# CAPITAL INVESTMENT, NETWORK QUALITY, AND PERFORMANCE IN WIRELESS TELECOMMUNICATIONS

**September 2014**

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. 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.

- **Mr. Fernando Callorda** (BA, MA, Economics, Universidad de San Andres-Argentina) is consultant with Telecom Advisory Services LLC. He is also a researcher in the Universidad de San Andres (Argentina) and a consultant at Telecom Advisory Services, LLC. He specializes in econometric modeling in the telecommunications industry.

- **Cecilia Ya Wen** (BS, Applied Mathematics, Peking University) is a consultant with Telecom Advisory Services LLC. She specializes in quantitative analysis and the assessment of economic impact of telecommunications


Telecom Advisory Services LLC is an international consulting firm specialized in providing high-level consulting services in business, policy, and financial strategies to telecommunications and technology companies, governments and international organizations. Its clients comprise some of the largest private sector telecommunications and technology companies in the world, as well as international organizations such as the International Telecommunication Union, the World Bank, the United Nations Economic Commission for Latin America, the GSMA, the CTIA, the FTTH Council (Europe), and the Corporación Andina de Fomento. TAS has also provided consulting services to the governments of Colombia, Mexico, Costa Rica, Peru, Ecuador, Brazil, and United Arab Emirates.


This study was funded by Ericsson. The authors are solely responsible for the views expressed in this study.

**TABLE OF CONTENTS**

## EXECUTIVE SUMMARY

This study focuses on the impact capital investment has on wireless network performance and the subsequent causal links between network quality and carrier performance, both commercial and financial. Its purpose is to investigate whether an increase in CAPEX has a noticeable impact on quality metrics and if such an impact results, in turn, in an improvement of operator performance.

While there is some research on the impact of network quality on customer satisfaction and purchase intentions, most of it is based on survey data as opposed to carrier commercial metrics. On the other hand, while not focused on the wireless industry, most of the research literature on the strategic value of capital investment argues that a combination of "source of advantages" yields "positional advantages (cost or differentiation)" ultimately resulting in "performance outcomes (most often market share and profitability)". In the context of this study, superior wireless network quality would represent a source of advantage that would, theoretically, translate into a positional advantage, leading to better market and financial performance.

Along these lines, a firm that invests in upgrading a critical component of its delivery infrastructure can achieve a unit cost position lower than that of its competitors by leveraging economies of scale or being the first to gain experience in reducing its production cost. In this study's terms, a firm that pioneers the migration to LTE technology should gain an economic advantage.

Furthermore, an early investor in upgrading key elements of its delivery infrastructure can secure absolute competitive advantage by preempting rivals in the acquisition of scarce assets. Given a set of attributes on which the customer preferences differ, the first mover can occupy the most attractive niche in terms of geographic locations, product characteristics, distribution channels, and/or market segments. Again, an aggressive investor in wireless broadband technology can enhance its capacity of acquiring most valued postpaid customers.

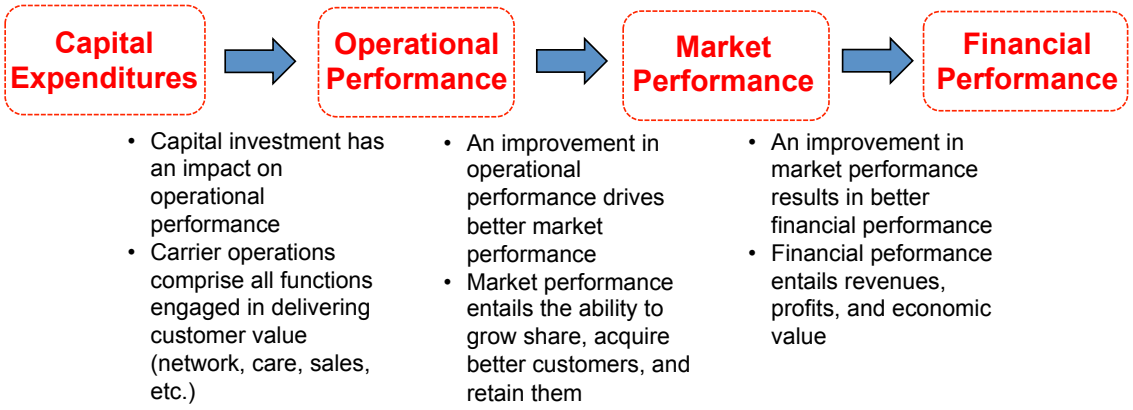
Third, the advantage of an aggressive investor in upgrading its delivery infrastructure may be further strengthened by perceived switching costs and choice inertia from the part of the consumers. Switching cost is more compelling in markets where the demand is homogeneous, such as wireless telecommunications. Intuitively, when the market has different preferences as to which features are desirable for a product, or when there is different minimum quality requirements from consumers, it is easier for a late-comer to enter and become profitable by targeting a niche market.

Beyond switching costs, an aggressive investor in delivery infrastructure builds an advantage in terms of how consumers learn about brands and form their preferences. First-movers can have a major influence on how attributes are valued and ideally bundled. In addition, pioneers can become strongly associated with the product category as a whole, and as a result, attain certain insulation against later entrants that are positioned close to it.

Finally, a firm that ramps its spending in anticipation of a wave of technological change tends to benefit from network effects. In other words, technological intensity adds to the first mover's advantage in networked economies.

All in all, the research literature developed through analysis of firm behavior in multiple industries would indicate that companies that increase their investment in a key resource of their delivery stream (i.e. the network) would tend to build a competitive advantage, leading to superior performance. The advantage could translate into higher differentiation (i.e. better network quality) or lower costs (i.e. lower operating expenses), and ultimately into higher profitability. The theoretical framework of the study comprises a four-stage transitive causality chain (see figure A).

**Figure A. Causality Chain Linking CAPEX to Carrier Performance**




The quantitative and qualitative evidence provided in this paper has allowed us to prove the hypotheses regarding the importance of capital spending in driving carrier performance in the wireless industry.

The study's first and most important hypothesis established that there is a direct transitive relationship between capital investment, network quality and wireless carrier performance. In fact, the statistical analyses conducted with carrier data for the Brazilian, Mexican, and US markets confirmed this hypothesis.

First, an increase in CAPEX yields an immediate improvement in network performance KPIs (e.g. improvement in speech call quality, increase in download speeds, latency reduction, etc.). For example, in the Brazilian market, an increase of

1 million Reais (the local currency) in average quarterly CAPEX for a year yields an increase of the Speech Call Quality index of 0.0032 units, while a similar increase in capital investment for three years yields an improvement in data accessibility rate of 0.01867 points, an increase in data completion rate of 0.0241 points, and a growth in data sessions higher than 1 Mbps of 0.025872 points.

Second, an improvement in network performance results, in turn, in better market performance (ARPU, share, churn reduction) either in the same quarter of the improvement or typically after two quarters. For example, a reduction of 1 millisecond in latency in the Mexican market yields an increase of 0.0086 percentage points on mobile broadband market share, while an increase in 1 Kbps in average download speed of data sessions yields an increase in ARPU of MXN 0.00865.

Third, as expected, an improvement in market performance causes an immediate rise in financial performance (Revenues, and EBITDA margin). An increase of 1 percentage point in market share in the US market yields an increase in revenues of USD 447.722 Millions, while a decrease of 1 percentage point in churn, yields an increase on revenues of USD 127.543 Millions three quarters after.

Fourth, based on the statistical models reviewed above, a temporary reduction in free cash flows due to an increase in capital spending at the beginning of the time period is compensated by an increase of this metric over time, resulting in a positive net present value. For example, assuming that a Brazilian national carrier increases its annual CAPEX by 10%, EBITDA margin jumps from 30% to 32.1%, while annual free cash flows grows from US$ 891 million to US$ 1,097. The Net Present Value of such an increase in CAPEX is $219 million over 5 years. If rather than 10%, CAPEX were to be raised by 20%, the 10 year Net Present Value would jump from US$ 601 million to $1,200 million. Similarly, a 10% increase in CAPEX in the Mexican market would increase EBITDA margin from 48.6% to 49.1%, while cash flows grow from US$ 4,996 million in 2013 to US$ 5,101 in 2017. The Net Present Value of such an increase in CAPEX is US$ 297 million over 5 years.

Beyond the quantitative evidence, three qualitative case studies also confirmed the transitive causal relationship between capital investment and financial performance:

- Verizon's consistent CAPEX/revenues ratio of 13% yielded highest EBITDA margin among wireless carriers in the United States (44%)
- Softbank's increase of CAPEX/revenues from 10% to 27% triggered a rise in EBITDA margin from 28% to 36%
- Swisscom's average CAPEX/revenues ratio of 15% in 2008-09 yielded a sustained EBITDA margin since 2010 (50%)

The second study hypothesis posited that, by increasing CAPEX levels, a dominant wireless player having an economy of scale advantage, puts pressure on its

competitors that are constrained in their ability to keep up with the incumbent in order to create short term value to shareholders. While the statistical analysis did not allow us to prove this postulate, two case studies gave ample confirmation of this effect:

- Verizon enjoys a CAPEX scale which allows it to invest proportionally less (13% of revenues) than its competitors, which results in a competitive advantage in terms network performance;
- Similarly, Swisscom's CAPEX scale allows them to invest less (7% of revenues) than its competitors since 2010 and yet, have a technology advantage vis-à-vis its competitors.

The third study hypothesis argued that sustained capital spending could enhance a carrier's ability to monetize a market opportunity and reduce operating costs. Again, case studies provided evidence that supported this argument:

- With highest connectivity rate and download speed (15 Mbps), Softbank was able to increase mobile broadband market share in the Japanese market from 17% to 24% in 3 years;
- By consistently investing more than Movistar (CAPEX/revenues ratio 4 percentage points higher) since 2008, Entel Chile succeeded in overcoming Movistar in profitability terms.

Finally, the fourth hypothesis stated that an increase in CAPEX could also result in a first mover advantage, which yields competitive superiority over time. Qualitative evidence amply supported this point:

- With a deployed LTE network before its competitors, Verizon achieved the market lowest churn (1.28%), highest ARPU ($57.72), and highest quarterly growth in post-paid subscribers (4.35%);
- Increasing CAPEX also helped a lagging performer, such as Softbank, to catch up and surpass the competition in the Japanese market;
- As the first carrier in market to deploy 3G, and LTE, Swisscom has an average margin per user ($21.63) higher than its competitors;
- As first carrier to launch mobile broadband, Entel succeeded in remaining the dominant mobile broadband player (47% share) in the Chilean market.

In summary, as the research literature indicated for other industries, increasing capital investment in wireless telecommunications could yield superior market and financial performance. The benefit of increasing CAPEX is higher in the case of incumbent players for two reasons: 1) their scale allows them to invest in network upgrades at a proportionally lower unit value than its peers, forcing the latter into an expensive "arms race", 2) by pioneering the migration into new technologies, incumbents build additional barriers, thereby solidifying their network effects.

Additionally, as demonstrated in the research literature, wireless carriers that increase their CAPEX relative to their competitors can achieve a lower cost position by either leveraging economies of scale or learning curve. In fact, the faster they increase their investment, the higher the advantage achieved relative to their peers. Finally, carriers that anticipate their peers in increasing their investment in network quality will benefit from economies of scale, experience curve, brand equity, competitive preemption for more valuable customers, and network effects.

## 1. INTRODUCTION

This study focuses on the impact capital investment has on wireless network performance and the subsequent causal links between network quality and carrier performance, both commercial and financial. In other words, its purpose is to investigate whether an increase in CAPEX has a noticeable impact on quality metrics and if such an impact results, in turn, in an improvement of operator performance. The strategic implications of understanding these interrelationships are multi-fold.

First, if one were to be able to model the quality returns of CAPEX and the financial returns to quality, operators would have a tool at their disposal that would allow them to determine the optimal level of capital spending to achieve a strategic objective. This is no trivial matter since conventional approaches to capital planning in the telecommunications industry have been typically based on either what engineering needs or what can be afforded, rather than what is strategically required.

Second, by looking at the strategic implications of investment on network quality, we attempt to turn the issue of CAPEX, on its head. It is common for equity analysts to look at CAPEX purely as a financial metric (in other words, is the company over or underinvesting when considering its CAPEX as percent of sales?). We believe this approach to be quite superficial in terms of its strategic implications. For example, it might the case that a wireless carrier that is overinvesting as a percent of sales is in actuality enhancing its ability to monetize a market opportunity in the long run. And yet, the conclusion of an analysis based on financial appropriateness of investment would probably miss the point.

Third, by understanding the links of CAPEX to wireless carrier performance, we attempt to understand specific strategic moves by operators. For example, a player might be overinvesting in the network to build product differentiation based on network reliability (first mover advantage). Alternatively, an operator increases its CAPEX to develop the network extensively in order to erase any reputation of poor connectivity and build parity with the dominant player (challenger strategy).

The methodological implications of quantifying the causal link between CAPEX and financial returns are not trivial. First, while the hypothesis sounds intuitively correct, it is not easy to prove. Correlation, on its own, does not prove causality: as it has been the case, investment has been sometimes driven by the availability of cash, rather than by the strategic objective of improving financial performance. Second, external factors, like changes in macroeconomic conditions or other actions of players, need to be controlled for in order to make sure that the effects of the CAPEX increase can be isolated.

This paper begins by reviewing the evidence of research literature on two areas: the

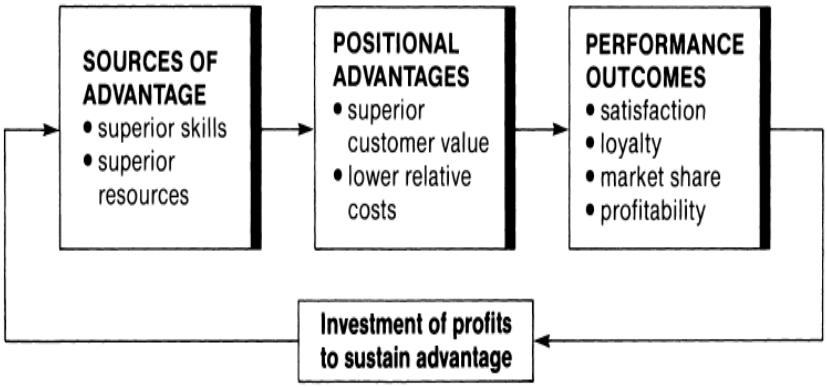
impact of network quality and customer satisfaction and purchasing behaviors, and the strategic importance of capital investment (chapter 2). Chapter 3 outlines the study's theoretical framework and methodology. Chapter 4 presents and discusses findings of the quantitative analyses, while the next chapter presents the qualitative evidence of case studies. Finally, by presenting a simulation model based on statistical analyses, chapter 6 elaborates on the strategic implications for operators.

## 2. RESEARCH LITERATURE

While there is some research on the impact of network quality on customer satisfaction and purchase intentions, most of it is based on survey data as opposed to carrier commercial metrics. For example, Kuo et al (2009) collected data among students and graduates at 15 Taiwanese universities and built a model explaining the relationship between wireless service quality, perceived value, and future purchase intentions. The research confirmed the relationship between perceived value and network metrics such as network availability and coverage, content quality, interface visual design and connection speed. Furthermore, perceived value was directly related with service repurchase intention. Similarly, Zera et al. (2013) researched the relationship between network quality and customer satisfaction among university students in Turkey. In their research, the authors found a strong relationship between service availability and terminal ease of use and customer satisfaction. Finally, Zhao et al (2012) confirmed the effect of service quality on customer satisfaction and, ultimately continuance intention of mobile services based on data collected from 1,000 users in China. The analysis of this body of research reveals the lack of research on the interaction between network quality (possibly resulting from capital investment) and customer purchase intentions and commercial results based on carrier data.

On the other hand, most of the research literature on the strategic value of capital investment has focused on the resource theory of competitive strategy. The basic premise of this theory is based on the notion of sequential determinism whereby a combination of "source of advantages" yields "positional advantages (cost or differentiation)" ultimately resulting in "performance outcomes (most often market share and profitability)" (Day and Wensley, 1988) (See Figure 1).

**Figure 1. The Elements of Competitive Advantage**




*Source: Day and Wensley, 1988*

In the context of this study, superior wireless network quality represents a source of advantage that would, theoretically, translate into a positional advantage, leading to better market and financial performance. What are the mechanisms that support these causal links?

First, the research literature has yielded considerable evidence that creating superior performance in a firm's resources (such as the network) allows it to deliver superior customer value at a low relative cost position. A firm that invests in upgrading a critical component of its delivery infrastructure can achieve a unit cost position lower than that of its competitors by leveraging economies of scale or being the first to gain experience in reducing its production cost (Lieberman, 1987; Kessler et al, 2000; Spence, 1981). In this study's terms, a firm that pioneers the migration to LTE technology should gain an economic advantage. This advantage can be reinforced when considering the time it takes for competitors to respond. The longer the elapsed time between the entry of the first mover and that of later entrants, the more opportunities become available to the first mover to achieve cost and differentiation advantages (Kerin et al 1992).

Second, an early investor in upgrading key elements of its delivery infrastructure can secure absolute competitive advantage by preempting rivals in the acquisition of scarce assets (Lieberman & Montgomery 1988). Here the advantage comes from the exclusiveness in the first mover's ownership or control of an asset or industry environment. There are mainly two types of preemption factors: cost asymmetries in factor inputs and spatial preemption (Kerin et al, 1992). In the first case, the first mover enjoys competitive advantage if, at the beginning of market formation, it can acquire input factors at prices below those that will prevail later in the market

(Lieberman & Montgomery 1988). Another set of first mover advantage arises when firms engage in competition for customers with dissimilar tastes. Given a set of attributes on which the customer preferences differ, the first mover can occupy the most attractive niche in terms of geographic locations, product characteristics, distribution channel, and market segment (Kerin et al, 1992). Again, an aggressive investor in wireless broadband technology can enhance its capacity of acquiring most valued postpaid customers.

Third, the advantage of an aggressive investor in upgrading its delivery infrastructure may be further strengthened by perceived switching costs and choice inertia from the part of the consumers (Brown et al, 1994; Gomez et al, 2011). Switching costs provide incentives for the existing buyer-seller relationship to continue into the future. This mechanism makes the demand of the customers of the aggressive investor more inelastic, therefore obstructing entries of potential competitors and preserving the first-mover advantage (Klemperer 1987). Switching cost is more compelling in markets where the demand is homogeneous (Capone et al, 2013), such as wireless telecommunications. Intuitively, when the market has different preferences as to which features are desirable for a product (horizontal fragmentation), or when there is different minimum quality requirements from consumers (vertical fragmentation), it is easier for a late comer to enter and become profitable by targeting a niche market.

Fourth, beyond switching costs, an aggressive investor in delivery infrastructure builds an advantage in terms of how consumers learn about brands and form their preferences (Hoch et al, 1992; Kardes et al, 1992). The explanation has two components. First, in the early stages of market development, consumers know little about the importance of attributes or their ideal combination (Nelson, 1970). Thus, first-movers can have a major influence on how attributes are valued and ideally bundled. Second, the pioneer can become strongly associated with the product category as a whole, and as a result, attain certain insulation against later entrants that are positioned close to it (Carpenter et al, 1989).

Fifth, a firm that ramps its spending in anticipation of a wave of technological change tends to benefit from network effects (Katz et al, 1994; Lee et al, 2007). Technological intensity adds to the first mover's advantage in networked economies. The effect can come from two sources: first, higher technological complexity requires the user to invest more in co-specializing assets, pushing up non-contractual switching cost; second, technologically complex products require more discretion from R&D to commercialization, giving the first mover a longer window of opportunity before its competitors catch up (Teece, 1986). Srinivasan et al (2004) tested that technological intensity improves pioneers' survival probability in networked markets.

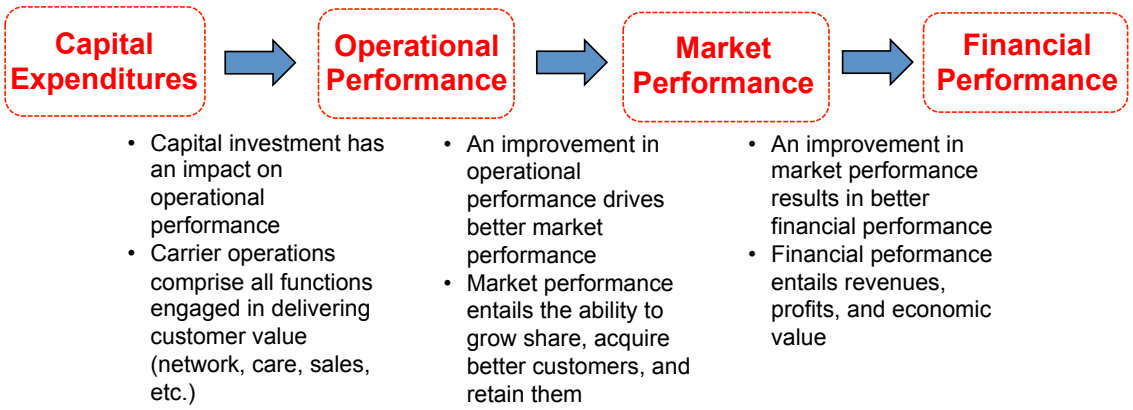
All in all, the research literature developed through analysis of firm behavior in multiple industries would indicate that companies that increase their investment in a key resource of their delivery stream (i.e. the network) would tend to build a

competitive advantage, leading to superior performance. The advantage could translate into higher differentiation (i.e. better network quality) or lower costs (i.e. lower operating expenses), and ultimately into higher profitability. The remainder of the paper will present the approach and results implemented to test these postulates.

## 3. THEORETICAL FRAMEWORK AND METHODOLOGY

This study aims at quantifying the importance of capital investment in driving competitive advantage and superior performance in the wireless industry. The theoretical framework of the study comprises a four-stage transitive causality chain (see figure 2).

**Figure 2. Causality Chain Linking CAPEX to Carrier Performance**




Capital expenditures are of three types: 1) capacity upgrades (base station deployment, small cells, and backhaul upgrade), 2) network modernization (spectrum acquisition, new network deployment, and OSS deployment), and 3) conventional periodic maintenance (cable and equipment replacement). An increase in capital expenditures will theoretically increase carrier operational performance (network operations, distribution, customer care, etc.). Obviously, not all CAPEX will uniformly affect performance. Maintenance CAPEX could reduce network failures by decreasing periodic repairs. Capacity upgrades have an impact on network quality metrics such as dropped calls. Finally, modernization CAPEX (e.g. LTE migration) will have an impact network performance such as download speed in mobile broadband. There are even some CAPEX categories beyond the three mentioned above that could have no impact whatsoever in operational performance (e.g. buildings, HVAC). Nevertheless, taking it all together investment should have an impact on operational metrics. This study is particularly interested in metrics that relate to network operations (download speed, latency, speech call quality).

Operational performance drives, in turn, better market performance, which is the ability to increase market share, acquire more (and especially better) customers, and retaining them. As such, market performance is measured by market share (of

prepaid and postpaid customers), ARPU, and churn. An improvement in market performance will, as expected, have an impact on financial performance, which is measured by revenues, EBITDA, and overall shareholder value.

This theoretical framework was utilized to test the following four hypotheses:

> **H1**: **There is a direct transitive relationship between capital investment, network quality and wireless carrier performance.** As the research literature indicated for other industries, increasing capital investment in wireless telecommunications could yield superior performance.
>
> **H2: By increasing CAPEX levels, a dominant player having an economy of scale advantage, puts pressure on their competitors that have to limit their ability to create short term value to shareholders in order to keep up with the incumbent.** The benefit of increasing CAPEX is higher in the case of incumbent players for two reasons: 1) their scale allows them to invest in network upgrades at a proportionally lower unit value than its peers, forcing them into an expensive "arms race", 2) by pioneering the migration into new technologies, incumbents build additional barriers, thereby solidifying their network effects.
>
> **H3: Sustained capital spending can enhance a carrier's ability to monetize a market opportunity and reduce operating costs.** As demonstrated in the research literature, wireless carriers that increase their CAPEX relative to their competitors can achieve a lower cost position by either leveraging economies of scale or learning curve. In fact, the faster they increase their investment, the higher the advantage achieved relative to their peers.
>
> **H4: An increase in CAPEX can also result in a first mover advantage, which yields competitive superiority over time.** Carriers that anticipate their peers in increasing their investment in network quality will benefit from economies of scale, experience curve, brand equity, competitive preemption for more valuable customers, and network effects.

These hypotheses will be tested through two methodologies. The quantitative analysis provides a measure of the degree of impact that CAPEX has on network quality, and network quality of market on financial performance. The statistical analysis begins by drawing descriptive statistics assessing the correlation between investment, network quality, market and financial performance. Building on this preliminary understanding, the econometric analysis assesses the causality among the four variables. With the results of the econometric analysis, we built simulation models to test the sensitivity of alternative CAPEX scenarios.

The qualitative analysis provides an understanding of the mechanisms by which the causality works, as well as a perspective of the importance of market and competitive dynamics. The qualitative analysis comprises four case studies of carriers that have undergone an increase in their CAPEX and attempts to identify the results of this move. The carriers studied are Softbank (Japan), Verizon (United States), Swisscom (Switzerland), and Entel (Chile). The case studies serve two purposes: on the one hand they provide the necessary evidence to support some of the simulation model causal mechanics (how much an investment of x% in CAPEX triggers an improvement in financial performance); on the other hand, causal impact analysis has to control for some exogenous variables (e.g. an increase in CAPEX with a botched distribution strategy would not necessarily result in an improvement in financial performance). The interrelationship between variables sometimes is not that clean statistically. Case studies help us understand how the different levers of financial performance interact (in methodological terms, cases are more comprehensive and inclusive than financial models). At the end, the cases help understand the importance of different levers in yielding a financial performance improvement.

### 3.1. Quantitative Analyses

This analysis focuses on three markets: Brazil, Mexico, and the United States proceeding along four work steps:

- Data gathering and staging: collection of data; organization of datasets in formats suited to statistical analysis;
- Statistical descriptive analysis: testing of relationships through correlation analysis;
- Discrete Regression models: analysis of causality across all variables through multi-variate regression analysis (output included separately)
- Integration of results: compilation of discrete regression equations within a single simulation model predicting impact of spending on performance

Historical data was collected for each major wireless carrier in the three markets under consideration. Time series for each market could vary according to data availability (see time series compiled by market in table 1).

**Table 1. Data Compiled by Market**

| | | Brazil | | | | Mexico | | | United States | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Operator 1 | Operator 2 | Operator 3 | Operator 4 | Operator 5 | Operator 6 | Operator 7 | Operator 8 | Operator 9 | Operator 10 | Operator 11 |
| **Capital Expenditures** | CAPEX | | | | | | | | | | | |
| **Operational Performance** | WCDMA Throughput rate | | | | | | | | | | | |
| | WCDMA data acccessibility (***) | | | | | | | | | | | |
| | WCDMA data completion (*) | | | | | | | | | | | |
| | WCDMA accessibility speech call (**) | | | | | | | | | | | |
| | WCDMA completion speech call (**) | | | | | | | | | | | |
| | WCDMA integrity speech call (**) | | | | | | | | | | | |
| | WCDMA retainability speech call (**) | | | | | | | | | | | |
| | Mobile broadband connections | | | | | | | | | | | |
| | Latency | | | | | | | | | | | |
| | Download Speed | | | | | | | | | | | |
| **Market Performance** | Subscribers | | | | | | | | | | | |
| | ARPU | | | | | | | | | | | |
| | Churn | | | | | | | | | | | |
| **Financial Performance** | Revenues | | | | | | | | | | | |
| | Opex/revenue | | | | | | | | | | | |
| | EBITDA Margin | | | | | | | | | | | |

(*) Data completion is defined as the ability to successfully complete data sessions, from the call attempt to the normal disconnection. It is a combination of accessibility and retainability figures, for all traffic types.
(**) All speech quality metrics are combined into a composite index of speech call quality.
(***) Data Accessibility Rate is a percentage of call attempts within a CS64 service made by the end-user that are successful. Setup failures can be due to lack of network resources on various levels (for example radio link problem, signaling failure and so on).
NOTE: In green data available; in red data not available; in yellow data estimated.

*Sources: Brazil (GSMA, Ericsson, GSMA, Ookla, Strategy Analytics); Mexico (GSMA, Strategy Analytics, Bank Of America, Ookla); United States (GSMA, Bank of America, Ookla, Strategy Analytics)*

Once the data was compiled and staged, correlational and regression analysis was conducted to establish the causal link between variables. All regression variables were run for the panels, including fixed effects for controlling of variables that might bias the predictor.

At the completion of the econometric analyses, three simulation models were built to test alternative impact scenarios of CAPEX investment level. The models predict the evolution over time of conventional financial metrics (EBITDA, free cash flows,

Net Present Value) resulting from an aggressive move to upgrade service quality by raising CAPEX.

### 3.2. Qualitative Analyses

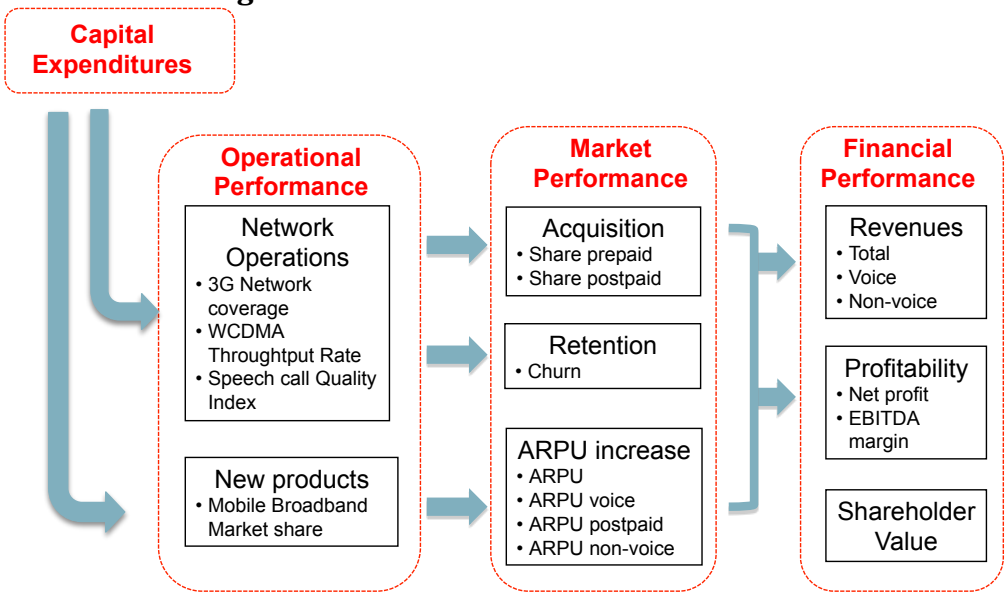
Four case studies of quality leaders were developed to illustrate the points made in the theoretical framework and tested in the statistical analyses. Developed based on desk-based research and interviews, the case studies served two purposes: on the one hand they provide the necessary evidence to support some of the simulation model causal mechanics (how much an investment of x% in CAPEX triggers an improvement in financial performance); on the other hand, causal impact analysis has to control for some exogenous variables. The interrelationship between variables sometimes is not that clean statistically. In that case, case studies help us understand how the different levers of financial performance interact (in methodological terms, cases are more comprehensive and inclusive than financial models). The cases used were the following:

- Verizon
- Softbank
- Entel Chile
- Swisscom

### 3.3. Market simulation

The results of the quantitative analyses served as a basis for developing simulation models. The simulation models developed are based on the causal path researched in the quantitative analyses and validated through the case studies (see figure 3).

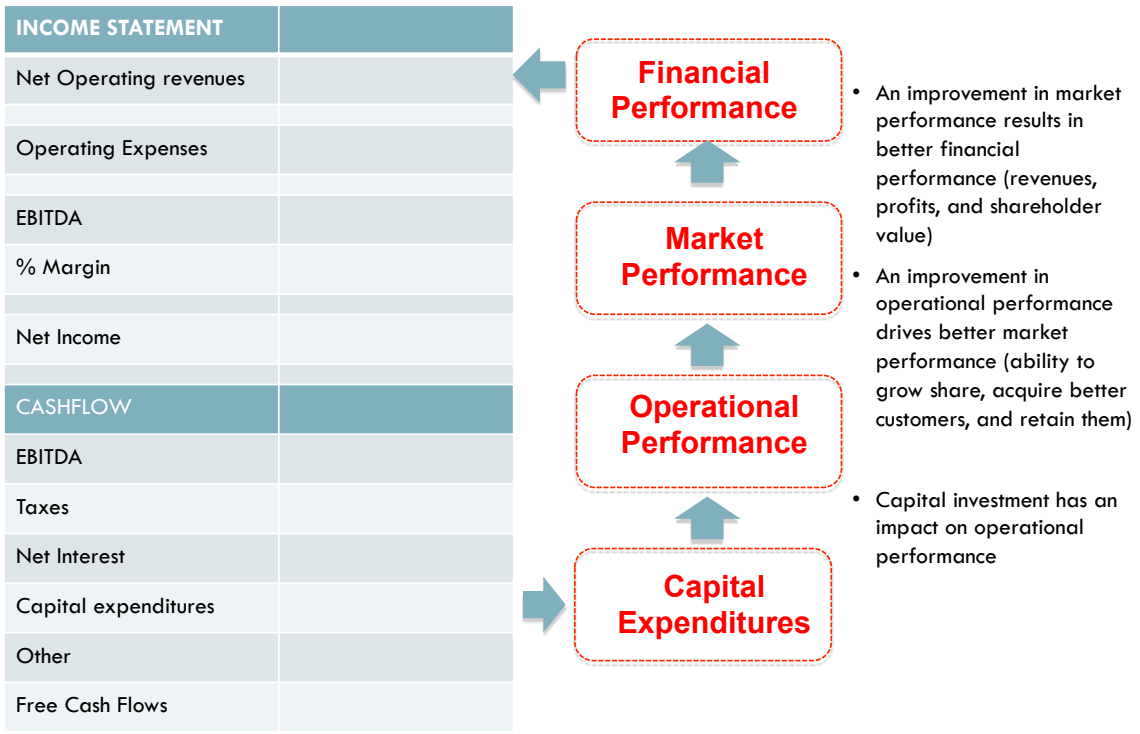
**Figure 3. Structure of Simulation Models**



Since not all variables depicted in figure 3 are statistically available, only those that were utilized in the quantitative analyses (presented in table 1) were considered.

The following simulation models need to be based on the specific impacts of a CAPEX increase for a specific operator in each market: for Brazil, operator 1 was selected; operator 5 was selected in Mexico; and operator 10 for the United States case. Each case simulation started by capturing the carrier's 2013 income statement for their wireless business (therefore, the wireline business for Telefonica do Brazil was excluded). Since the segmented income statement is not readily available in most cases, we relied on analysts' reports to generate a "pro forma" statement to be used as a starting point. On this basis, the simulation model uses the coefficients calculated from each regression to estimate the business impact of alternative CAPEX scenarios (see figure 4).

**Figure 4. Simulation Scenario**




By relying on impact coefficients, the simulation estimated the contribution of a CAPEX increase of 10% on financial performance. In addition to the impact of CAPEX on network quality, and market performance (ARPU, churn, and share), we constructed a model assessing the impact of capital spending on operating expenditures (opex). This additional model allows estimating the impact of CAPEX

increase on financial performance (Revenues, EBITDA). All estimates are presented in US dollars[1].

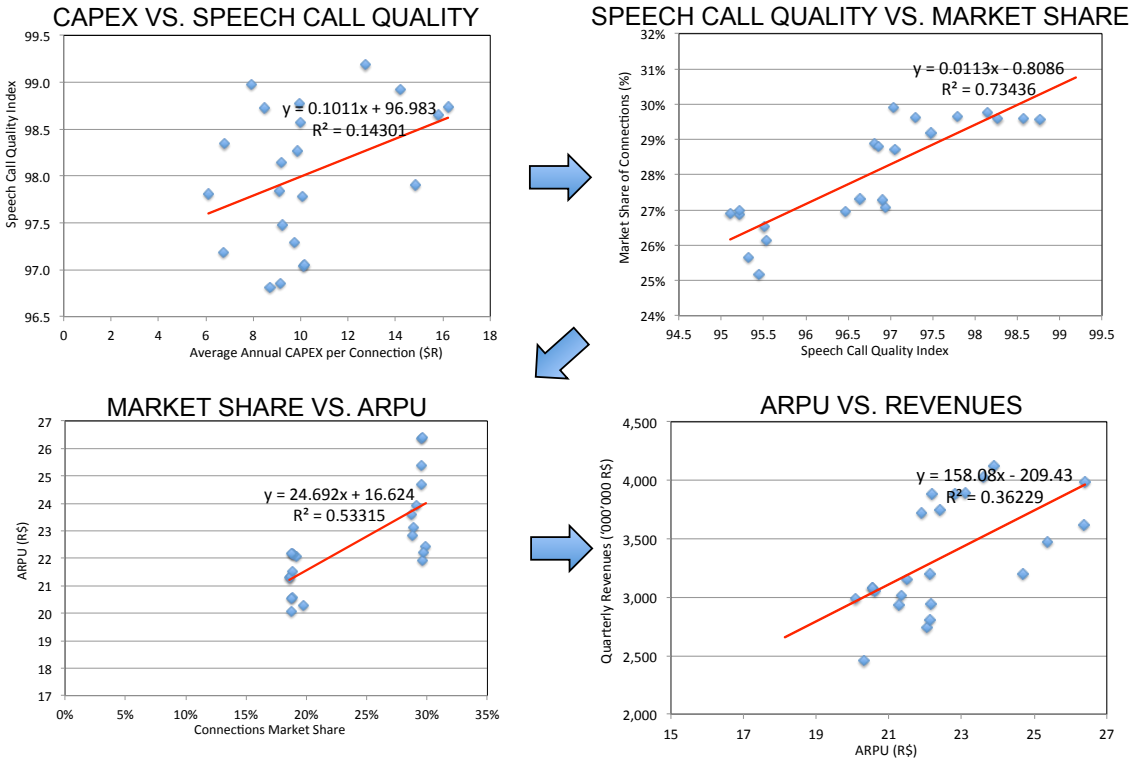
## 4. RESULTS OF THE QUANTITATIVE ANALYSIS

The following chapter presents the results of the quantitative analyses for each of the countries considered. The models predict the evolution over time of conventional financial metrics (Revenues, EBITDA, free cash flows) resulting from an aggressive move to upgrade service quality by raising CAPEX. In addition, the models have the capability of testing alternative investment scenarios. For example, what would the impact be of increasing CAPEX by 10%? Each simulation model was customized to reflect the specific market dynamics (and coefficients of regression) in Brazil, Mexico and the United States.

### 4.1. Brazil quantitative analysis

As a starting point, a simple descriptive analysis for the Brazilian data indicates the existence of correlation among variables (see figure 5).

**Figure 5. Brazilian Carriers: Correlation Analysis**




[1] While all the regressions were made in local currency to avoid any extraneous bias due to FX volatility, the simulations were converted to US dollars to facilitate comparability.

As indicated, the correlation analysis indicates that, *prima facie*, there appears to be some relationship between: 1) CAPEX and Speech Call Quality, 2) Speech quality and market share, 3) Market share and ARPU, and 4) ARPU and revenues. However, in order to understand the causal links, we needed to conduct regression analyses.

The first set of regressions, built to link CAPEX to network KPIs indicates an important effect both in terms of voice and data quality (see table 3).

**Table 3. Brazil: Results of Regression Analyses of CAPEX and Operational Performance**

| CAPEX impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Speech Call quality | 0.0032 pp. (***) | An increase of 1 million $R in average quarterly CAPEX for a year yields an increase of Speech Call Quality Index of 0.0032 units |
| Data Accessibility | 0.0187 pp. (**) | An increase of 1 million $R in average quarterly CAPEX for three years yields an increase on data accessibility rate of 0.01867 points |
| Data Completion | 0.0241 pp. (***) | An increase of 1 million $R in average quarterly CAPEX for three years yields an increase on data completion rate of 0.0241 points |
| Download Speed | 0.02587 pp. (*) | An increase of 1 million $R in average quarterly CAPEX for three years yields an increase on data session higher than 1 Mbps of 0.025872 points |

(***) Statistically significant at 99% (**) Significant at 95% (*) Significant at 90%
Note: All regressions from now on contain fixed effects for year and operator to control for macroeconomic and carrier fluctuations.
Note: Regression outputs under separate cover.

As an interpretation of results of the first equation, if the speech quality index equals 97.8037 (which was that of operator 3 in 1Q11), an incremental investment of $R 5 million per quarter would improve the speech call quality index to 97.8197 a year later. Similarly, if the data accessibility rate equals 98.9127 (again as was operator 3 in 1Q11), an incremental investment of $R 5 million per quarter for three years, would improve the data accessibility rate to 99.0601. Finally, in the case of the last equation, if the share of sessions conducted at a download speed higher than 1 Mbps equals 24.33% (a metric for operator 1 in 1Q11), an incremental investment of $R 5 million per quarter for three years, would raise that share to 24.46 %. In sum, CAPEX was found to have a positive contribution to the improvement of voice and data traffic in Brazil. Furthermore, evidence also indicates that the extent of the CAPEX contribution to network quality is higher in data sessions than on speech calls.

Having proven the first step in the causal link (CAPEX to operational performance), we now move to test the contribution of operational to market performance (see table 4).

**Table 4. Brazil: Results of Regression Analyses of Operational Performance and Market Performance**

| Speech Call Quality impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Overall market share | 0.3681 pp. (***)[1] | An increase of 1 point in the speech call quality index, yields an increase of 0.3681 percentage points in the operator market share |
| Churn | -0.2413 pp. (**)[1] | An increase of 1 point in the speech call quality index, yields a decrease of 0.2413 percentual points in the overall churn a quarter after |
| ARPU | 0.4903 $R (**) | An increase of 1 point in the speech call quality index yields an increase of 0.4903 Reais in the overall ARPU two quarters later |

| Data Accessibility impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Overall market share | 0.1846 pp. (***)[1] | An increase of 1 percentage point in the accessibility rate yields an increase of 0.1846 percentage points in the operator market share |
| Churn | -0.1080 pp. (**)[1] | An increase of 1 percentage point in the accessibility rate, yields a decrease of 0.1080 percentual points on the operator churn a quarter later |
| ARPU | 0.2518 $R (**) | An increase of 1 percentage point in the accessibility rate, yields an increase of 0.2518 Reais on the operator ARPU two quarters later |

| Data Completion impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Overall market share | 0.1582 pp. (***)[1] | An increase of 1 percentual point in the completion rate, yields an increase of 0.1582 percentage points on the operator market share |
| Churn | -0.0942 pp. (**)[1] | An increase of 1 percentual point in the completion rate, yields a decrease of 0.0942 percentage points on the operator churn a quarter later |
| ARPU | 0.1981 $R (**) | An increase of 1 percentage point in the completion rate, yields an increase of 0.1981 Reais on the |

| | | |
|---|---|---|
| | | operator ARPU a quarter later |

| Download Speed impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Overall market share | 0.1405 (***)[1] | An increase of 1 percentage point in the share of data sessions over 1 Mbps, yields an increase of 0.1405 percentage points on the operator market share |
| Churn | -0.0172 pp. (**)[1] | An increase of 1 percentage point in the share of data sessions over 1 Mbps, yields a decrease of 0.0172 percentage points on the operator churn a quarter later |
| ARPU | 0.0527 $R (***) | An increase of 1 percentage point in the share of data sessions over 1 Mbps, yields an increase of 0.0527 Reais on the overall ARPU three quarters later |

(***) Statistically significant at 99% (**) Significant at 95% (*) Significant at 90%

[1] The difference in the number of decimals between the coefficient in regression output and the value above is due to the fact that the dependent variable is accounted in percent, which requires an adjustment of two decimal points

Note: Regression outputs under separate cover.

As an interpretation of results of the first equation, if the market share equals 19.75% (which was that of operator 3 in 1Q11), an increment in speech call quality index of 1 point (from 97.8037 to 98.8037) would increase market share to 20.12%. Similarly, if a Brazilian carrier churn equals 2.60% (operator 3 in 1Q11), an increment in speech call quality index of 1 point (from 97.8037 to 98.8037) would reduce churn to 2.36%. Finally, if a Brazilian carrier blended ARPU equals $R 20.31 (which was operator 3 in 1Q11), an increase in the speech call quality index of 1 point (from 97.8037 to 98.8037) would result in an increase of blended ARPU to $R 20.80. To sum up, speech call quality was found to have a positive contribution to the improvement of market performance of Brazilian wireless carriers. Similar effects were identified for data accessibility rate, and completion rate.

Of note is the impact in improvement of average download speed in data sessions. If the share of data sessions over 1 Mbps equals 29.58% (operator 1 rate in 1Q11), an increase of 1 percentage point (from 24.33% to 25.33%) would improve the carrier's market share to 29.72%. Similarly, if the carrier churn equals 2.70% (which was that of operator 1in 1Q11), an increase in the share of data sessions over 1 Mbps of 1 percentage point (from 24.33% to 25.33%), would reduce churn to 2.68%. Finally, if the carrier's ARPU equals $R 24.68 (operator 1 in 1Q11), an increase in the share of data sessions over 1 Mbps of 1 percentage point (from 24.33% to 25.33%), would increase ARPU to $R 24.73.

The contribution of network quality to market performance varies in terms of the temporal impact. Focusing on the impact of speech call quality, the analyses indicate that improvement in quality of speech calls has an immediate impact of increasing market share (same quarter). On the other hand, the improvement in speech call quality has an impact on churn reduction after one quarter. This is intuitively right since subscribers will decide to stay within their carrier only after they have accumulated sufficient experience in terms of quality of voice calls. In addition, the improvement of speech call quality contributes to an increase in ARPU only after two quarters. This represents an important finding in terms of Brazilian customer behavior in reaction to the improvement of voice quality: first, he/she decides to remain within the same carrier, and over time increases spending either by purchasing other services or increasing the minutes of use.

Moving to the analysis of the causal link between market and financial performance, the results also confirm the causal link (see table 5).

**Table 5. Brazil: Results of Regression Analyses of Market Performance and Financial Performance**

| ARPU impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Revenues[2] | $R 134 million (***) | An increase of one Real in ARPU increases revenues by 134.162 millions Reais |
| EBITDA[2] | $R 84 million (**) | An increase of one Real in ARPU increases EBITDA by 83.918 millions Reais |

| Market Share impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Revenues[2] | $R 104 million (*) | An increase of 1 percentage point in market share increases revenues by 104.493 millions Reais |
| EBITDA[2] | $R 78 million (***) | An increase of 1 percentage point in market share increases EBITDA by 77.832 millions Reais |

| Churn impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Revenues | -6.86 %[1] | A decrease of 1 percentage point in overall churn increases revenues by 6.86% two quarters later |
| EBITDA | -10.28 % (*) | A decrease of 1 percentage point in overall churn increases EBITDA by 10.28% |

(***) Statistically significant at 99% (**) Significant at 95% (*) Significant at 90%

[1] The difference in the number of decimals between the coefficient in regression output and the value above is due to the fact that the dependent variable is accounted in percent, which requires an adjustment of two decimal points.

[2] These regressions contain an autoregressive variable to control for biases, assuming the value of the dependent variable is partly driven by inertia by the value in the prior quarter.
Note: Regression outputs under separate cover.

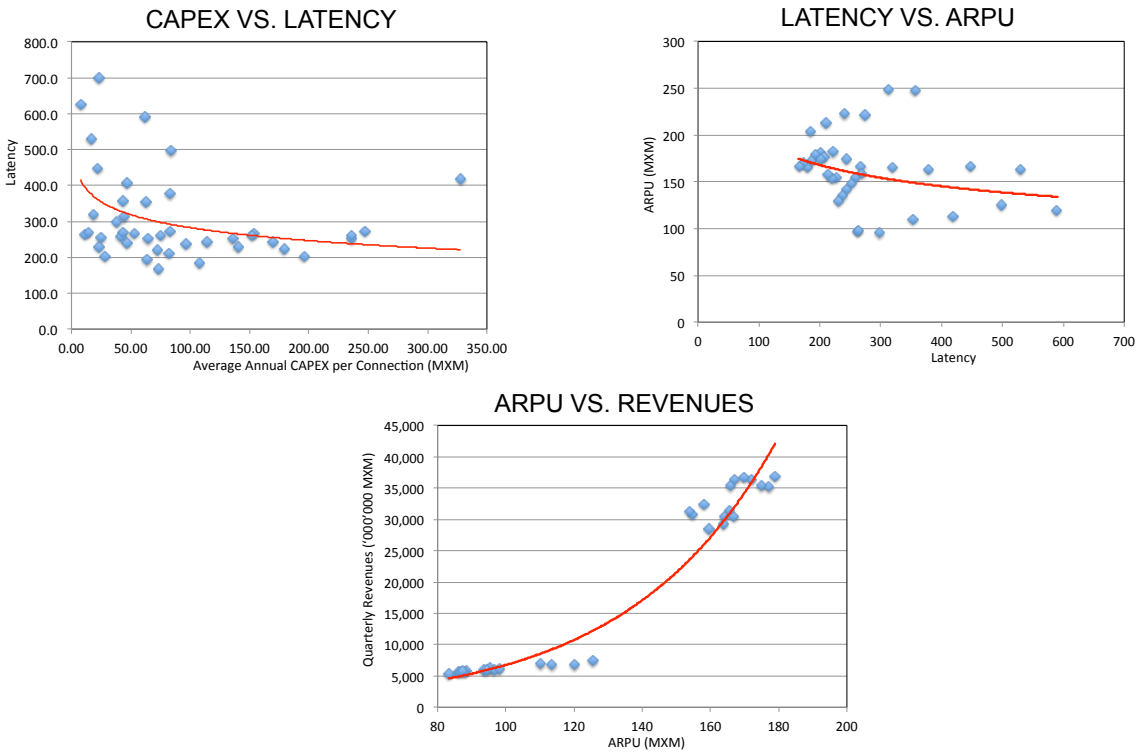
As with the impact of operating to market performance, the positive contribution of market performance to financial results has also been verified. For example, an increase of 1 percentage point in market share (from 29.58% to 30.58% for operator 1 in 1Q11), increases revenues by $R 104.493 million (from $R 3,194.310 million to $R 3,298.803 million). Similarly, an increase of 1 percentage point in market share (from 29.58% to 30.58% for operator 1 in 1Q11), grows EBITDA by $R 77.832 million (from $R 847.782 million to $R 925.614 million). Similar effects have been identified for ARPU and a reduction of churn.

The discrimination of voice versus data quality metrics at the beginning of the causal chain also allows calculating the impact of voice versus data improvements resulting from CAPEX increase. For that purpose, we multiply the results for each of the data quality metrics in the first set of regressions (data accessibility, data completion, and download speed) to value the impact on first market, and then financial metrics, and compare the results against the impact of the voice quality metrics. Along these lines, the impact of CAPEX on data quality improvement will result in $R 189 million incremental revenues, while the impact of voice quality improvement will only yield $R 25 million. This finding is particularly useful to understand the importance of wireless broadband in the Brazilian market.

### 4.2. Mexico quantitative analysis

While the descriptive statistical analysis for the Mexican data also indicates a correlation among variables, some differences emerge when compared with the Brazilian results (see figure 6).

**Figure 6. Mexican Carriers: Correlation Analysis**




As indicated in figure 6, the correlation analysis indicates that the existence of directional causality between 1) CAPEX and latency, 2) Latency and ARPU, and 3) ARPU and revenues. However, the difference in correlational patterns between the Brazilian linear results (figure 4) and the non linear ones of the Mexican market above relate to differences in market structure of each country. The Brazilian national wireless market comprises four fairly equally balanced players in terms of market share[2] while Mexico comprises one player that controls 74% of the market (Telcel) and two smaller players (Movistar and Iusacell). Along these lines, when players are equally balanced, any change in CAPEX has a linear impact on performance variables. On the other hand, when the operators' market shares are not similar, two dynamics are at play. First, in the relationship between CAPEX and latency, an increase in CAPEX of small players has an immediate effect on latency (small increases in CAPEX have large effects on latency) while the large player due to its size needs increase its investment significantly more to have an impact (tail end of the curve). Second, with regards to the relationship between ARPU and revenues, a "return to scale" appears to be at play. Any small increase in ARPU of a large player yields a big impact on revenues because big operators benefit from large number of users (in other words, for a large player, a point of ARPU is worth more than for a small player).

In order to understand the causal links, we needed to conduct regression analyses.

[2] Oi is a bit smaller than other three

As in the case of Brazil, the first set of regressions for the Mexican wireless market, built to link CAPEX to network KPIs indicates an important effect in terms of data quality (see table 6)[3].

**Table 6. Mexico: Results of Regression Analyses of CAPEX and Operational Performance**

| CAPEX Square impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Latency | 0.00000452 (**) | An increase of MXN $1 Million squared quarterly CAPEX (CAPEX elevated to power of two), yields a reduction of 0.00000452 millisecond in latency in data sessions |
| Download Speed | 0.0001266 kbp/s (*) | An increase of MXN $1 Million in squared quarterly CAPEX (CAPEX elevated to power of two), yields an increase of 0.0001266 Kbp/s in average download speed in data sessions |

(***) Statistically significant at 99% (**) Significant at 95% (*) Significant at 90%
Note: Regression outputs under separate cover.

As an interpretation of results of the first equation, a quarterly CAPEX increase of MXN 242 Millions (10% CAPEX increase for operator 5) yields a reduction in latency from 166.52 milliseconds to 77.55 milliseconds (in other words, a reduction of 53%). Similarly, a quarterly CAPEX increase of MXN 242 Millions (10% CAPEX increase for operator 5) improves the carrier's download speed of data sessions from 4.2 Mbp/s to 6.7 Mbp/s (a 60% increase). In sum, CAPEX was found to have a highly positive contribution to the improvement in quality of data traffic in Mexico (both latency and download speed). It should be noted however, that the final impact of CAPEX increase depends on the capital spent in prior periods, which is why the impact will be higher for companies with higher relative spending.

Having proven the first step in the causal link (CAPEX to operational performance), we now move to test the contribution of operational to market Performance (see table 7).

**Table 7. Mexico: Results of Regression Analyses of Operational Performance and Market Performance**

| Latency impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Mobile Broadband market share | -0.00856 pp (***)[1] | A reduction of 1 millisecond in latency, yields an increase of 0.0086 percentage points on mobile broadband market share |

[3] The impact of CAPEX on voice quality was not estimated for lack of data, rather than by consideration that voice call quality did not have impact whatsoever.

| | | |
|---|---|---|
| ARPU | -0.1516 (***)[1] | A reduction of 1 millisecond in latency, yields an increase of 0.1516 MXN on ARPU |

| Broadband Speed Impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Mobile Broadband market share | 0.0005653 pp (**) | An increase in 1 Kbp/s in the average download speed yields an increase in mobile broadband market share of 0.0005653 percentage points |
| ARPU | 0.00865 (**) | An increase in 1 Kbp/s in average download speed of data sessions yields an increase in ARPU of MXN 0.00865 |

(***) Statistically significant at 99% (**) Significant at 95% (*) Significant at 90%
Note: Regression outputs under separate cover.

As an interpretation of results of the first equation, a decrease in average latency from 166.52 milliseconds (operator 5, 4Q13) to 165.52 milliseconds yields an increase in mobile broadband market share from 72.62% to 72.63%, and an increase in ARPU from MXN 167.000 to MXN 167.1516. Similarly, an increase in average download speed of data sessions from 4,202.58 Kbps (operator 5, 4Q13) to 4,302.58 Kbps results in an increase in mobile broadband market share from 72.62% to 72.68% and an increase in ARPU from MXN 167.00 to MXN 167.86.

Moving to the analysis of the causal link between market and financial performance, the results also confirm the causal link (see table 8).

**Table 8. Mexico: Results of Regression Analyses of Market Performance and Financial Performance**

| ARPU impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Revenues | MXN 16.822 million (*) | An increase of MXN $1 in ARPU, yields an increase on revenues of MXN 16.822 Millions |
| EBITDA | MXN 11.227 million (**) | An increase of MXN $1 in ARPU, yields an increase on EBITDA of MXN 11.227 Millions |

| Mobile Broadband Market Share impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Revenues | MXN 112.627 million (**) | An increase of 1 percentual point in mobile broadband market share, yields an increase on revenues of MXN 112.627 Millions |
| EBITDA | MXN 104.502 million | An increase of one percentual point in mobile |

| | | |
|---|---|---|
| | (**) | broadband market share, yields an increase on EBITDA of MXN 104.502 Millions |

Note: Regression outputs under separate cover.

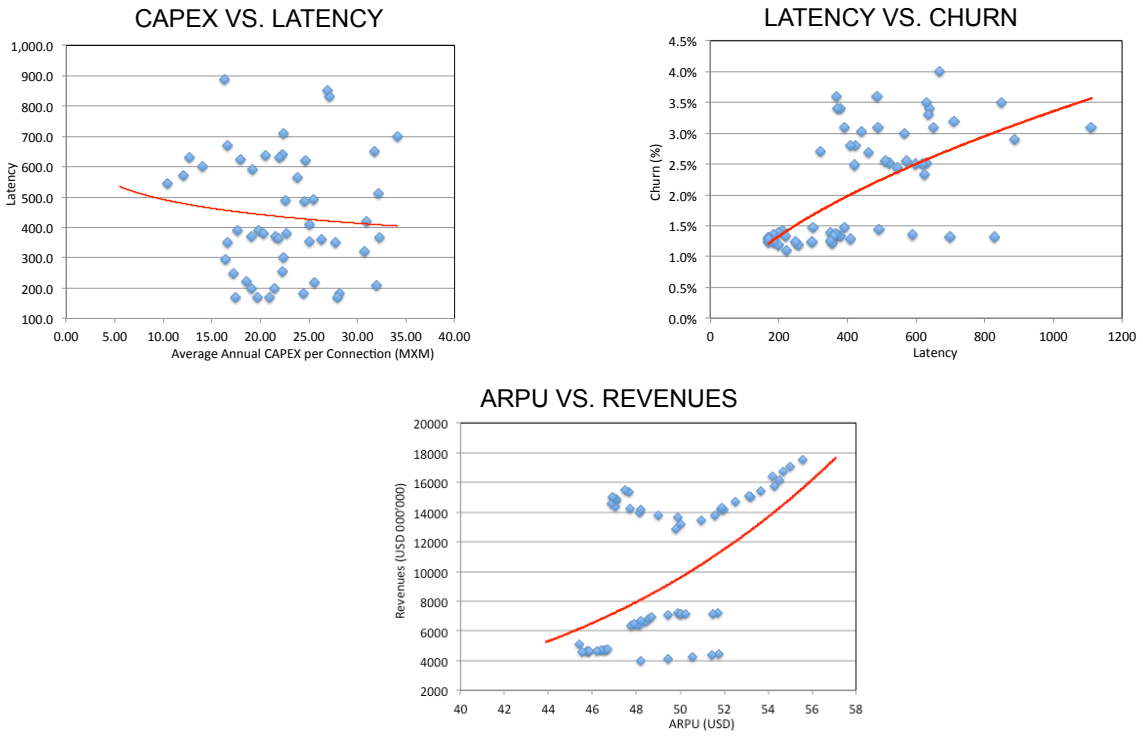
As with the impact of market performance to financial results, its contribution has also been verified. For example, according to the regression results, if quarterly revenues of a Mexican wireless carrier equal MXN 174,062 million (those of operator 5 in 4Q13), an incremental ARPU of MXN 1.00 (from MXN 167 to MXN 168 would increase quarterly revenues to MXN 174,079 million. Similarly, if EBITDA of the same carrier equals MXN 84,537 million (operator 5 in 4Q13), an incremental ARPU of MXN 1.00 would increase EBITDA to MXN 84,548 million.

As for the impact of mobile broadband market share, with the same quarterly revenues, an incremental mobile broadband market share of one percentage point (from 72.62% to 73.62%) would grow revenues to MXN 174,175 million. If EBITDA equals MXN 84,537 Million (operator 5 in 4Q13), an incremental mobile broadband market share of one percentage point (from 72.62% to 73.62%), would increase EBITDA to MXN 84,642 million.

### 4.3. United States quantitative analysis

The descriptive statistical analysis for the United States data also indicates a correlation among the four sets of variables with a pattern that resembles the Brazilian analysis (see figure 7).

**Figure 7. United States Carriers: Correlation Analysis**



As indicated in figure 7, the correlation analysis indicates that the existence of some directionally causal linkage between: 1) CAPEX and latency, 2) Latency and churn, and 3) ARPU and revenues. The similarity in patterns between the Brazilian (figure 2) and the United States linear correlations confirm that differences in market structure have an impact on causality. In a similar structure as the Brazilian wireless market, the United States national wireless market comprises four fairly equally balanced players in terms of market share[4]. To reiterate, when players are equally balanced, any change in CAPEX has a linear impact on performance variables, which would not be the case if one of the players controls a much larger share of the market, as is the case of Mexico.

In order to understand the causal links, we needed to conduct regression analyses. As in the case of Brazil and Mexico, the first set of regressions for the United States wireless market, built to link CAPEX to network KPIs indicates an important effect both in terms of data quality (see table 9).

**Table 9. United States: Results of Regression Analyses of CAPEX and Operational Performance**

| CAPEX impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Latency | -0.2822 (***) | An increase of 1 million USD in average quarterly CAPEX a year before, yields a reduction of 0.2822 units in latency |
| Download Speed | 0.0425 p.p. (***) | An increase of 1 million USD in average quarterly CAPEX a year before, yields an increase on sessions over 1 Mbps of 0.0425 percentual points |

(***) Statistically significant at 99% (**) Significant at 95% (*) Significant at 90%
Note: Regression outputs under separate cover.

As an interpretation of results of the first equation, an increase in the average quarterly CAPEX for a year of US$ 108 Millions (10% CAPEX increase for operator 10) yields a reduction in latency from 280 to 250 milliseconds (a reduction of 11%). A similar CAPEX increase yields an increase in the share of sessions over 1 Mbps from 83.00% to 87.60% (a 6% increase). In sum, CAPEX was found to have a positive contribution to the improvement in quality of data traffic in the United States.

[4] Sprint and T-Mobile are somewhat smaller than Verizon and ATT.

Having proven the first step in the causal link (CAPEX to operational performance), we now move to test the contribution of operational to market performance (see table 10).

**Table 10. United States: Results of Regression Analyses of Operational Performance and Market Performance**

| Latency impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Total market share | 0.0058 p.p. (***) | A reduction of 1 millisecond in latency, yields an increase of 0.0058 percentage points in total market share |
| Churn reduction | 0.0014 p.p. (***) | A reduction of 1 millisecond in latency yields a reduction of 0.00144 percentage points on churn a quarter after |
| ARPU | 0.0065 USD (*) | A reduction of 1 millisecond in latency, yields an increase of USD 0.0065 in ARPU two quarters after |

| Broadband Speed Impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Total market share | 0.0117 p.p. (*) | An increase of 1 percentage point in data sessions over 1 Mbps, yields an increase of 0.0117 percentage points in market share a quarter after |
| Churn | -0.0159 p.p. (***) | An increase of 1 percentage point in data sessions over 1 Mbps yields a decrease of 0.0159 percentage points in churn |
| ARPU | 0.0476 USD (*) | An increase of 1 percentage point in data sessions over 1 Mbps yields an increase in ARPU of USD 0.0476 |

(***) Statistically significant at 99% (**) Significant at 95% (*) Significant at 90%
Note: Regression outputs under separate cover.

As an interpretation of results of the first equation, a decrease in average latency from 280 milliseconds (operator 10, 4Q13) to 250 milliseconds yields an increase in market share from 13.58 % to 13.75 %, a reduction in churn from 3.20 % to 3.16 %, and an increase in ARPU from US$ 39.48 to US$ 39.68. Similarly, an increase in data sessions over 1 Mbps from 83.00 % (operator 10, 4Q13) to 85.00 % yields an increase in market share from 13.58 % to 13.60 %, a decrease in churn from 3.20 %

to 3.17%, and an increase in ARPU from US$ 39.48 to US$ 39.58. It is important to underscore that the impact of a decrease in latency on churn reduction will become effective a quarter after the improvement in service quality, while the increase in ARPU will become effective only two quarters after. Similarly, the impact of an increase in broadband download speed on market share will become effective one quarter later.

Moving to the analysis of the causal link between market and financial performance, the results also confirm the causal link (see table 11).

**Table 11. United States: Results of Regression Analyses of Market Performance and Financial Performance**

| ARPU impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Revenues | USD 187.912 million (***) | An increase of USD 1 in ARPU yields an increase in revenues of USD 187.912 Millions |
| EBITDA | USD 151.184 million (***) | An increase of USD 1 in ARPU yields an increase on EBITDA of USD 151.184 Millions |

| Market Share impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Revenues | USD 447.722 million (***) | An increase of 1 percentage point in market share yields an increase on revenues of USD 447.722 Millions |
| EBITDA | USD 230.057 million (***) | An increase of 1 percentage point in market share yields an increase in EBITDA of USD 230.057 Millions |

| Churn impact on: | Coefficient and level of significance of explanatory variable | Interpretation |
|---|---|---|
| Revenues | USD 127.543 million (***) | A decrease of 1 percentage point in churn, yields an increase on revenues of USD 127.543 Millions three quarters after |
| EBITDA | USD 41.6674 million | A decrease of 1 percentage point in churn yields an increase on EBITDA of USD 41.667 Millions three quarters after; however, the statistical significance of this result is higher than 85 % |

Note: Regression outputs under separate cover.

As with the impact of operating performance on market performance, the contribution of the latter on financial results has also been verified. For example, if revenues equal US$ 26,100 million and the EBITDA US$ 5,387 million (operator 10 in 4Q13), an incremental ARPU of US$ 1.00 (from US$ 39.48 to US$ 40.48), would increase revenues to US$ 26,288 Million and the EBITDA to US$ 5,538 million. Similarly, under the same financial results, an incremental market share increase of one percentage point would increase revenues to US$ 26,548 million and the EBITDA to US$ 5,617 million. Finally, a decrease in churn of one percentage point (from 3.20% to 2.20%) would result in a revenue increase to US$ 26,228 million and an EBITDA growth to US$ 5,429.

## 5. RESULTS OF THE QUALITATIVE ANALYSIS

The quantitative analyses relying on Brazilian, Mexican and United States data have confirmed the causal relationship between capital investment, operational performance, market performance and financial results, outlined in the first hypothesis of this study. As the research literature indicated for other industries, this research has proven the point that increasing capital investment in wireless telecommunications yields superior carrier performance. Beyond this, our research also indicated that, while the causal effects exist, the strength of a causal pattern might change according to market structure: in highly concentrated markets, the impact of capital investment benefits more the dominant player than the secondary ones (in other words, there appears to be a return to scale in capital investment).

The next question to investigate is the interplay of these factors (CAPEX, network quality and carrier performance) in the context of strategic imperatives. The remaining hypotheses defined at the beginning of the study were three:

- **H2: By increasing CAPEX levels, a dominant player having an economy of scale advantage, puts pressure on their competitors that need to limit their ability to create short-term value to shareholders in order to keep up with the incumbent.**

- **H3: Sustained capital spending can enhance a carrier's ability to monetize a market opportunity and reduce operating costs.**

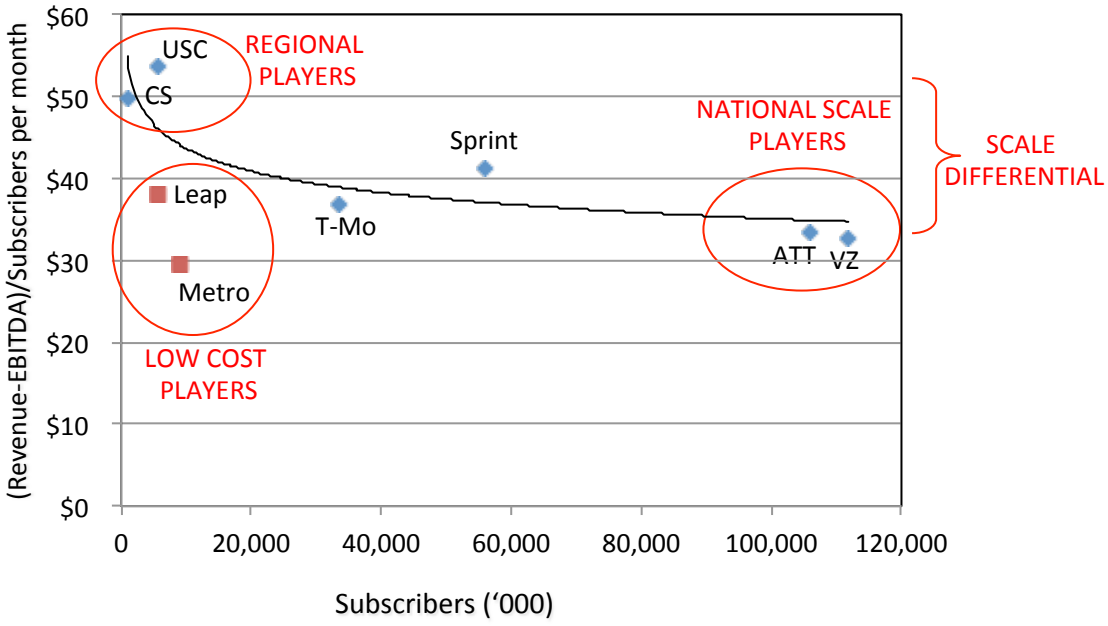
- **H4: An increase in CAPEX can also result in a first mover advantage, which yields competitive superiority over time.**

In order to test these hypotheses, we have relied on case studies of wireless carriers in four countries: Swisscom in Switzerland, Softbank in Japan, Verizon in the United States, and Entel in Chile.

### 5.1. The economy of scale advantage of dominant player CAPEX

Even in markets with balanced structures, there are some carriers that have a more advantaged position in terms of market share. For example, in the United States market, Verizon and ATT command a lead in market share with respective shares of 33.99% and 33.03%[5]. As expected, given the level of capital intensity of the wireless industry, one would expect that larger players would benefit from operational economies of scale. This is clear in figure 8.

**Figure 8. United States: Economies of Scale (2013)**

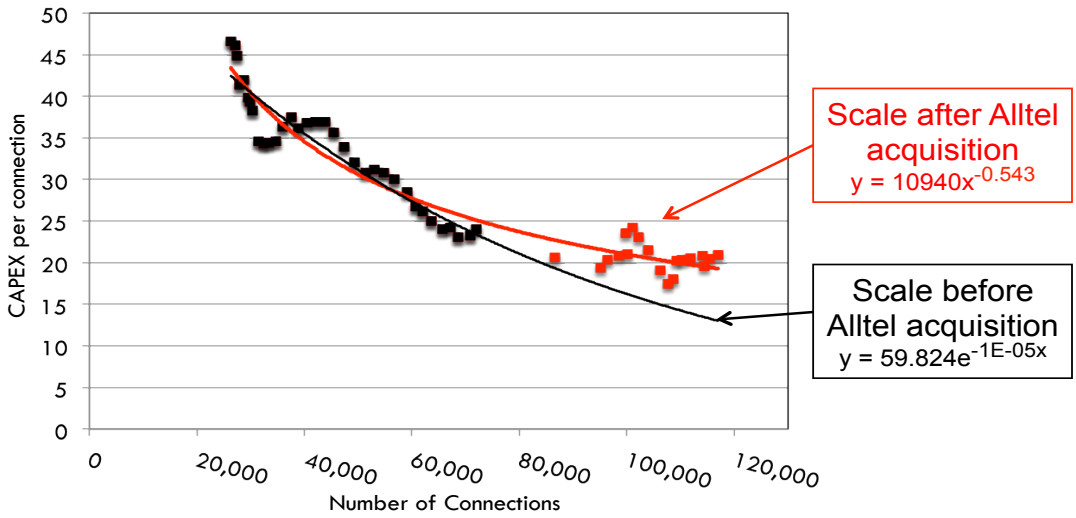



*Source: TAS analysis*

[5] Source: GSMA Intelligence.

As figure 8 indicates, due to their larger subscriber base, Verizon and ATT exhibit lower unit operating costs than their peers. However, beyond operating expenditures, capital spending is also affected by economies of scale. Figure 8 depicts CAPEX per subscriber for Verizon Wireless between 2000 and 2013 (see figure 9).

**Figure 9. Verizon Wireless: CAPEX Economies of scale (4Q00-3Q13)**



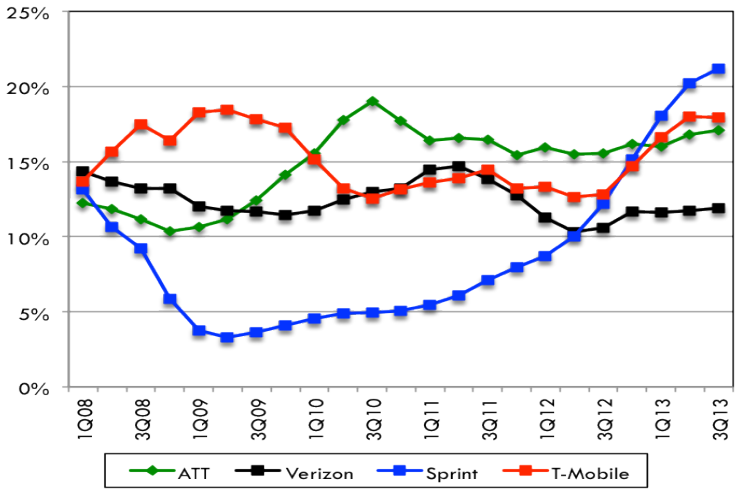

*Source: TAS analysis*

Over time, the larger Verizon's customer base, the lower its CAPEX per connection. In other words, despite the conventional wisdom that wireless is essentially a "pay as you go" industry, where network investments are proportional to the size of the subscriber base (and therefore variable), the fact is that there a number of components of its cost structure that are shared by the whole facility and therefore, subject to scale effects.

If scale matters to capital investment, large players would have an advantage insofar that they can preempt their peers in investing toward capitalizing in the next wave of technological innovation. In other words, economies of scale lead to a first mover advantage, which is reinforced when considering that less-endowed players would take time to respond. Kerin et al (1992) showed that the longer the elapsed time between the entry of the first mover and that of later entrants, the more opportunities becomes available to the first mover to achieve cost and differentiation advantages.

This is exactly what happens in the wireless industry. The evolution of CAPEX as percent of revenues in the United States wireless sector indicates that Verizon maintains a middle ground position approximating 13% of sales (see figure 10).

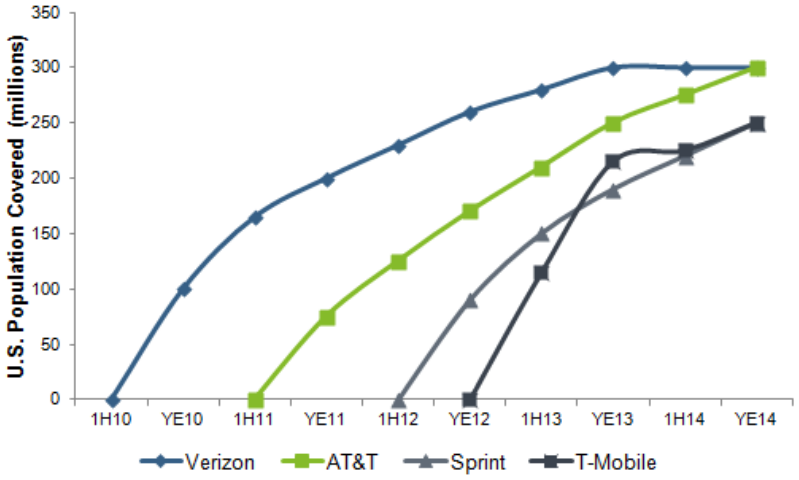
**Figure 10. United States: CAPEX as percent of revenues (in %)**




Note: CAPEX is expressed as a forward rolling average for 12 months
*Source: GSMA Intelligence; TAS analysis*

Yet, despite this comparatively moderate investment as percent of sales, Verizon has anticipated its peers in the deployment of LTE (see figure 11).

**Figure 11. United States: LTE Coverage**

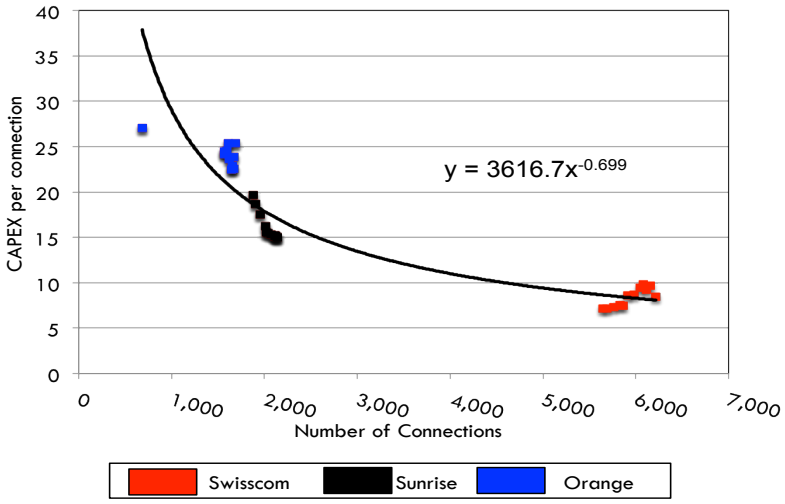



*Source: Company data; Stifel*

By becoming the leader in LTE deployment, Verizon Wireless can profit before its competitors, and achieve the lowest churn (1.28%), highest ARPU ($57.72), and highest quarterly growth in post paid subscribers (4.35%).

A same case in point can be seen in the case of Swisscom, the dominant player in the Swiss market. Again, Swisscom's economies of scale in CAPEX are substantial vis-à-vis its peers (see figure 12).

**Figure 12. Swiss Wireless Industry CAPEX Economies of Scale (1Q10-3Q13)**




*Source: GSMA Intelligence; TAS analysis*

As a result, Swisscom invests proportionally less than its peers, and yet is capable to maintain market leadership. The carrier considers investment in its network as a long-term innovation strategy. As such, it was the first carrier in Switzerland to deploy 3G, 3.5G, and LTE. As a result, it was able to capitalize in the mobile broadband opportunity (27% of its revenues are data driven) and achieve higher profitability per subscriber (its average margin per user ($21.63) is higher than its competitors. In sum, dominant players leverage their scale advantage to become first movers through capital spending, which allows them to become the standard for the service category, carve out the most profitable segment, and lock-in subscribers by raising switching costs.

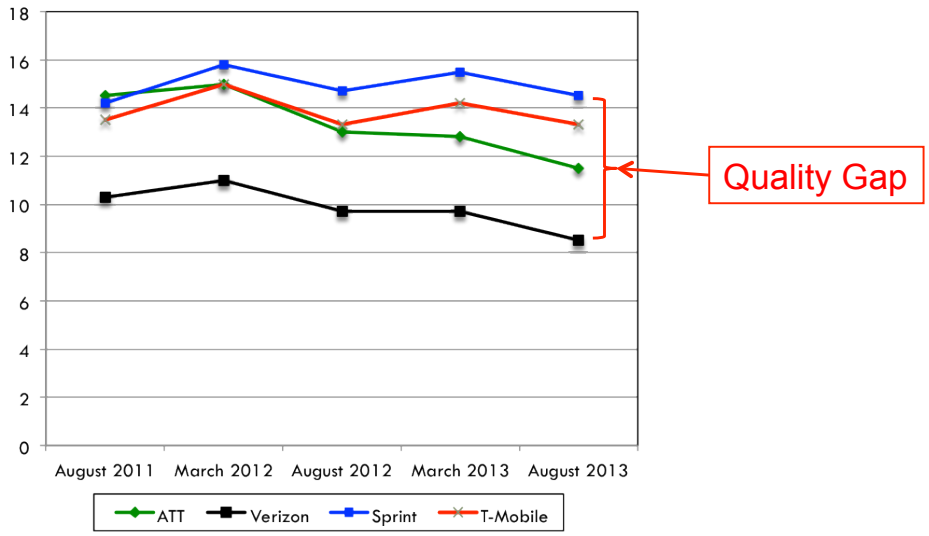
### 5.2. Capital investment as a strategy to monetizing market opportunities and reducing operating expenses

The benefits of increasing capital investment in order to achieve superior network quality are associated with two key benefits. The first one is gaining a large share of emerging opportunities, while the second one is related to achieving a lower cost position.

#### 5.2.1. Network quality and superior market performance

The strategy to invest in the network in order to achieve superior market performance has been found to be applicable not only to dominant carriers but also to challengers. For example, ever since 2003, Verizon's technology strategy has focused on building product differentiation based on network reliability to capture the mobile broadband opportunity. At the time, the carrier anticipated two key market trends: 1) significant market demand for increasing network speeds, and 2) Increasing demand for mobile broadband. This is the time when its capital spending started focusing on high growth markets, most notably high-speed wireless broadband. Verizon believed that the combination of devices and network quality would drive smartphone adoption, network usage and loyalty. As a result, the carrier invested at least $6.5 billion per year between 2005 and 2008 to increase network coverage and capacity while adding new services. The investment paid off in terms of customer perception, with the quality gap between Verizon and the other national carriers increasing over time (see figure 13).

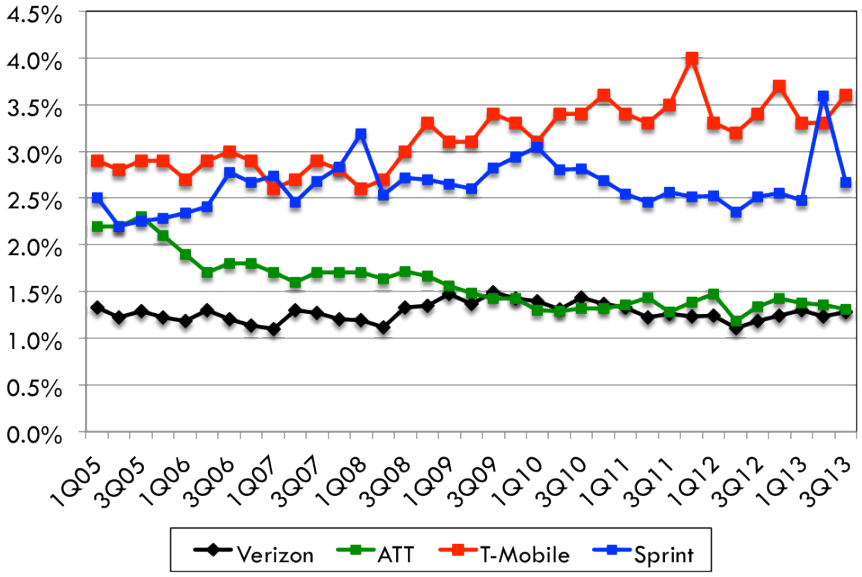
**Figure 13. United States Wireless Carriers: Network Quality Performance Ratings (*)**



(*) The lower the rating, the better is network quality performance
*Source: J.D. Power*

As demonstrated in the quantitative analysis above, Verizon was capable of leveraging its superior network quality to achieve the lowest market churn (although its position is under challenge by ATT) (see figure 14).

**Figure 14. United States Wireless Carriers: Quarterly Churn (2005-13)**




*Source: GSMA Intelligence*

Verizon Wireless' superior network quality had also several key positive contributions in terms of commercial and financial performance:

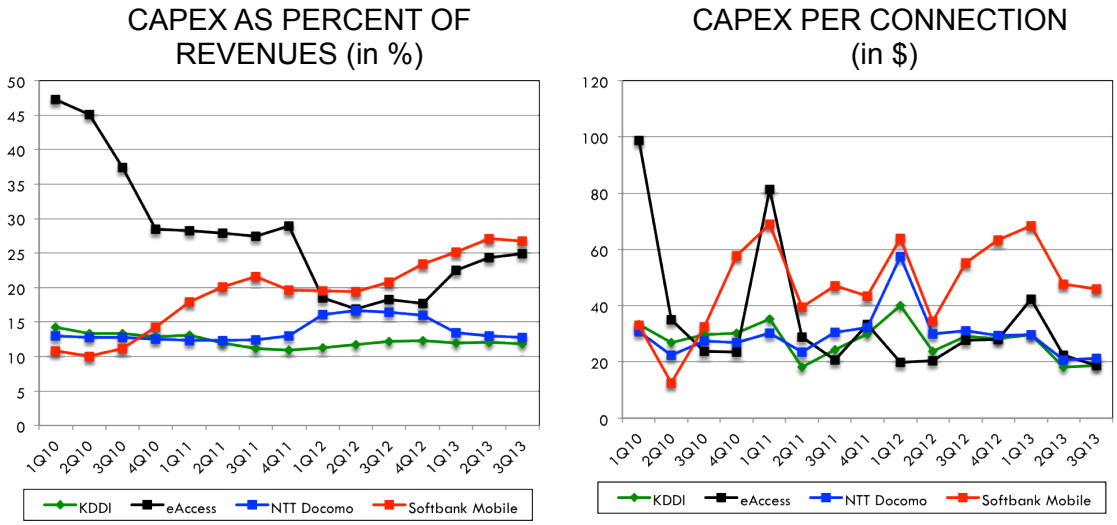
- Highest growth rate in postpaid since 2011
- The carrier with the highest ARPU since the same year
- The highest volume of smartphone sales since 2013
- Highest revenues (despite the inorganic effect of the Alltel acquisition)
- Superior EBITDA margins since 2007

As mentioned above, the strategy of increasing network investment to capitalize on an emerging business opportunity is also available to wireless challengers. In 2006, Softbank was underperforming its competitors in Japan across all market metrics: third in market share (15.6%), highest churn (1.3%), and third in ARPU ($49). Poor network quality was the underlying reason of these shortfalls. Twenty-six percent of subscribers churning justified their decision on the basis of weak radio signal, while 47% of subscribers that did not enroll in a Softbank plan said it was due to poor quality network. At that point, Softbank determined that the carrier transformation

had to be defined around the need to completely erase any reputation for poor network quality.

Since 2010, the carrier consistently increased its CAPEX as a percent of revenues, outpacing its competitors in terms of capital invested per connection (see figure 15).

**Figure 15. Japan Wireless Industry**




*Source: GSMA; TAS analysis*

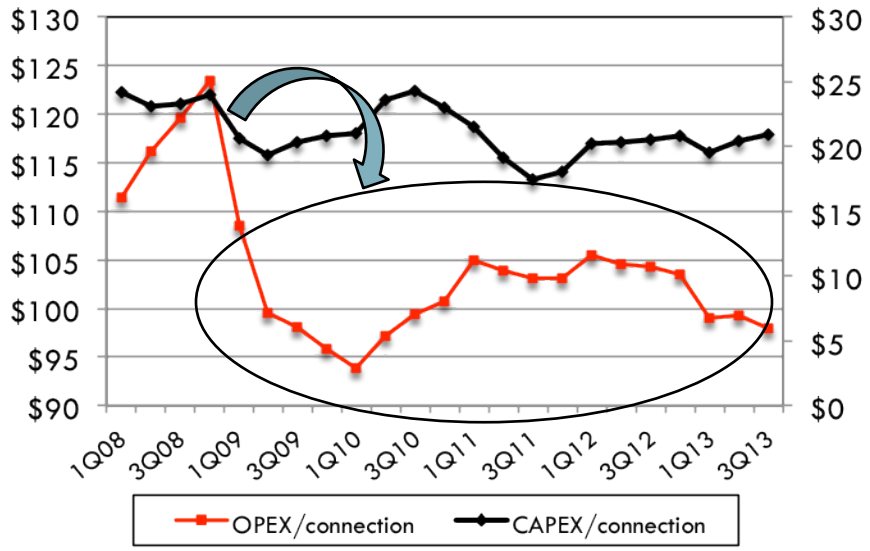
The investment was primarily targeted to match the dominant market player, NTT Docomo, in terms of network performance by focusing on LTE roll-up and Wi-Fi off-loading. Two and a half years later, Softbank surpassed all its competitors in terms of data connectivity rates for smartphones, LTE download speed, and voice call connection rate. As a result of this improvement, the carrier increased market share to 24% (and mobile broadband 25%), reduced churn to 1.1%, and increased ARPU in the last year. The market results were consistently trending up: highest growth in the industry, highest EBIT and superior EBITDA margins.

### 5.2.2. Network quality and low operating costs:

The postulate that front-loading investment in the network could not only yield product differentiation but also cost benefits could run counter the conventional theory of competitive advantage which establishes that the latter can be achieved through either low cost or product differentiation. In fact, more recent research has shown that, rather than being at opposite ends of the strategy spectrum, quality (or differentiation) and low cost may not be antithetical. Companies can hold to a dual advantage if those are not defined by trade-offs (in other words, sacrifice network quality for low cost). This can be the case if low cost results from scale, while differentiation results for technology innovation (Siegel et al., 2005).

Consistent with the prior research, our study in the wireless industry indicates that while investment in network infrastructure is primarily geared at delivering a quality, differentiated product, a common by-product of investment leaders is lower OPEX driven by more efficient operations and maintenance. For example, by leading in LTE deployment (among other factors), Verizon Wireless was able to bring down opex per connection by 12% since 2008 (see figure 16).

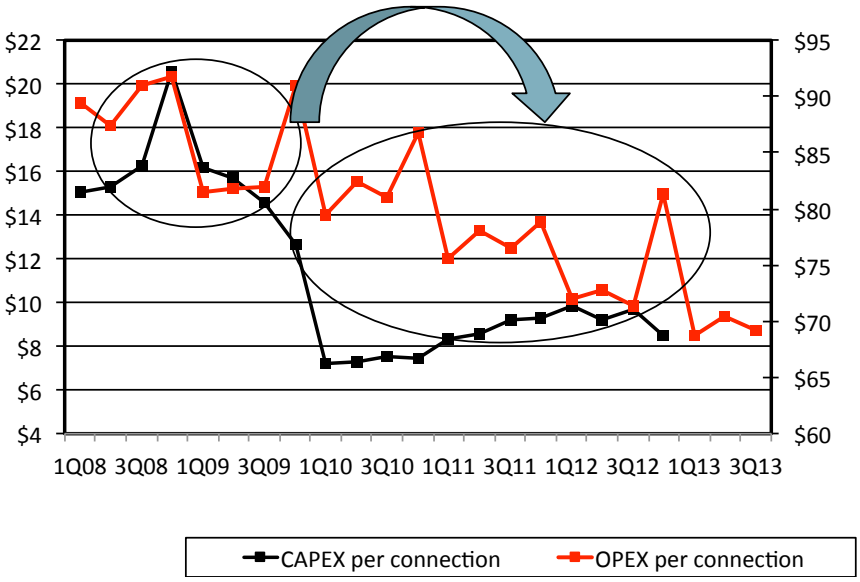
**Figure 16. Verizon Wireless: CAPEX and OPEX per connection (2008-2013)**




*Source: GSMA Intelligence; TAS analysis*

In a similar case, by consistently spending on its network, Swisscom was able to reduce its OPEX by 22.6% since 2010 (see figure 17).

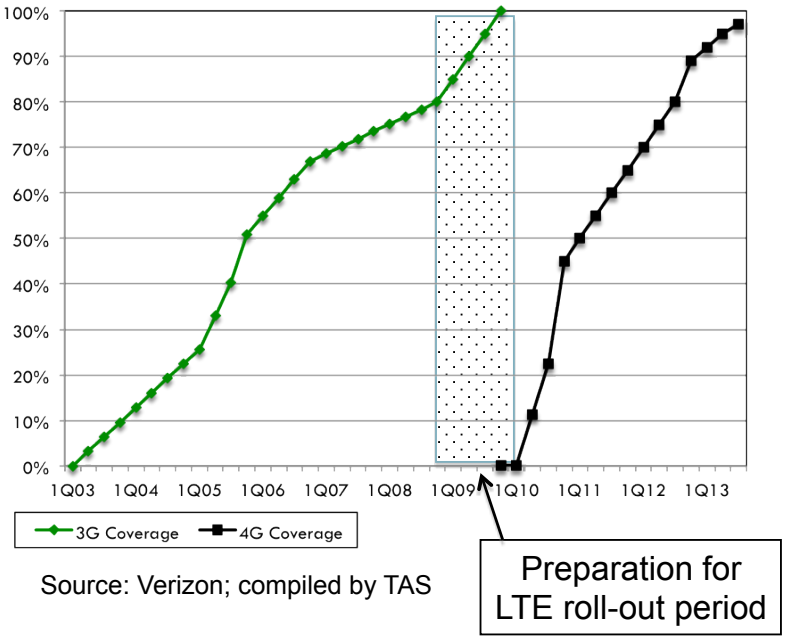
**Figure 17. Swisscom Wireless: CAPEX and OPEX per connection (2008-2013)**




*Sources; GSMA Intelligence; Strategy Analytics; TAS analysis*

How can we explain the opex reduction effect of front-loading the migration to LTE? The research literature points out that, in the presence of potential learning to manage new production infrastructure, the best decision for a first mover is to produce as many units as possible above marginal cost. The final cost is the one achieved after some period of learning in the market, and is usually lower than the cost at the time when the company first enters (Spence, 1981). An analysis of the behavior of Verizon Wireless indicates that learning effects are at the core of cost reductions. For example, data would indicate that Verizon has developed a fairly good approach to technology migration strategy. In 2007, while continuing to upgrade its 3G network, the carrier shifted its network strategy to LTE. After purchasing spectrum, the carrier implemented a streamlined approach to network construction and roll-out. The build-up and deployment of LTE infrastructure started in 2009, comprising a modification of antennas at every LTE cell, the upgrading of the cell site backhaul at every LTE cell, and a conversion of the network to MPLS. The net result of a better management of network transition significantly shortened the time to deployment of LTE (see figure 18).

**Figure 18. Verizon Wireless: Network Coverage (2005-2013)**




In addition, the LTE migration gave Verizon a capital efficiency advantage To begin with, 700 MHz enhances network performance. Beyond that, the depth of existing cell sites allowed for an efficient deployment of infrastructure, and an improved cost per MB.

To sum up, case study data would indicate that front-loading investment in the network would yield benefits not only in terms of quality differentiation, but also with regards to cost reduction. More importantly, case studies also demonstrate that there is a false trade-off between CAPEX increase and financial results. On the contrary, case study data indicates that, under certain market conditions, sustained capital spending expenditures can enhance a carrier ability to monetize a market opportunity like mobile broadband.

### 5.3. Capital investment and first mover advantage

Does the research literature support the basic postulate that focusing CAPEX on network investment in order to become the first to market with a new generation of wireless technology yields competitive advantage? Central to this argument is the idea of first mover advantage. The relationship between market pioneering and subsequent superior market performances is noted in various industries and has spurred academic interest since the late 1970s (Lieberman et al, 1988). The mechanisms by which being a first mover translates into competitive advantage that have been identified thus far can be categorized under four domains, namely economic, preemption, technological and behavioral (Kerin et al, 1992). Each of these factors focuses on a different aspect of the market dynamics and/or corporate capabilities, explaining how being the first in the market could build competitive advantage and achieve long-term superior performance (see table 12):

**Table 12. Advantages of a First Mover**

| Domains | Benefits |
|---|---|
| Economic | • By rapidly building economies of scale, the first mover can achieve lower unit costs than its competitors (Krouse, 1994)<br>• The first mover can start learning how to optimize production under new technology before its competitors (Lieberman, 1987)<br>• Being the first to introduce a new technology, the first mover can compete in more favorable market conditions, while the followers need to operate in a more crowded market (Bowman et al, 1996) |
| Preemption | • The first mover can acquire inputs at prices below those that will prevail in the market later (Lieberman & Montgomery, 1988; Lee et al, 2007)<br>• Similarly, the first entrant can gain better access to distribution channels (Dierckx et al, 1989)<br>• The first mover has the ability to identify, assess and nurture resources or capabilities that yield an asymmetry relative to competitors (Hidding, 2001)<br>• The first mover can occupy the most attractive niches in terms of geographic location, product characteristics, distribution channels, and market segments (Kerin et al, 1992) |
| Behavioral | • By leveraging switching costs, the first mover can raise barriers to entry for its followers (Klemperer, 1987)<br>• Switching cost is a more compelling barrier in markets where the demand is homogeneous (Capone et al, 2013)<br>• First-movers can have major influence on how attributes are valued and ideally bundled, and can become strongly associated with the product category as a whole, and as a result, attain certain insulation against later entrants that are positioned close to it (Carpenter et al, 1989)<br>• In a market where there is asymmetric information about product quality, rational consumers are willing to pay a higher price for a product of known quality (that of the first mover) than for a product of unknown quality (that of new comers) (Conrad, 1983)<br>• A consumer can be incentivized to adopt the product of the first mover if he expects that it represents the dominant offering in the future (Koski et al, 2004) |
| Technological | • The smoother the innovation process and the more stable the customer needs, the more easily the first mover profit from its own innovations (Kerin et al, 1992)<br>• Same as technological innovations, administrative innovations yield opportunities of profit for early adopters and penalize non-adopter with worse performance (Teece, 1980) |

The importance of these factors in determining first-mover advantage has started to be tested in the telecommunications industry (Fernandez et al, 2009) as well. In our study, Entel Chile remains the prototypical example of a first mover in mobile

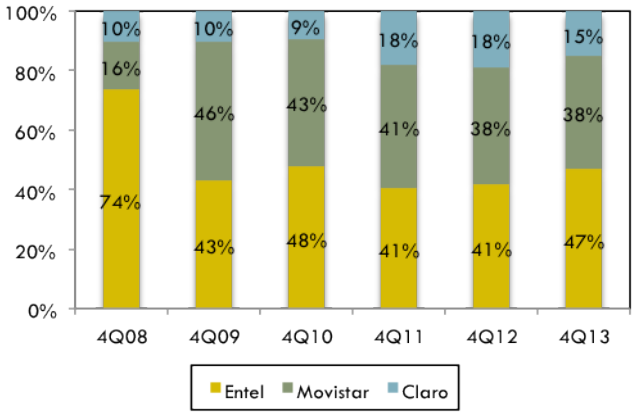
broadband. Beginning in 2010, the carrier formulated a strategy aimed at maintaining a leading technology position and superior service quality in order to meet market demand in mobile broadband. As a result, the carrier consistently invested four percentage points more (as a percent of sales) than its competitors. Investments have focused consistently on network technology (see table 13).

**Table 13. Entel Chile: Capital investment patterns over time**

| 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|
| • 80% of CAPEX focused on expanding the carrier 3G network<br>• ENTEL launches the first commercial HSPA+ network in Latam | • 69% of CAPEX focused on mobile network<br>• ENTEL conducts the first LTE trials in Latam | • 70% of CAPEX is focused on mobile services<br>• $230 million is invested in postpaid handsets<br>• ENTEL is the first Latin American company to launch dual-carrier HSPA evolution (DC-HSPA+) | • 71.5% of CAPEX focused on mobile services<br>• Expansion of carriers and deployments of nodes on the 1,900 and 900 MHz bands to improve quality in indoor capacity and meet the high growth in data traffic<br>• Awarded the central block of the 2,600 MHz spectrum for LTE<br>• Deployed 519 2G base stations in rural areas, and 1,300 nodes in 3G | • 46% of CAPEX is focused on mobile services based on 3G and 4G network and coverage<br>• LTE to be launched in March 2014 |

While it is unclear whether Entel Chile was able to profit from all advantages of a first mover outlined above, it is certain that some of the behavioral, preemptive and technological factors mentioned in table 12 are at work in the Chilean market, thus benefitting Entel Chile. Entel was the first carrier in Chile to launch mobile broadband, which created an insurmountable position. Despite the late reaction of Movistar and Claro, it has succeeded in remaining the dominant player (47% share) (see figure 19).

**Figure 19. Chile Wireless Industry: Mobile Broadband Market Share (2008-12)**




First mover advantage also applies to the carriers that leverage their scale to raise barriers to entry that affect the followers, such as Verizon and Swisscom.

## 6. RESULTS OF MARKET SIMULATION

Having concluded the qualitative case studies that validated the statistical analyses, we developed a set of simulation models to test the sensitivity of capital spending to carrier performance. A model was developed for each market using one of the carriers as the subject of analysis.

### 6.1. The Brazilian market simulation

Operator 1 income statement indicates that carrier revenues are US$ 9,632 million, while EBITDA is US$ 2,905 million (see table 14).

**Table 14. Operator 1: Income Statement and Selected Operating metrics (in '000'000 US except for CAPEX / connection and OPEX / connection)**

| | 2013 |
|---|---|
| Revenues | $ 9,632 |
| Operating Expenses | $ 6,727 |
| EBITDA | $ 2,905 |
| Tax | $ 395 |
| Net Interest Expenses | $ -54 |
| CAPEX | $ 1,564 |
| FCF | $ 891 |
| CAPEX/Revenues | 16.23% |
| CAPEX/ connection | $ 20.25 |
| OPEX/ connection | $ 87.09 |

*Source: GSMA; Stifel; BofA; TAS analysis*

Notice that Operator 1 is at the upper end of what analysts might consider being the ratio CAPEX/revenue (16.23%). Based on the statistical models presented in section 4.1, 10% increase in CAPEX would have the following percentage contribution to operational, market and financial metrics (see table 15).

**Table 15. Operator 1: Impact of a 10% CAPEX increase**

| Impact on variable (and time lag to the beginning of observed effect) | Operator 1 |
|---|---|
| Annual Incremental CAPEX (Millions) | US$ 157 |
| Δ Accessibility rate increase (same quarter) | 1.8 % |
| Δ Data completion rate increase (same quarter) | 2.4 % |
| Δ Percent connections higher than 1 Mbps (same quarter) | 4.7 % |
| Δ Speech call quality index (same quarter) | 0.3 % |
| Δ Market Share increase (same quarter) | 4.0% |
| Δ Churn reduction (after one quarter) | -12.0% |
| Δ ARPU increase (after one quarter for data completion, two quarters for data accessibility and speech call quality, and three quarters for download speed) | 4.9% |
| Δ Revenues increase (same quarter) | 5.5 % |
| Δ EBITDA increase (same quarter) | 12.3 % |
| Δ EBITDA Margin increase (same quarter) | 6.4 % |
| Δ FCF increase (same quarter) | 19.7% |

*Source: TAS analysis*

Additionally, based on a regression model with year and operator fixed effects with data from Operator 3, 2 and 1 between 2007 and 2013, an increase of one percentage point in the CAPEX/Revenue relationship, yields a decrease on the Opex/Revenue share of 0.1141 percentage points.

With these coefficients, a pro-forma income statement for 2017 was generated, assuming that Operator 1 increases its annual CAPEX by US$ 157 million (or 10% on an annual basis evenly distributed across quarters). The results are presented in table 16.

**Table 16. Operator 1: Income Statement and Selected Operating metrics**

**(in '000'000 US except for CAPEX / connection and OPEX / connection)**

| | 2017 |
|---|---|
| Revenues | $ 10,157 |
| Operating Expenses | $ 6,898 |
| EBITDA | $ 3,258 |
| Tax | $ 417 |
| Net Interest Expenses | $ -57 |
| CAPEX | $ 1,721 |
| FCF | $ 1,064 |
| CAPEX/Revenues | 16.94 % |
| CAPEX/ connection | $ 19.39 |
| OPEX/ connection | $ 77.70 |

*Source: TAS analysis*

As the data on table 16 indicates, EBITDA margin jumped from 30% to 32.1%, while annual free cash flows grew from US$ 891 million to US$ 1,097. In addition, due to economies of scale of capital and operating expenditures referred to above, CAPEX per connection declined from US$ 20.25 to US$ 19.39, while opex per connection decreased more significantly from US$ 87.09 to US$ 77.70. The Net Present Value of such an increase in CAPEX is $219 million over 5 years (see table 17).

**Table 17. Operator 1: Free Cash flow Statement (in million US$)**

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018-2023 |
|---|---|---|---|---|---|---|
| Revenues | $ 9,632 | $ 9,709 | $ 9,897 | $ 10,058 | $ 10,157 | $ 10,164 |
| OPEX | $ 6,727 | $ 6,748 | $ 6,808 | $ 6,862 | $ 6,898 | $ 6,903 |
| EBITDA | $ 2,905 | $ 2,961 | $ 3,089 | $ 3,196 | $ 3,258 | $ 3,262 |
| EBITDA Margin | 30.16 % | 30.50 % | 31.21 % | 31.77 % | 32.08 % | 32.09 % |
| Taxes | $ 395 | $ 398 | $ 406 | $ 413 | $ 417 | $ 417 |
| Net Interest expenses | $ 54 | $ 55 | $ 56 | $ 57 | $ 57 | $ 57 |
| CAPEX | $ 1,564 | $ 1,721 | $ 1,721 | $ 1,721 | $ 1,721 | $ 1,721 |
| CAPEX/Revenues | 16.24 % | 17.73 % | 17.39 % | 17.11 % | 16.94 % | 16.93 % |
| Free Cash Flow | $ 891 | $ 787 | $ 906 | $ 1,005 | $ 1,064 | $ 1,066 |
| Incremental FCF | - | $ -104 | $ 15 | $ 114 | $ 172 | $175 |
| PV of Incremental FCF | - | $ -93 | $ 12 | $ 83 | $ 113 | $ 486 |

| | | | | |
|---|---|---|---|---|
| Incremental Quarterly CAPEX | $ 39 | | Total NPV Incremental FCF 5 years | $ 219 |
| Incremental annual CAPEX (%) | 10.0 % | | Total NPV Incremental FCF 10 years | $ 601 |
| Discount Rate | 11.1 % | | Total NPV Incremental FCF perpetuity | $ 1,153 |

Note: Discount rate reflects the value estimated with market data.
*Source: TAS analysis*

This scenario (increase of 10% of CAPEX) is highly sensitive. The sensitivity of EBITDA results from an important increase in revenues combined with only a moderate increase in OPEX as a result of economies of scale. For example, if rather than 10%, CAPEX were to be raised by 20%, the 10 year Net Present Value would jump from US$ 601 million to $1,200 million.

### 6.2. The Mexican market simulation

A similar value creation effect can be identified in the Mexican wireless industry. Operator 5 income statement indicates that carrier 2013 revenues are US$ 13,073 million, while EBITDA is US$ 6,351 million (see table 18).

**Table 18. Operator 5: Income Statement and Selected Operating metrics**

**(in '000'000 US except for CAPEX / connection and OPEX / connection)**

| | 2013 |
|---|---|
| Revenues | $ 13,073 |
| Operating Expenses | $ 6,722 |
| EBITDA | $ 6,351 |
| Tax | $ 469 |
| Net Interest Expenses | $ -158 |
| CAPEX | $ 727 |
| FCF | $ 4,996 |
| CAPEX/Revenues | 5.56 % |
| CAPEX/ connection | $ 9.89 |
| OPEX/ connection | $ 91.44 |

*Source: GSMA; Stifel; BofA; TAS analysis*

Based on the statistical models presented in section 4.2, 10% increase in CAPEX would have the following percentage contribution to network quality, market and commercial performance metrics (see table 19).

**Table 19. Operator 5: Impact of a 10% CAPEX increase[6]**

| Impact on variable (and time lag to the beginning of observed effect) | |
|---|---|
| Annual Incremental CAPEX (Millions) | US$ 73 |
| Δ Latency reduction (same quarter) | 53.4 % |
| Δ Downlink broadband speed increase (same quarter) | 59.3 % |
| Δ Market Share increase (same quarter) | 3.0 % |
| Δ ARPU increase (after one, two or three quarters) | 21.0 % |
| Δ Revenues increase (same quarter) | 1.9 % |
| Δ EBITDA increase (same quarter) | 2.9 % |
| Δ EBITDA Margin increase (same quarter) | 1.0 % |
| Δ FCF increase (same quarter) | 2.0 % |

*Source: GSMA; Stifel; BofA; TAS analysis*

[6] In the case of Mexico, the lack of opex data for operator 5 prevented us from building an OPEX model, as done in the Brazilian and United States cases.

It is important to note that the effects take a shorter time to emerge in Mexico (same quarter than CAPEX increase) than in the case for Brazil (one, two or more quarters later).

With these coefficients, a pro-forma income statement for 2017 was generated, assuming that Operator 5 increases its annual CAPEX by US$ 73 million (evenly distributed across quarters). The results are presented in table 20.

**Table 20. Operator 5: Income Statement and Selected Operating metrics (in '000'000 US except for CAPEX / connection and OPEX / connection)**

| | 2017 |
|---|---|
| Revenues | $ 13,323 |
| Operating Expenses | $ 6,786 |
| EBITDA | $ 6,537 |
| Tax | $ 478 |
| Net Interest Expenses | $ -161 |
| CAPEX | $ 800 |
| FCF | $ 5,098 |
| CAPEX/Revenues | 6.00 % |
| CAPEX/ connection | $ 9.48 |
| OPEX/ connection | $ 80.46 |

*Source: TAS analysis*

EBITDA margin increases from 48.6% to 49.1%, while cash flows grow from US$ 4,996 million in 2013 to US$ 5,101 in 2017. The Net Present Value of such an increase in CAPEX is US$ 297 million over 5 years (see table 21).

**Table 21. Operator 5: Free Cash flow Statement (in million US$)**

| (USD) | 2013 | 2014 | 2015-2023 |
|---|---|---|---|
| Revenues | $ 13,073 | $ 13,206 | $ 13,323 |
| OPEX | $ 6,722 | $ 6,756 | $ 6,786 |
| EBITDA | $ 6,351 | $ 6,450 | $ 6,537 |
| EBITDA Margin | 48.58 % | 48.84 % | 49.07 % |
| Taxes | $ 469 | $ 474 | $ 478 |
| Net Interest expenses | -158 | -159 | -161 |
| CAPEX | $ 727 | $ 800 | $ 800 |
| CAPEX/Revenues | 5.56 % | 6.06 % | 6.00 % |
| Free Cash Flow | $ 4,996 | $ 5,016 | $ 5,098 |
| Incremental FCF | - | $ 22 | $ 105 |
| PV of Incremental FCF | - | $ 19 | $491 |

| | | | |
|---|---|---|---|
| Incremental Quarterly CAPEX | $ 18 | Total NPV Incremental FCF 5 years | $ 297 |
| Incremental annual CAPEX (%) | 10.0 % | Total NPV Incremental FCF 10 years | $ 510 |
| Discount Rate | 11.6 % | Total NPV Incremental FCF perpetuity | $ 802 |

Note: Discount rate reflects the value included in operator 5 balance sheet.
*Source: TAS analysis*

The simulation model shows the great advantage that operator 5 would incur by increasing its capital expenditures, which are, by industry standards, quite low (in terms of the CAPEX/revenue ratio). It should be noted, however, that, given the extreme concentration in the Mexican market, the effect of CAPEX on performance would be greater for operator 5 than for the other players.

### 6.3. The United States market simulation

Operator 10 income statement indicates that carrier revenues are US$ 26,100 million, while EBITDA is US$ 5,387 million (see table 22).

**Table 22. Operator 10: Income Statement and Selected Operating metrics**

**(in '000'000 US except for CAPEX / connection and OPEX / connection)**

| | 2013 |
|---|---|
| Revenues | $ 26,100 |
| Operating Expenses | $ 20,713 |
| EBITDA | $ 5,387 |
| Tax | $ 43 |
| Net Interest Expenses | $ -1,540 |
| CAPEX | $ 4,330 |
| FCF | $ -526 |
| CAPEX/Revenues | 16.59 % |
| CAPEX/ connection | $ 92.75 |
| OPEX/ connection | $ 443.69 |

*Source: Hudson Square; BofA; TAS analysis*

Based on the statistical models presented in section 4.3, 10% increase in CAPEX would have the following percentage contribution (see table 23).

**Table 23. Operator 10 Impact of a 10% CAPEX increase**

| Impact on variable (and time lag to the beginning of observed effect) | |
|---|---|
| Annual Incremental CAPEX (Millions) | US$ 433 |
| Δ Percent connections higher than 1 Mbps (same quarter) | 1.2 % |
| Δ Latency reduction (same quarter) | 10.9 % |
| Δ Market Share increase (after one quarter) | 1.7 % |
| Δ Churn reduction (same quarter for speed, after one quarter for latency) | 3.7 % |
| Δ ARPU increase (same quarter for speed, after two quarters for latency) | 1.1 % |
| Δ Revenues increase (same quarter for ARPU and share, three quarters after for churn) | 5.1 % |
| Δ EBITDA increase (same quarter for ARPU and share, three quarters after for churn) | 12.2 % |
| Δ EBITDA Margin increase (same quarter) | 6.8 % |
| Δ FCF increase (same quarter) | 37.7 % |

*Source: GSMA; Stifel; BofA; TAS analysis*

Additionally, based on a regression model with year and operator fixed effects with data from operators 9, 10, and 11 between 2007 and 2013, an increase of one percentage point in the CAPEX/Revenue relationship, yields a decrease on the Opex/Revenue share of 0.3503 percentage points.

With these coefficients, a pro-forma income statement for 2017 was generated, assuming that Operator 10 increases its annual CAPEX by US$ 157 million (evenly distributed across quarters. The results are presented in table 24.

**Table 24. Operator 10: Income Statement and Selected Operating metrics (in '000'000 US except for CAPEX / connection and OPEX / connection)**

| | 2017 |
|---|---|
| Revenues | $ 27,423 |
| Operating Expenses | $ 21,347 |
| EBITDA | $ 6,046 |
| Tax | $ 45 |
| Net Interest Expenses | $ -1,566 |
| CAPEX | $ 4,763 |
| FCF | $ -328 |
| CAPEX/Revenues | 17.37 % |
| CAPEX/ connection | $ 87.19 |
| OPEX/ connection | $ 391.31 |

*Source: TAS analysis*

The Net Present Value of such an increase in CAPEX is $382 million over 5 years (see table 25).

**Table 25. Operator 10: Free Cash flow Statement (in million US$)**

| | 2013 | 2014 | 2015 | 2016-2023 |
|---|---|---|---|---|
| Revenues | $ 26,100 | $ 26,487 | $ 27,260 | $ 27,423 |
| OPEX | $ 20,713 | $ 20,868 | $ 21,271 | $ 21,377 |
| EBITDA | $ 5,387 | $ 5,620 | $ 5,988 | $ 6,046 |
| EBITDA Margin | 20.64 % | 21.22 % | 21.97 % | 22.05 % |
| Taxes | $ 43 | $ 44 | $ 45 | $ 45 |
| Net Interest expenses | $ -1,540 | $ - 1,566 | $ - 1,566 | $ - 1,566 |
| CAPEX | $ 4,330 | $ 4,763 | $ 4,763 | $ 4,763 |
| CAPEX/Revenues | 16.59% | 17.98% | 17.47% | 17.37% |
| Free Cash Flow | $ -526 | $ -753 | $ -386 | $ -328 |
| Incremental FCF | - | $ -227 | $ 140 | $ 198 |
| PV of Incremental FCF | - | $ -214 | $ 125 | $ 1,094 |

| | | | | |
|---|---|---|---|---|
| Incremental Quarterly CAPEX | $ 108 | | Total NPV Incremental FCF 5 years | $ 382 |
| Incremental annual CAPEX (%) | 10.0 % | | Total NPV Incremental FCF 10 years | $ 1,005 |
| Discount Rate | 6.0 % | | Total NPV Incremental FCF perpetuity | $ 2,848 |

*Source: TAS analysis*

A sensitivity analysis of CAPEX increase indicates a positive improvement in profitability and a sharp increase in Net Present Value. For example, a 20% increase in CAPEX (rather than 10%) would increase the 10-year NPV from US$ 1,005 million to US$ 2,009 million.

## 7. CONCLUSIONS

The quantitative and qualitative evidence provided in this paper has allowed us to prove the hypotheses regarding the importance of capital spending in driving carrier performance in the wireless industry.

The study's first hypothesis established that there is a direct transitive relationship between capital investment, network quality and wireless carrier performance. In fact, the statistical analyses showed that:

- An increase in CAPEX yields an immediate improvement in network performance KPIs (e.g. Improvement in speech call quality, increase in download speeds, latency reduction, etc.);
- Improvement in network performance results, in turn, in better market performance (ARPU, share, churn reduction) either in the same quarter of the improvement or typically after two quarters;
- As expected, an improvement in market performance causes an immediate rise in financial performance (Revenues, and EBITDA margin);
- A temporary reduction in free cash flows due to an increase in capital spending at the beginning of the time period is compensated by an increase of this metric over time, resulting in a positive NPV.

In addition, three qualitative case studies also confirmed the transitive causal relationship between capital investment and financial performance:

- Verizon's consistent CAPEX/revenues ratio of 13% yielded highest EBITDA margin among wireless carriers in the United States (44%)
- Softbank's increase of CAPEX/revenues from 10% to 27% triggered a rise in EBITDA margin from 28% to 36%
- Swisscom's average CAPEX/revenues ratio of 15% in 2008-09 yielded a sustained EBITDA margin since 2010 (50%)

The second hypothesis posited that, by increasing CAPEX levels, a dominant wireless player having an economy of scale advantage, puts pressure on its competitors that are constrained in their ability to keep up with the incumbent in order to create short term value to shareholders. While the statistical analysis did not allow us to prove this postulate, two case studies gave ample confirmation of this effect:

- Verizon enjoys a CAPEX scale which allows it to invest proportionally less (12% of revenues) than its competitors, which results in a competitive advantage in terms network performance;
- Similarly, Swisscom's CAPEX scale allows them to invest less (7% of revenues) than its competitors since 2010 and yet, have a technology advantage vis-à-vis its competitors.

The third hypothesis argued that sustained capital spending could enhance a carrier's ability to monetize a market opportunity and reduce operating costs. Again, case studies provided evidence that supported this argument:

- With highest connectivity rate and download speed (15 Mbps), Softbank was able to increase mobile broadband market share from 17% to 24% in 3 years;
- By consistently investing more than Movistar (CAPEX/revenues ratio 4 percentage points higher) since 2008, Entel succeeded in overcoming Movistar in profitability terms.

Finally, the fourth hypothesis stated that an increase in CAPEX could also result in a first mover advantage, which yields competitive superiority over time. Qualitative evidence amply supported this point:

- With a deployed LTE network before competitors, Verizon achieved lowest churn (1.28%), highest ARPU ($57.72), and highest quarterly growth in post paid (4.35%);
- Increasing CAPEX also help a lagging performer such as Softbank to catch up and surpass the competition in the Japanese market;
- Swisscom: As the first carrier in market to deploy 3G, and LTE, Swisscom has an average margin per user ($21.63) higher than its competitors;
- As first carrier to launch mobile broadband, Entel succeeded in remaining the dominant mobile broadband player (47% share) in the Chilean market.

In summary, as the research literature indicated for other industries, increasing capital investment in wireless telecommunications could yield superior market and financial performance. The benefit of increasing CAPEX is higher in the case of incumbent players for two reasons: 1) their scale allows them to invest in network upgrades at a proportionally lower unit value than its peers, forcing the latter into

an expensive "arms race", 2) by pioneering the migration into new technologies, incumbents build additional barriers, thereby solidifying their network effects. Additionally, as demonstrated in the research literature, wireless carriers that increase their CAPEX relative to their competitors can achieve a lower cost position by either leveraging economies of scale or learning curve. In fact, the faster they increase their investment, the higher the advantage achieved relative to their peers. Finally, carriers that anticipate their peers in increasing their investment in network quality will benefit from economies of scale, experience curve, brand equity, competitive preemption for more valuable customers, and network effects.

**BIBLIOGRAPHY**


Bowman, Douglas, and Hubert Gatignon. "Order of entry as a moderator of the effect of the marketing mix on market share." *Marketing Science* 15.3 (1996): 222-242.

Brown, Christina L., and James M. Lattin. "Investigating the relationship between time in market and pioneering advantage." *Management science* 40.10 (1994): 1361-1369.

Carpenter, Gregory S., and Kent Nakamoto. "Consumer preference formation and pioneering advantage." *Journal of Marketing Research* (1989): 285-298.

Capone, Gianluca, Franco Malerba, and Luigi Orsenigo. "Are Switching Costs Always Effective in Creating First-Mover Advantage? The Moderating Role of Demand and Technological Regimes." *Long Range Planning* 46.4 (2013): 348-368.

Conrad, Cecilia A. "The advantage of being first and competition between firms." *International Journal of Industrial Organization* 1.4 (1983): 353-364.

Day, George S., and Robin Wensley. "Assessing advantage: a framework for diagnosing competitive superiority." *The Journal of Marketing* (1988): 1-20.

Dierickx, Ingemar, and Karel Cool. "Asset stock accumulation and sustainability of competitive advantage." *Management Science* 35.12 (1989): 1504-1511.

Fernández, Zulima, and Belén Usero. "Competitive behavior in the European mobile telecommunications industry: Pioneers vs. followers." *Telecommunications Policy* 33.7 (2009): 339-347.

Gómez, Jaime, and Juan Pablo Maícas. "Do switching costs mediate the relationship between entry timing and performance?" *Strategic Management Journal* 32.12 (2011): 1251-1269.

Hidding, Gezinus J. "Sustaining strategic IT advantage in the information age: how strategy paradigms differ by speed." *The Journal of Strategic Information Systems* 10.3 (2001): 201-222.

Hoch, Stephen J., and John Deighton. "Managing what consumers learn from experience." *The Journal of Marketing* (1989): 1-20.

Kardes, Frank R., and Gurumurthy Kalyanaram. "Order-of-entry effects on consumer memory and judgment: An information integration perspective." *Journal of Marketing Research* (JMR) 29.3 (1992).

Katz, Michael L., and Carl Shapiro. "Systems competition and network effects." *Journal of economic perspectives* 8 (1994): 93-93.

Kerin, Roger A., P. Rajan Varadarajan, and Robert A. Peterson. "First-mover advantage: A synthesis, conceptual framework, and research propositions." *Journal of marketing* 56.4 (1992).

Kessler, Eric H., Paul E. Bierly, and Shanthi Gopalakrishnan. "Internal vs. external learning in new product development: effects on speed, costs and competitive advantage." *R&D Management* 30.3 (2000): 213-224.

Klemperer, Paul. "Markets with consumer switching costs." *The Quarterly Journal of Economics* 102.2 (1987): 375-394.

Koski, Heli, and Tobias Kretschmer. "Survey on competing in network industries: firm strategies, market outcomes, and policy implications." *Journal of industry, competition and trade* 4.1 (2004): 5-31.

Krouse, Clement G. "Market rivalry and learning-by-doing." *International Journal of Industrial Organization* 12.4 (1994): 437-456.

Kuo, Ying-Feng; Wu, Chi-Ming; and Deng, Wei-Jaw. "The relationships among service quality, perceived value, customer satisfaction, and post-purchase intention in mobile value-added services." *Computers in Human Behavior* 5.4 (2009): 887-896.

Lee, Khai Sheang, and Irene CL Ng. "An integrative framework of pre-emption strategies." *Journal of Strategic Marketing* 15.4 (2007): 327-348.

Lee, Deishin, and Haim Mendelson. "Adoption of information technology under network effects." *Information Systems Research* 18.4 (2007): 395-413.

Lieberman, Marvin B. "The learning curve, diffusion, and competitive strategy." *Strategic management journal* 8.5 (1987): 441-452.

Lieberman, Marvin B., and David B. Montgomery. "First-mover advantages." *Strategic management journal* 9.S1 (1988): 41-58.

Nelson, Phillip. "Information and consumer behavior." *The Journal of Political Economy* (1970): 311-329.

Siegel, J., and James Jinho Chang. *Samsung Electronics*. Boston, MA: Harvard Business School, 2005. Case No. 705508

Spence, A. Michael. "The learning curve and competition." *The Bell Journal of Economics* (1981): 49-70.

Srinivasan, Raji, Gary L. Lilien, and Arvind Rangaswamy. "First in, first out? The effects of network externalities on pioneer survival." *Journal of Marketing* 68.1 (2004): 41-58.

Teece, David J. "Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy." *Research policy* 15.6 (1986): 285-305.

Teece, David J. "The diffusion of an administrative innovation." *Management Science* 26.5 (1980): 464-470.

Zera, Alper; Argang, Mehpare, T.; and Arganc, Meting. "The effect of mobile service quality dimensions on customer Satisfaction." *Procedia - Social and Behavioral Sciences*, (2013), Volume 99, Page 428.

Zhao, Ling; Lu,Yaobin; Zhang, L.; and Chau, Patrick Y.K., "Assessing the effects of service quality and justice on customer satisfaction and the continuance intention of mobile value-added services: An empirical test of a multidimensional model." *Decision Support Systems*, (February 2012), Volume 52, Issue 3: 645-656.