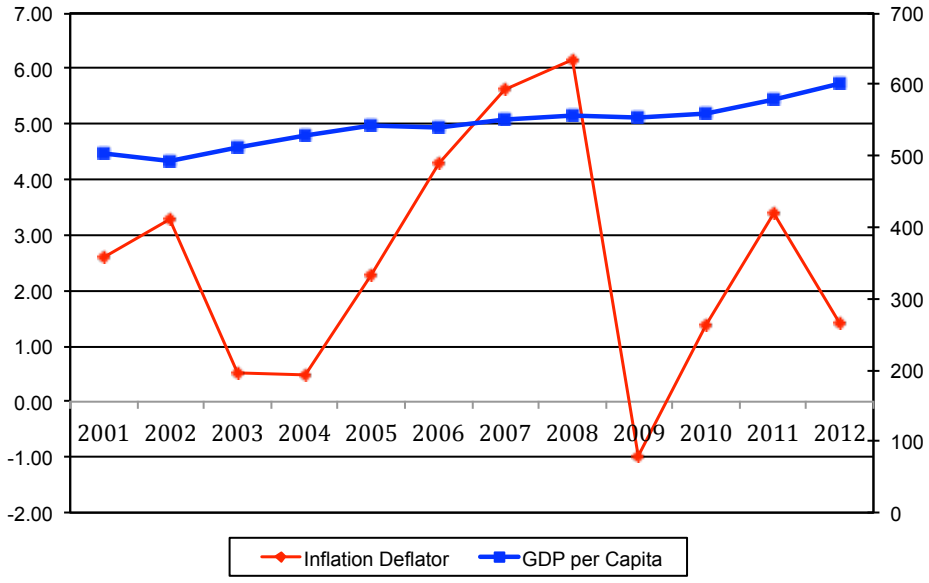

Figure 4: GDP per capita and Inflation
Source: World Bank (2013)

Total imports of goods and services had steadily grown after 2001, reaching a peak of 53.8% of GDP in 2008, but experienced a sudden drop thereafter, declining to 44% of GDP in 2010. Exports fell to 24% in 2011, further expanding the external balance of goods and services (see Figure 5).

[9] IMF http://www.imf.org/external/pubs/ft/weo/2012/01/index.htm
[10] African Economic Outlook: http://www.africaneconomicoutlook.org/en/countries/west-africa/senegal/
[11] World Bank.
[12] http://www.tradingeconomics.com/calendar.

Figure 5: Imports, Exports, Gross Fixed Capital Formation and Foreign Direct Investment as % of GDP
Source: World Bank (2013)

Foreign Direct Investment dropped from 3.01% to 1.62% of GDP between 2008 and 2009, reaching 1.98% in 2011. The rate of investment measured by the Gross Fixed Capital Formation (GFCF) was positive: 27.97% of GDP in 2009, 28.93% in 2010, and 30.3% in 2011. Per forecasts, Senegal's external position will gradually improve during 2013 (7.1%) and 2014 (6.7%) after the steep increase to 7.6% in 2011[13]. The overall budget deficit, including grants, increased from 5.2% of GDP in 2010 to 6.7% in 2011, but decreased to 5.9% in 2012. It is estimated to drop to 4.9% in 2013 and 4.3% in 2014.

In light of these macro-economic trends, it would be relevant to explore whether the relationship between the sector and the overall economy has changed since the initial study. Has the elasticity between GDP growth and telecommunications output changed? Has the sector benefitted from the increase in Gross Capital Formation?

3.2. Changes in the Telecommunications industry since 2010

As reported in the 2010 study, over the last 15 years, the telecommunications sector in Senegal experienced rapid growth primarily driven by the adoption of mobile telephony (see Figure 6).

[13] The 2011 IMF Debt sustainability Analysis (DSA)

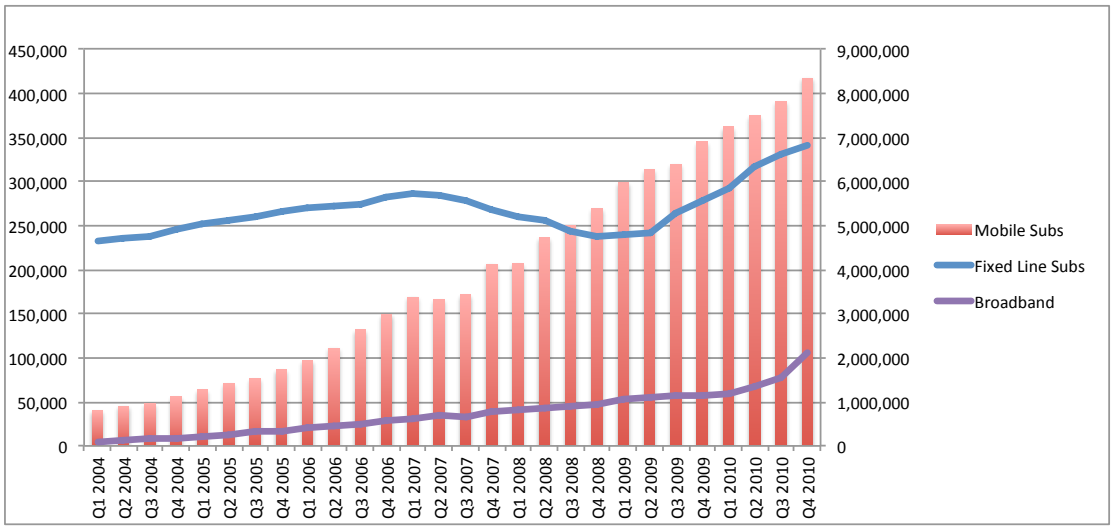

Figure 6: Mobile, Fixed-line, Broadband subscribers in Senegal
Source: ARTP Senegal (2011)

Since 2010, wireless has continued to grow, albeit with a momentary slow-down in 2011 (see Table 3).

	2008		2009		2010		2011		2012	
	Value	Annual Delta	Value	Annual Delta	Value	Annual Delta	Value	Annual Delta	Value	Annual Delta
Wireless Connections	5,389,133	48.43%	6,901,492	28.06%	8,343,717	20.90%	9,325,828	11.77%	11,470,996	23.00%
Market Penetration	45.72 %		57.00 %		67.10 %		72.93 %		87.51 %	
Wireless Subscribers	3,467,227	34.57%	4,165,843	20.15%	4,778,799	14.71%	5,208,366	8.99%	5,955,032	14.34%
Market penetration	29.02 %		33.95 %		37.93 %		40.26 %		44.84 %	

Note: The difference in the value between connections and subscribers is driven by double SIMs
Table 3: Wireless Connections and Subscribers in Senegal
Sources: ARTP Senegal; GSMA Intelligence; IMF; Telecom Advisory Services analysis

In addition to the dramatic increase in wireless subscribership, fixed lines also increased from 2008. Fixed lines experienced a very slow rate of adoption prior to 2007, reaching 286,000 lines. Significant substitution effects took place after the quick adoption of mobile services, resulting in a 21% drop in fixed line services during 2007-2009. This three-year drop in fixed line subscribers lasted until the second quarter of 2009. A steep rise in the demand of ADSL lines after 2009 turned this trend, with fixed lines reaching an all time high in 2011 (346,400 lines) before declining slightly in 2012 to 338,167. This phenomenon of simultaneous growth of both technologies indicates an industry context of a market searching for any possibility to meet its needs through either technology. While the growth rate is dramatically higher for mobile telephony than for wireline, the Senegalese market continues to exhibits less of a technology substitution dynamic than what is seen in

other emerging countries, exhibiting a relationship of complementarity between the two technologies.

Total broadband subscriptions in Senegal (including both fixed and mobile) reached 528,358 in June 2012, up 186,655 from the start of the year. Of these connections, 18.1% were on an ADSL connection and 71.1% were for mobile (3G) accounts. One-year prior, mobile connections only accounted for a mere 28.5% of the total market.

Thus, the most important change since 2010 in the telecommunications market has been the development of mobile broadband. While ADSL lines continue to grow, the the deployment and launch of 3G networks - that now account for 80% of total broadband connections (see Table 4) - has led to a significant boost in the Senegalese broadband market.

		2009		2010		2011		2012	
		Number	Annual Growth Rate	Number	Annual Growth Rate	Number	Annual Growth Rate	Number	Annual Growth Rate
Fixed Broadband	Number	58,720	23.99%	78,647	33.94%	92,713	11.88%	95,561	3.07%
	Penetration	0.49%		0.63%		0.73%		0.73%	
Wireless Broadband	Number	5,067		35,591	602.41%	188,362	429.24%	447,786	137.73%
	Penetration	0.04%		0.29%		1.48%		3.42%	

Table 4: Subscriber market shares across telecommunications platforms in Senegal (2010)
Sources: IMF; Orange; ITU; Telecom Advisory Services analysis

From an industry structure standpoint, the mobile market was still monopolized by the local incumbent – Sonatel, now Orange Senegal - until a second operator – Tigo – entered in 1999. In 2009, Expresso, the third operator, launched services in the Senegalese market. While the market is still primarily controlled by Sonatel (62.85% in 2012), Tigo claims 24.30% of the customer base, and Expresso the remaining 12.85% (see Table 5).

Player	**Fixed Line**		**Fixed Broadband**		**Wireless**	
	2010	**2012**	**2010**	**2012**	**2010**	**2012**
Orange Senegal	92.4%	86.4%	97.41%	96.30%	60.41%	62.85%
Tigo Senegal					27.96%	24.30%
Expresso	7.53% (*)	13.6%	2.59%	3.70%	11.63%	12.85%
Total	100%	100%	100%	100%	100%	100%

(*) Fixed wireless offering

Table 5: Subscriber market shares across telecommunications platforms in Senegal (2010)
Sources: Orange Sonatel; Business Monitor International; Telecom Advisory Services analysis

Despite the apparent stability of market shares, competitive intensity in the wireless market has increased since 2010. The Herfindahl Hirschman Index (HHI), which measures market concentration, declined from 4634 in 2010 to 4603 at the end of

2012, reaching 4506 by mid-2013. An assessment of wireless market share by specific products highlights the centers of competition (see Table 6).

Player	Prepaid		Postpaid		Wireless Broadband	
	2010	2012	2010	2012	2010	2012
Orange Senegal	60.89 %	61.99 %	77.44 %	72.45 %	100 %	68 %
Tigo Senegal	28.35 %	23.08 %	11.55 %	13.64 %		
Expresso	10.75 %	14.93 %	11.02 %	13.91 %		32 %
Total	100 %	100 %	100 %	100 %	100 %	100 %

Table 6: Subscriber market shares across telecommunications platforms in Senegal (2010)
Source: GSMA Intelligence

As Table 6 indicates, all segments of the wireless industry have experienced intense competition (as noted by market share volatility). Since 2010, Tigo has lost five points of its share of the prepaid market at the expense of Orange and Expresso. Orange has lost 5 points of postpaid share and Orange and Expresso are currently fighting over the wireless broadband market.

Finally, total service revenues have increased by US$ 100 million since 2010, reaching US$ 1.5 billion. The trend clearly relates to the rise in mobile adoption and usage as well. However, the slight increase since 2010 does not match the previous momentum between 2002 and 2008 (see Figure 7).

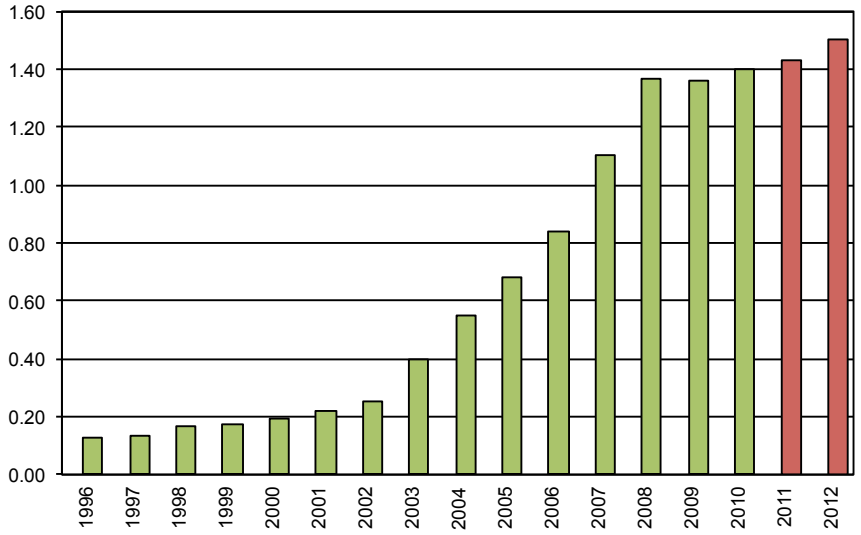

Figure 7: Telecommunications Service Revenues 1996-2010
Sources: ITU; Euromonitor; The Economist; Telecom Advisory Services analysis

As a result, the telecommunications market is mirroring the growth rates of the larger economy (see Figure 8).

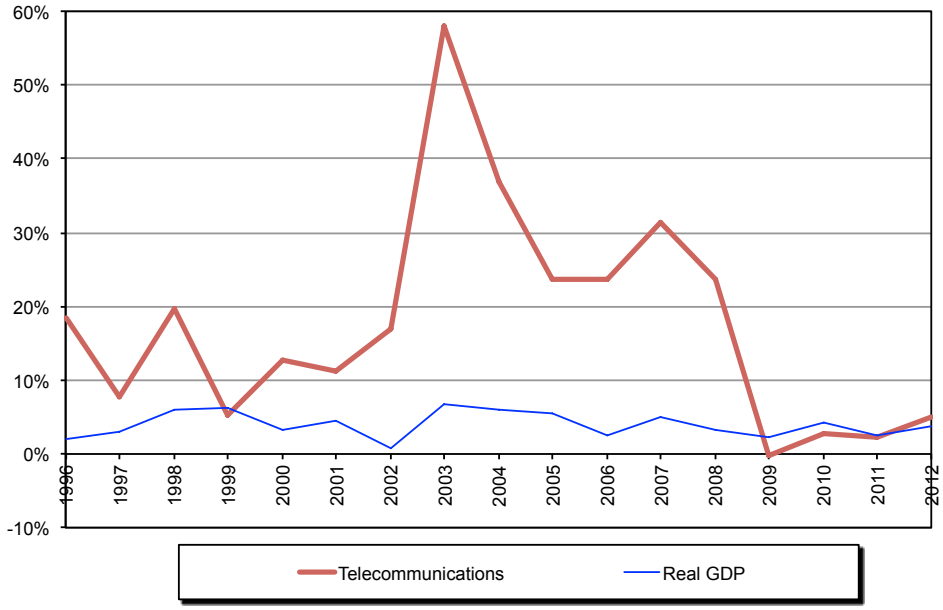

Figure 8: Annual change in real GDP and Telecom Market (1996-2012)
Sources: ITU; World Bank; IMF; ISI; Telecom Advisory Services analysis

This trend has to be considered in the context of the dramatic growth of mobile telephony. In fact, the stabilization of revenue growth is primarily due to the decline in mobile ARPU(Average Revenue per User) resulting from increased competition. Section 5 will provide an interpretation of this trend.

4. New study results

To what extent do the changes in both the economy and the telecommunications sector changed the economic impact equation? We will explore this question in terms of descriptive economic statistics similar to the ones reported in the first study for the direct effects, as well as equivalent econometric modelling techniques for the indirect effects.

4.1. Direct economic contribution since 2010

Two years after the 2010 study, the total revenues of the Senegalese telecommunications industry increased by US$ 100 milion, reaching US$ 1,503 million (slightly dropping as a percent of the GDP from 10.8% in 2010 to 10.3% in 2011, and increasing to 10.6% in 2012)[14]. Relatively stable since 2009 (see Figure 9), this ratio had previously shown consistently growth since 2003, indicating the increasing importance of the sector.

[14] National Accounts are still not published for 2012. Data for 2012 sector revenues is estimated by Hot Telecom Services.

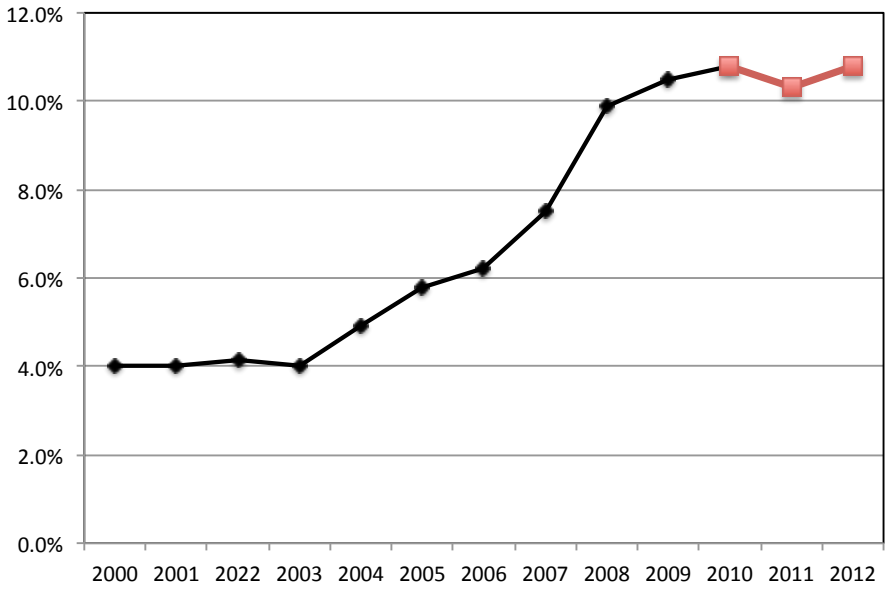

Figure 9. Telecommunications as percentage of GDP (2000-12)
Sources: IMF; World Bank (2012)

In comparative terms, the output of the telecommunications and postal services sectors reached Franc CFA 438 billion. While this figure is still higher than construction and finance, the telecom sector is losing ground following the rebound of the other two sectors (see Figure 10).

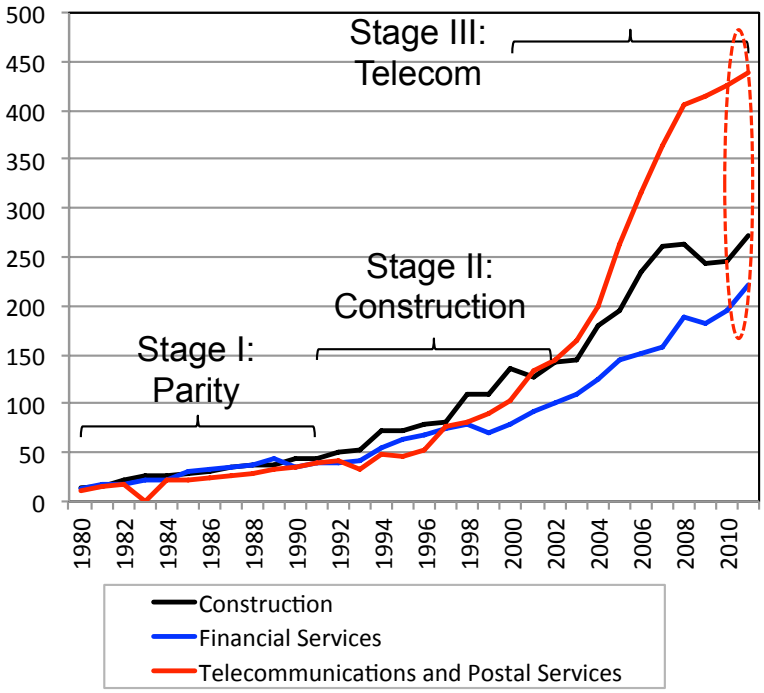

Figure 10. Senegal: GDP by industry (1980-2011)
Source: National Accounts (2012)

4.2. Indirect economic impact since 2010

4.2.1. Wireless telephony

To measure the indirect economic impact since 2010, we constructed a model similar to the one specified for the 2010 mobile telephony study. To reiterate, the model consists of four equations: an aggregate production function modeling the economy and, subsequently, three demand, supply and output functions. The last three functions model the wireless market operation and, controlling for the reverse effects, the actual impact of the infrastructure is estimated. In the production function, GDP is linked to the fixed stock of capital, labor, and the mobile infrastructure proxied by mobile penetration. The demand function links mobile penetration to the average consumption propensity of individuals proxied by GDP per capita, the cost of a basic mobile service, and the competition in the mobile market, measured by the HHI index. The supply function links the aggregate mobile revenue to mobile price levels proxied by ARPU (Average Revenue per User), the industry concentration index of the mobile market (HHI), and GDP per capita. The infrastructure equation links annual change in mobile penetration to mobile revenues, used as a proxy of the capital invested in a country during one year.

The econometric specification of the model is as follows:

Aggregate Production function:

$$GDP_{it} = a_1 K_{it} + a_2 L_{it} + a_3 Mob\_Pen_{it} + \varepsilon_{1it} \quad (1)$$

Demand function:

$$Mob\_Pen_{it} = b_1 MobPr_{it} + b_2 GDPC_{it} + b_3 HHI_{it} + \varepsilon_{2it} \quad (2)$$

Supply function:

$$Mob\_Rev_{it} = c_1 MobPr_{it} + c_2 GDPC_{it} + c_3 HHI_{it} + \varepsilon_{3it} \quad (3)$$

Output function:

$$\Delta Mob\_Pen_{it} = d_1 Mob\_Rev_{it} + \varepsilon_{4it} \quad (4)$$

Based on these models, mobile telephony has been found to have a significant effect on the Senegalese economy during the last 7 years (2004-2011). The annualized average contribution to the Gross Domestic Product equals an estimated 0.061% of GDP for every 1% increase of mobile penetration (see Table 7).

Variables	Mobile Model
Growth (GDP_{it})	
Labour force (L_{it})	0.366***
Fixed Capital Stock (K_{it})	0.785***
Mob Penetration (Mob_Pen_{it})	0.061*
Constant	-
Demand (Mob_Pen_{it})	
GDPC ($GDPC_{it}$)	5.365***
Mob. Price ($MobPr_{it}$)	0.6223
Market Concentration (HHI_{it})	-0.0002
Constant	-39.324***
Supply (Mob_Rev_{it})	
Mob Price ($MobPr_{it}$)	1.594***
GDPC ($GDPC_{it}$)	5.750***
Market Concentration (HHI_{it})	-.0005***
Constant	-36.806***
Output (ΔMob_Pen_{it})	
Mob Revenue (Mob_Rev_{it})	0.539***
Constant	9.545***
Year Effects	YES
Quarter Effects	YES
Operator Effects	YES
R^2	(1)
Growth	0.99
Demand	0.62
Supply	0.90
Output	0.23

Table 7. Results of Mobile Telephony Model
Source: Telecom Advisory Services analysis

The model results confirm the economic spillover of wireless telephony in Senegal. In addition, the structural model yields other interesting findings:

- Capital deepening has an unusually high impact on economic growth (coefficient of 0.785 versus 0.1349 for Cote d'Ivoire)
- Incomes are crucial for adoption and investments (coefficient: 5.635), which indicates that affordability remains a critical barrier for demand
- Competition has a positive impact on investments (coefficient: -0.0005 and significant), but not on adoption (not significant)

The actual contribution of mobile technology was calculated by multiplying the compound annual growth rate of wireless penetration between 2005 and 2013 (Formula 5) by the coefficient of economic impact derived from the econometric model presented in Table 7 (Formula 6):

CAGR = (Wireless penetration 2Q2013 (92.68%)-Wireless penetration 4Q2005 (15.70%)) ^ (1/7.5)-1 (5)

The CAGR for Senegal wireless telephony for the period 2005-2013 is 26.71%.

Impact of wireless on GDP (2005-2013)= CAGR (26.71%)*Coefficient of Impact (0.061) (6)

According to the formula, the annual contribution to GDP from mobile phones is 1.63% of GDP. Based on the difference between the 2012 GDP of US$ 14,159 million and the 2005 GDP of US$ 8,699 million, the indirect annual contribution of wireless telephony amounts to US$ 176 million (see calculations in Appendix B).

Furthermore, looking at the results in light of the Gruber and Koutroumpis' model (2011), the impact forecasted in 2010 study is confirmed. To reiterate, in 2010, with a median mobile penetration of approximately 35% in the sample period, the country had a coefficient of 0.044. Next, considering that mobile penetration was forecast to reach 115% by the end of 2016, the median mobile penetration for the period of study (2004-2016) would have shifted to 61.4%, resulting in a coefficient of 0.05%. Now, with median mobile penetration in the 2010-2016 period shifting to 59.2%, the coefficient has increased to 0.061, indicating an acceleration of impact (see Figure 12).

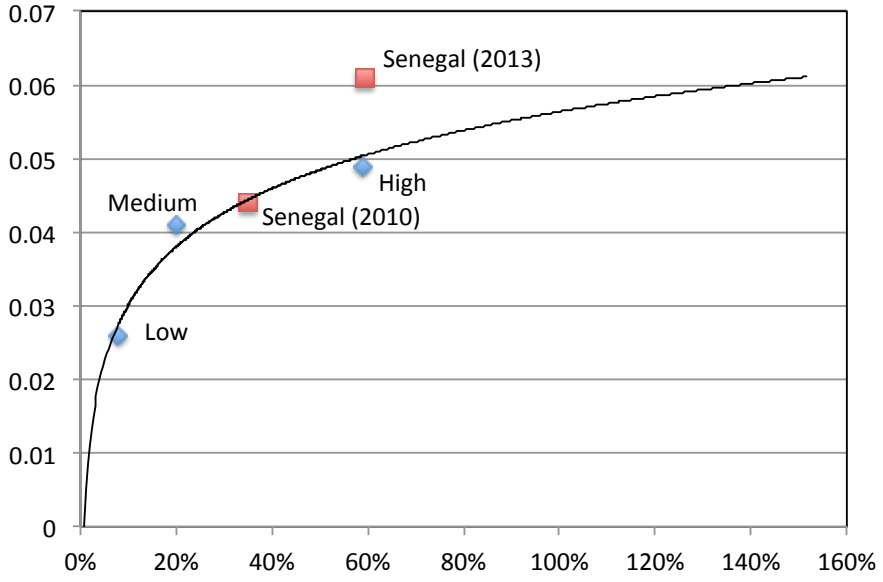

Figure 12: Estimate based on fitted line of previous studies (median mobile penetration: 2004-2010: ~35%; 2010-2016: 59.2%)
Source: Telecom Advisory Services analysis

The fact that the new coefficient is higher than the one estimated by Gruber and Koutroumpis' model could be partially explained by the vast heterogeneity experienced in their global sample. The curve represents the "average case" and each country can perform differently depending on its particular macroeconomic and institutional conditions. However, we remain cautious about another potential explanation: that the economic contribution of mobile telephony is accelerating due to the launch of new services that rely on telecommunications to reach consumers,

particularly financial services like mobile money that rely on text messaging.

4.2.2. Mobile Broadband:

For the analysis of the impact of mobile broadband on the Senegalese economy, a model similar to the mobile telephony structural model was utilized. The model also consists of four equations: an aggregate production function modeling the operation of the economy and subsequently three demand, supply, and output functions. The latter functions model the mobile broadband market operation and estimate the economic impact of mobile broadband while controlling for the reverse effects. The demand function links mobile broadband penetration to the average consumption propensity of individuals proxied by GDP per capita, the cost of a basic mobile broadband service (price of a monthly subscription), the percent of individuals that fulfill secondary education, and the percent of the population residing in densely populated urban areas. The supply function links the aggregate mobile broadband revenue to the relevant price levels and the GDP per capita. The infrastructure equation links annual change in mobile broadband penetration to the market revenues, used as a proxy of the capital invested in a country during one year.

The econometric specification of the model is as follows:

Aggregate Production function:

$$GDP_{it} = a_1 K_{it} + a_2 L_{it} + a_3 BB\_Pen_{it} + \varepsilon_{1it} \quad (6)$$

Demand function:

$$BB\_Pen_{it} = b_1 BBPr_{it} + b_2 GDPC_{it} + b_3 Edu_{it} + b_4 Urb_{it} + \varepsilon_{2it} \quad (7)$$

Supply function:

$$BB\_Rev_{it} = c_1 BBPr_{it} + c_2 GDPC_{it} + c_3 HHI_{it} + \varepsilon_{3it} \quad (8)$$

Output function:

$$\Delta BB\_Pen_{it} = d_1 BB\_Rev_{it} + \varepsilon_{4it} \quad (9)$$

According to the model, mobile broadband appears to have an initial effect on the economy. Contrary to the 2010 results that showed no statistically significant results, every 1% increase in mobile broadband penetration yields 0.022% growth in GDP (see Table 8).

Variables	Mobile Broadband Model
Growth (GDPit)	
Fixed Capital Stock (lfcapital)	0.632***
Labor Force (llabedu)	0.960***
Mobile Broadband Penetration (lmbbusers)	0.022***
Constant	-21.742***
Demand (lmbbusers)	
GDPC (lgdpc)	-1.565
Mobile Broadband Price (lmocost)	-6.332***
Competitive Intensity (hhi_mb)	-2.719***
Constant	36.994**
Supply (lrevenue)	
GDPC (lgdpc)	-0.157
Mobile Broadband Price (lmocost)	0.246***
Competitive Intensity (hhi_mb)	-0.252***
Constant	19.885***
Output (dmbob)	
Mobile Broadband Revenue (lrevenue)	11.687
Constant	-218.389
Year Effects	YES
Quarter Effects	YES
R^2	
Growth	0.99
Demand	0.96
Supply	0.39
Output	0.00

Table 8. Results of Mobile Broadband Model
Source: Telecom Advisory Services analysis

This effect is quite reasonable considering that while the coefficient is lower than what is found in comparable fixed broadband studies, a smaller effect would be expected since mobile broadband is not as intensively used for accessing the Internet as fixed broadband.

The actual contribution of mobile technology was calculated by multiplying the compound annual growth rate of wireless penetration between 2005 and 2013 (Formula 5) by the coefficient of economic impact derived from the econometric model presented in table 7 (Formula 6):

CAGR = (Wireless penetration 2Q2013 (4.59%)-Wireless penetration 2Q2012 (2.87%)) ^ (1/1)-1 (5)

The CAGR for Senegal mobile broadband for the period 2012-2013 is 59.93%.

Impact of wireless on GDP (2005-2013)= CAGR (26.71%)*Coefficient of Impact (0.061) (6)

According to the formula, the annual contribution on GDP from wireless broadband is 1.32% of GDP. Based on the difference between the 2012 GDP of US$ 14,159

million and the 2010 GDP of US$ 12,855 million, the indirect contribution of wireless telephony amounts to $ 173 million (see calculations in Appendix C).

5. Discussion of Study Results

The interpretations of the new study results in light of the 2010 evidence are quite enlightening. The data on the telecommunications sector's direct economic contribution indicate that its overall impact has not substantially changed. The sector revenues as a percentage of the GDP have stabilized in the range of 10% since 2009, signifying that the relative importance of telecommunications has remained constant. The significant decline in unit prices as a result of competition primarily explains this stabilization. For example, the effective price per voice minute dropped US$ 0.03 between 2005 and 2009 and US$ 0.05 between 2009 and 2012. Similarly, ARPU (total spend per customer) decreased from US$ 10.36 in 2005 to US$ 9.93 in 2009, but then dropped to US$ 5.78 by 2012. The decline in prices is fairly correlated with the increase in competitive intensity in the wireless sector across segments.

In terms of its annual contribution to GDP, in 2012, telecommunications effects amounted to US$ 1,852 million: US$ 1.5 billion in direct effects and US$ 349 million in indirect effects, representing a 15% increase in contribution from 2010. This is a contribution of 13.08% (2012 GDP: US$ 14,160 million).

Annual contribution to GDP	2010	2012
Direct effects of telecommunications	US$ 1,400	US$ 1,503
Indirect effects of mobile telephony	US$ 210	US$ 176
Indirect effects of broadband	Not statistically significant	US$ 173
Total	US$ 1,610	US$ 1,852

Table 9. Cumulative Economic effects of telecommunications (in US$ millions)
Source: Telecom Advisory Services analysis

The comparison of both study results is particularly interesting. First, as mentioned above, the direct effects do not increase substantially between the two years. Second, assuming that the lack of statistical significance regarding the indirect effects of mobile broadband in 2010 represents no economic impact whatsoever, total indirect impact of telecommunications at this point in time is US$ 210 million. The increase in indirect effects from 2010 to 2012 is primarily the result of mobile broadband becoming a key platform that yields economic spillover. Third, the emergence of mobile broadband as a key driver of indirect contribution, and the decline in voice telephony indirect effects, signals a gradual transition from voice telephony to data communications.

The policy implications of these findings are manifold. It is critical that emerging markets first implement policies that encourage increased infrastructure investment in order to achieve critical mass in terms of network deployment and device adoption. Once achieved, policy focus needs to shift to the areas that maximize spillovers, focusing on the promotion of intense usage and stimulating technology innovation.

Along those lines, while direct contribution of the telecommunications sector is a relevant metric to monitor infrastructure deployment and adoption initially, over time policies should focus on maximizing indirect effects.

Beyond these effects, the Senegalese case demonstrates as a case study, that mobile broadband is, as expected, the technology best suited to tackle the digital divide in the emerging world. While it is reasonable to assume that not all 3G users utilize the technology to access the Internet, once the devices are in the hands of non-adopters, digital literacy, combined with increasing affordability of data plans, will stimulate Internet access over time.

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APPENDIX A: Data Sources

Data	Sources
Fixed Line subscribers	ITU
Mobile subscribers	ITU
Mobile unique subscribers	GSMA Intelligence
Internet subscribers	ITU
Fixed broadband subscriptions	ITU
GDP	World Bank
Total Wireless Service Revenues	GSMA Intelligence
Total Fixed Service Revenues	Pyramid Intelligence
HHI	GSMA Intelligence
GDP per capita	World Bank
Population	GSMA Intelligence
Total MTN Connections	GSMA Intelligence
MTN Market Share	GSMA Intelligence
Total Wireless Connections	GSMA Intelligence
Mobile-cellular prepaid – price of a three-minute local call (peak, on-net), in USD	ITU
Price of a three-minute local call to a fixed-telephone line (peak rate), in USD	ITU
Fixed (wired)-broadband monthly subscription charge, in USD	ITU
Gross fixed capital formation (current US$)	World Bank
Gross fixed capital formation (constant 2005 US$)	World Bank
Gross fixed capital formation (% of GDP)	World Bank
Gross capital formation (current US$)	World Bank
Gross capital formation (constant 2005 US$)	World Bank
Gross capital formation (% of GDP)	World Bank
Labor force, total	World Bank
School enrollment, tertiary (% gross)	World Bank
Total Mobile Connections/Population	GSMA Intelligence
100 - "Rural population (% of total population)"	World Bank
Total Mobile Connections Q2 2013	GSMA Intelligence
Internet Service Revenue (US$m)	Pyramid Research
Blended ARPU Total	GSMA Intelligence
Blended ARPU Total	WCIS
ARPU Postpaid	WCIS
ARPU Prepaid	WCIS
ARPU, by subscriber	GSMA Intelligence
Operator ARPU Per Month Postpaid in USD	INFORMA
Operator ARPU Per Month Postpaid in USD	INFORMA
Operator ARPU Per Month Prepaid in USD	INFORMA
Operator ARPU Per Month Prepaid in USD	INFORMA
Operator ARPU Per Month Blended in USD	INFORMA
Operator ARPU Per Month Blended in USD	INFORMA
Operator Total Revenue less Mobile Revenue	INFORMA
Operator Total Revenue less Mobile Revenue	INFORMA
Operator Total Revenue less Mobile Revenue	INFORMA
Operator CAPEX in Millions USD	INFORMA
Operator CAPEX in Millions USD	INFORMA
Operator CAPEX in Millions USD	INFORMA
Operator CAPEX in Millions USD	INFORMA
Operator CAPEX in Millions USD	INFORMA
Revenue Total	GSMA Intelligence

CAPEX Total	GSMA Intelligence
DSL Internet subscriptions	ITU
Percentage of the population covered by a mobile-cellular network	ITU
Network coverage, by population	GSMA Intelligence
Active mobile-broadband subscriptions	ITU
Mobile Broadband	GSMA Intelligence
Mobile broadband at least 1 GB of CAP (US$)	Google Data
Mobile Broadband "MTN"	GSMA Intelligence

APPENDIX B: Calculation of Wireless Telephony Indirect Contribution to GDP Impact in Senegal (2013)

Item	Component	Value	Source or Formula
1	Annual contribution of wireless telephony to GDP growth (for every 10% increase in wireless penetration)	0.61	Coefficient of model in table 8
2	Wireless broadband penetration 2Q2013	92.68 %	GSMA Intelligence
3	Wireless telephony penetration 2Q2005	15.70 %	GSMA Intelligence
4	CAGR Wireless telephony penetration	26.71 %	(Wireless telephony penetration 2Q2013/ Wireless telephony penetration 4Q2005)^(1/7.5 years)-1
5	Annual impact of wireless on GDP	1.63 %	(Annual contribution/10) * CAGR Wireless telephony penetration
6	CAGR GDP per capita (2005-2012)	7.21 %	(GDP PC 2012/ GDP PC 2005)^(1/7years)-1
7	Percent contribution of wireless telephony to GDP growth	22.60 %	Annual impact of wireless on GDP / CAGR GDP per capita (2005-2012)
8	Incremental GDP (2012-2005)	US$ 5,461 mm	GDP 2012 – GDP 2005
9	Total Impact of Wireless Telephony on Incremental GDP growth	US$ 1,234 mm	Incremental GDP (2012-2005) * Percent contribution of wireless telephony to GDP growth
10	Annualized impact	US$ 176 mm	Total impact/7

APPENDIX C: Calculation of Wireless Broadband Indirect Contribution to GDP Impact in Senegal (2013)

Item	Component	Value	Source or Formula
1	Annual contribution of wireless broadband to GDP growth (for every 10% increase in wireless penetration)	0.22	Coefficient of model in table 7
2	Wireless broadband penetration 2Q2013	4.59 %	GSMA Intelligence
3	Wireless broadband penetration 2Q2012	2.87 %	GSMA Intelligence
4	CAGR Wireless broadband penetration	59.93 %	(Wireless broadband penetration 2Q2013/ Wireless broadband penetration 2Q2012)^(1/1 years)-1
5	Annual impact of wireless broadband on GDP	1.32 %	(Annual contribution/10) * CAGR Wireless broadband penetration
6	CAGR GDP per capita (2010-2012)	4.95 %	(GDP PC 2012/ GDP PC 2010)^(1/2years)-1
7	Percent contribution of wireless broadband to GDP growth	26.64 %	Annual impact of wireless broadband on GDP / CAGR GDP per capita (2010-2012)
8	Incremental GDP (2012-2010)	US$ 1,304 mm	GDP 2012 – GDP 2010
9	Total Impact of Wireless Broadband on Incremental GDP growth	US$ 347 mm	Incremental GDP (2012-2010) * Percent contribution of wireless broadband to GDP growth
10	Annualized impact	US$ 173 mm	Total impact/7