Efficiency and Productivity Analysis of Deregulated Telecommunications Industries: A Comparative Study of the Cases of Canada and Nigeria

A Thesis submitted by

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Abstract

Following telecommunications industry deregulation in United Kingdom and the introduction of competition in the United States of America's long distance telecommunications services in the 1980s, telecommunications industries in other developed and developing countries have been deregulated. Contributing to the deregulation are the influences of globalization, technological advancement, fiscal policy restraint, lending institutions' requirements, regulatory costs curtailment and the desire for improved performance. However, the benefits of deregulation remain uncertain. The motivation for this research is to investigate the efficiency and productivity performance of telecommunications industries in deregulated environments. Comparatively analyzing the experiences of Canada and Nigeria, this research addresses two broad questions. First, how did deregulatory policies influence competitiveness in the industries in the two countres? This was addressed by: (i) investigating the forces that drove deregulation, (ii) exploring the similarities and differences in the deregulatory milieu in the two countries, and (iii) evaluating competitiveness in the industry. Second, how did the industries perform in the deregulated environments? The outcomes shed lights on the efficiency, productivity and the influence of environmental factors on efficiency performance. It also imbues the applicability of structure-conduct-performance model in the understanding of deregulatory outcomes.

The approach adopted entailed empirical analysis of the two countries in the context of 17 other telecommunications industries from High Income Countries and Middle Income Countries over a 13-year period (2001–13). The study used non-parametric Data Envelopment Analysis (DEA) and the Malmquist Productivity Index to assess the efficiency and productivity changes and a random effect (RE) panel Tobit model was used to evaluate the effect of environmental factors on efficiency performance. Furthermore, responses from industry participants were obtained to complement the DEA findings. The DEA results suggest that operating in deregulated environment improves efficiency and productivity performance; a finding validated by the views of the industry participants involved in the study. The two countries, though inefficient, showed improved technical efficiency. The productivity analysis revealed both countries experienced productivity growth but it has slowed. Also, the Mann-Whitney test showed that the two countries have

comparable productivity change. The Canadian telecommunications industry experienced technological progress and efficiency improvement, but the productivity change was mainly due to efficiency improvement attained through managerial effectiveness. On the other hand, the Nigerian telecommunications industry experienced technological retardation but efficiency progression. Its productivity change was due to efficiency improvements attained through enhanced operational scale.

The investigation of the influence of environmental factors on efficiency reveals that the number of years in deregulation has an insignificant negative influence on technical and scale efficiency. However, as a quadratic term, the effect is positive but remained insignificant. Revenue per subscription positively influences technical and scale efficiencies and is statistically significant. This indicates that higher prices may result in better technical efficiency and operational scale. Industry concentration level was found to have a positive but not statistically significant effect on technical and scale efficiencies and a negative but also statistically insignificant effect on pure technical efficiency. This signifies that telecommunications industry concentration is not consequential to performance. Capital expenditure to revenue ratio has no significant influence on technical efficiency but a statistically significant negative influence on scale efficiency. This signifies that scale efficiency could be attained by optimizing capital expenditure through full capacity utilization and by avoiding infrastructure duplication. Labour productivity influences technical efficiency but has an unimportant negative effect on scale efficiency. This implies that technical efficiency could be enhanced through labour productivity improvements. Also, change in real gross domestic product per capita has a negative and insignificant effect on technical and scale efficiencies. However, as a quadratic term, it has significant positive influence on scale efficiency, suggesting that countries with higher economic growth and wealth would display better scale efficiency performance. Inflation has significant positive influence on technical and scale efficiency performance. The level of development has insignificant relationship with technical and scale efficiency scores, implying that it is not an essential determinant of performance. The interaction of labour productivity and capital intensity undermines technical efficiency, signifying that efficiency improvement through labour productivity and increased use of capital is not sufficient to neutralize efficiency loss from increased capital intensity.

Certification of Thesis

This thesis is entirely the work of ABAYOMI OREDEGBE except where otherwise acknowledged. The work is original and has not previously been submitted for any other award, except where acknowledged.
Student and supervisors signatures of endorsement are held at USQ.

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List of Abbreviations

AE	Allocative efficiency
ARPS	Average revenue per subscriber
BCC	Banker, Charnes, & Cooper
BPE	Burreau of public enterprise
Capex	Capital expenditure
CapexRev	Capital expenditure to revenue ratio
CCR	Charnes, Cooper, & Rhodes
CDMA	Code divison multiple access
CPI	Consumer price index
CRS	Constant returns to scale
CRTC	Canadian Radio-television and Telecommunications Commission
DEA	Data envelopment analysis
DMU	Decision-making unit
DRS	Decreasing returns to scale
EBITDA	Earnings before interest, taxes, depreciation and amortization
EBRD	European Bank for Reconstruction and Development
EC	Efficiency change
ESR	Earnings share regulation
FDH	Free Disposal Hull
GDP	Gross domestic product
GSM	Global systems for mobile communications
HHI	Herfindahl-Hirschman index
HICs	High income countries
IMF	International Monetary Fund
IRS	Increasing returns to scale
ITU	International Telecommunications Union
IV	Instrumental variable
MFP	Multi factor productivity
MICs	Middle income countries
MNP	Mobile number portability
MPI	Malmquist Productivity Index

MPSS	Most productive scale size
NEIO	New empirical industrial organization
NIRS	Non-increasing returns to scale
NITEL	Nigerian Telecommunications Limited
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary least square
PCR	Price cap regulation
PFA	Partial factor analysis
PIM	Productivity improvement management
PMP	Partial measures of performance
PTE	Pure technical efficiency
PTEC	Pure technical efficiency change
PTIE	Pure technical inefficiency
RevSub	Revenue to subscription ratio
RGDPPC	Real GDP per capita
ROI	Return on investment
ROR	Rate-of-return regulation
RTS	Returns to scale
SAP	Structural Adjustment Programme
SMB	Slack base measurement
SE	Scale efficiency
SEC	Scale efficiency change
SFA	Stochastic Frontier Analysis
SIE	Scale inefficiency
SIM	Subscribers identity module
SOE	State-owned enterprise
SCP	Structure-conduct-performance model
SubEmp	Subscriptions to employment ratio
TC	Technical (technological) change
TE	Technical efficiency
TFA	Thick Frontier Approach
TFP	Total factor productivity
TFPC	Total factor productivity change
TFPG	Total factor productivity growth

TIE	Technical inefficiency
ToFA	Total factor analysis
TOPS	Technically optimal productive scale
UK	United Kingdom of Great Britain
US	United States of America
VRS	Variable returns to scale

Chapter 1
Introduction

1.1 Research background

In broad terms, the telecommunications industry is an industry that allows for the transfer of data and/or information between parties through a variety of channels (e.g., radio, television, cable, satellite communication, Internet and telephone) using wired or wireless means (Gupta, 2008). The International Bank for Reconstruction and Development (2011) confines the description to communications through telephony (i.e., wireless and wired) and the Internet. A more restricted view limits the description to telephony using wireless and wired means (Gu & Lafrance, 2012; CRTC, 2013). In this research, telecommunications is construed as the use of wired or wireless means to transfer information over a distance. Firms providing these services are viewed as telecommunications firms, and the industry as the telecommunications industry.

Traditionally, the telecommunications industry in most countries relied on a regulated monopoly due to the presumption of cost disadvantages associated with having more than one firm in the industry. Aside from the economic argument, the justification for government involvement in the industry via state-owned enterprises (SOEs) centred on promoting socio-economic interests and ensuring national security (Kerf & Geradin, 1999; OECD, 2002a). However, over the last three decades, the sway of economic and policy reforms, the integration of the global economy, rapid technological advancement and the poor performance of the industry have contributed to the shift away from the monopoly model. Conspicuously, a monopoly is touted as impeding performance and creating and sustaining an incumbent's 'market power' by according it the ability to maintain prices above what it would have been in a competitive environment (Uukkivi, Ots, & Koppel, 2012, p. 225). Seeking better performance, governments in various countries have introduced deregulatory policies to initiate competition and instill market discipline that conditions firms in the industry to make rational decisions.

The industry has changed significantly over the past three decades. Following the deregulation in the UK and the US in the 1980s, major industrialized nations and many developing countries have deregulated their telecommunications industries.

Primarily, efficiency and productivity are performance indicators that provide insight on the effectiveness of firms in allocating and transforming inputs into outputs. Studies show performance improvements in deregulated environments but the findings have not been consistent across all of the studies and the countries investigated. This research seeks to provide additional evidence on the effects of operating in deregulated environment through a comparative analysis of the performances of the Canadian and Nigerian telecommunications industries. Canada's *Telecommunications Act, 1993* aimed to enhance the performance and competitiveness of the industry by allowing it to rely on market forces and by eliminating entry barriers. The industry plays an important role in the Canadian economy with the 10 largest providers responsible for 95% of the revenue in the industry (CRTC, 2014). In 2013 the industry employed 111, 338 people and accounted for 2% of Canada's gross domestic product (GDP) (Statistics Canada, 2016). Another salient outcome of the industry in Canada is that it is saturated due to subscriptions growth decline and stagnant teledensity despite investment in the sector. Similar to Canada, the Nigerian telecommunications industry was deregulated to increase competition and to ensure the sector's performance met customers' needs. However, unlike Canada, the industry witnessed significant price decline and a phenomenal increase in subscriptions. Its teledensity of 91 in 2013 suggests more potential for growth. In addition, the industry attracted foreign direct investment and accounted for 7.8% of Nigeria's GDP in the last five years (NCC, 2016a).

Remarkably, the telecommunications industries in Canada and Nigeria continue to attract the attention of service providers seeking to enter the industry. However, the industry in the two countries has not fully garnered the attention of academics. Literature on the performance of the industry in the two countries is limited because existing literature focuses mostly on the industry's contribution to economic growth and development. This research shifts attention to the efficiency and productivity performance of the industry in the two countries. The disciplinary approach adopted is the field of economics. This provides a robust understanding of the phenomenon and enables the research to discuss the two countries' cases in the context of 17 others selected from the World Bank's categorization of middle income countries (MICs) (i.e., lower-middle income countries and upper-middle income countries), high income countries (HICs) and Organization for Economic Cooperation and Development (OECD) countries. Although not similarly affluent or at equivalent level of development, the two countries are of interest because they made similar policy decisions that culminated in the deregulation of their telecommunications industry. In addition, the industry is integral to each country's economy and serves as a beacon of deregulation. A comparison with other countries is necessary to allow for inferences to be made about potential differences in the outcome of deregulation in the two countries and to diminish potential differences in the economic conditions and development levels in the two countries. The 10 HICs are Australia (AUS), Belgium (BEL), Canada (CAN), Chile (CHL), Germany (DEU), Japan (JPN), New Zealand (NZL), South Korea (SKR), United Kingdom (UK) and United States of America (USA). The nine MICs are Brazil (BRA), China (CHN), India (IND), Indonesia (IDN), Kenya (KEN), Mexico (MEX), Nigeria (NGA), South Africa (SA) and Turkey (TUR). Thus the research analyzed panel data from 19 countries over a 13-year period (2001–13) for a total of 247 observations. The decision to investigate the telecommunications industry was based on the industry's constant transformations that continue to make new empirical knowledge important and the recognition that whereas the motives for the industry's deregulation are similar across countries, the outcomes have been divergent. In view of this, this research provides additional empirical evidence and contributes to the debate on telecommunications industry deregulation and its impact on the competitiveness and performance of the industry.

1.2 Motivation for this research

The initial motivation for this research stemmed from debate about deregulation and the telecommunications industry's structural transformation since the adoption of deregulatory mechanisms in Canada and Nigeria. Most of the literature on telecommunications industry deregulation focuses on US and European Union countries, making it difficult to apply the findings to Canada and Nigeria. Documenting the experiences of Canada and Nigeria fills a gap in the existing literature which and serves as the impetus for engaging in this research. The comparison of the two countries is based on the observation that even though they differ in characteristics, the motive for deregulation is the same. Thus, it is important to evaluate the efficiency and productivity performance of the two countries. Also, Nigeria imitated developed countries such as Canada and has sought improvement in performance by altering the structure of the industry. The comparison provides interesting understanding of the deregulatory approach in each country and the outcome. Additionally, the industry in both countries is dominated by a handful of large firms, making it suitable to compare them. Furthermore, focusing on the two countries provides avenue for obtaining insightful information on the outcome of deregulation which is relevant to regulatory and policy discuss centred on ascertaining differences in performance and what they could learn from each other. In addition, the Canadian and Nigerian telecommunications industries continue to attract quasi-regulatory policies that subject them to outside influences with respect to connectivity, subscribers' registration and network coverage. Given this evolving operating environment, this research embodies knowledge that contributes to the understanding of performance and the influence of environmental factors on it. Also, it may generate findings with potential effects on telecommunications industry policies by providing theoretical and empirical evidence that may be used to guide policy formulation by government agencies (i.e., the regulators and/or policy makers) responsible for setting rules that guide the industry. Policy makers could reference this research as empirical evidence to gauge their expectations of the industry and to formulate new policies aimed at improving the industry's performance.

1.3 Purpose and objective of the research

The main purpose of this research was directed at meeting the need for information on the efficiency and productivity of the telecommunications industry in deregulated environments. The pursuit of this information prompted the exploration of trends across multiple countries but with a focus on Canada and Nigeria. This was carried out using partial indicators of performance to investigate the efficiency and productivity. Next, the efficiency and productivity analyses were carried out using aggregate measures to generate benchmark frontier that served as reference when assessing the efficiency and productivity of the industry in the two countries. Additionally, the influence of environmental factors on efficiency was examined coupled with an evaluation of the evolution of the industry's efficiency and productivity from 2001 to 2013. Also, participants from the industry completed survey questionnaires and provided useful feedback that gave insightful details of trends in performance and on how the industry is shaped by the deregulated environment.

1.4 Research questions

Two general research questions were addressed in this study. Research on telecommunications industry deregulation note that deregulation provides the platform for increased competition (Hausman & Taylor, 2012). In view of this, the first research question seeks to understand the appropriateness of deregulation in conceptualizing competition in the Canadian and Nigerian contexts and how the structure of the industry in the two countries evolved from the monopoly model.

RQ_1: How have deregulatory policies influenced the competitiveness in the telecommunications industry in Canada and Nigeria?

$RQ_{1.1}$: What forces drove and are driving the deregulated telecommunications industry in Canadian and Nigerian context?

$RQ_{1.2}$: What are the similarities and differences in Canada's and Nigeria's deregulatory milieu?

$RQ_{1.3}$: What impact does operating in a deregulated environment have on the industry's competitiveness?

The second question examines how telecommunications industry deregulation influences performance. This question is premised on the view that deregulation has a positive effect on the efficiency and productivity of the industry.

RQ_2: How has the performance of the industry been in the deregulated environment?

$RQ_{2.1}$: What are the performances (i.e., efficiency and productivity) of the industry in the two countries and how do they compare?

$RQ_{2.2}$: What influence do environmental conditions have on the efficiency and productivity performance of the industry?

$RQ_{2.3}$: Ascertain the applicability of structure-conduct-performance model to deregulatory outcomes in the two countries.

1.5 Overview of methodology

Several activities were undertaken in order to answer these research questions. First, an understanding of changes in the industry was gained through a review of prior empirical studies. Second, a two-stage analysis of efficiency and productivity was conducted. Stage one engaged non-parametric Data Envelopment Analysis (DEA) and relied on DEA-based Malmquist Productivity Index (MPI) productivity improvement management software. It adopted the input-oriented approach for the analysis of 13 years of panel data involving 19 countries to discern any efficiency and productivity changes. The main data sources were the International Telecommunications Union (ITU), World Bank, and OECD communications outlook. Additional data were obtained from each country's national statistics agency, regulatory agencies and empirical studies with a focus similar to this research. For an in-depth analysis, the DEA relied on three inputs (Capital Expenditures, Subscriptions and Employment) and two outputs (Revenue and Teledensity) with the analysis carried out under constant returns to scale (CRS) and variable returns to scale (VRS) as described in the methodology and data section in Chapter 5 with the results of the analysis presented and discussed in Chapter 6.

In addition, Mann-Whitney test was conducted to reveal if there is statistical evidence to reject the null hypothesis that there is no difference in the efficiency and productivity performance of the industry in the two countries of focus. Stage two involved the use of censored Tobit model to regress the efficiency scores against environmental variables (e.g., number of years in deregulation [NYRS], subscriptions to employment ratio [SubEmp], change in real GDP per capita [CRGDPPC], revenue to subscriptions ratio [RevSub], industry concentration [HHI], capex to revenue ratio [CapexRev], consumer price index [CPI], and level of development [LDev]) to guage their influences on efficiency. Finally, industry participants were contacted to complete the questionnaire designed for this research. Their responses provided detailed information that enriched the understanding of the phenomenon being studied.

1.6 Summary of findings

Industry participants in both countries indicated that deregulation has altered the structure, conduct and performance of the industry. The removal of barriers has changed the structure of the industry and has led to an increase in competition. The impact of the structural change on conduct varies between the two counries. It has a high influence on product pricing and product/service differentiation in Canada whereas it influences advertising, promotion and product pricing to a great degree in Nigeria. There is a widely held view among industry participants that performance improved in the deregulated environment. However, it was noted that the industry in Canada was mature, signifying limited growth opportunities while the industry in

Nigeria is emerging, suggesting potential for growth. Additionally, the rationale for deregulating the industry was found to align with literature exposition on motivations for deregulating the industry. The basis for deregulating the industry includes universal provision, service quality improvement, promoting competition, economic development, investment promotion and reasonable prices. Nonetheless, the issues facing the industry differ between the two countries. Changing technology, infrastructure funding and scale economies were issues in Canada whereas inadequate financing, policy inconsistency relating to tariffs and spectrum allocation, inadequate infrastructure and firms' disregard for rules meant to level the playing field were issues afflicting the industry in Nigeria.

Although the research found that the telecommunications industry in the two countries was inefficient, both showed improvements with Canada displaying better efficiency. The inefficiency in both countries was due to inappropriate scale and managerial ineffectiveness in allocating inputs. The industry in the two countries would attain better efficiency by decreasing inputs and by adjusting operational scale. The findings relating to the productivity of the industry showed the two countries experienced comparable levels of productivity increase but the path through which it was attained differed. Canada achieved productivity increase through technological progress and efficiency improvement. The technological progress came from innovation and the adoption of new technologies while efficiency came from improved managerial capabilities. The industry in Nigeria attained productivity through efficiency improvement only. However, unlike Canada, the efficiency improvement was achieved through enhanced operational scale. Since efficiency improvement contributed to productivity growth in both countries, it appears productivity could easily be augmented through efficiency improvement.

The findings relating to the exogenous environmental factors' influence on performance were exhilarating. First, industry concentration declined in the two countries, suggesting that the deregulated environment caused structural change and led to increased competitive intensity in the industry. However, the level of concentration indicates an oligopoly structure and suggests a handful of firms dominate the industry in each country, but this does not appear to have a significant role in determining performance. Second, the average revenue per subscriber (ARPS), which is an indicator of prices that customers pay, is higher in Canada than in Nigeria. Interestingly, one of the views for deregulating the industry was that increased competition would cause prices to decline. However, the findings show ARPS increased slightly in Canada but declined significantly in Nigeria which indicates that competition has benefitted customers in Nigeria. Because RevSub was found to have a positive and significant influence on performance, telecommunications industry with a higher ARPS will perform better, hence the superior performance of the Canadian telecommunications industry. Third, labour productivity was measured by SubEmp and the findings showed that it increased in both countries but is higher in Canada. In addition, this research found that labour productivity has a significant effect on technical efficiency performance. Thus, when evaluating performance, a telecommunications industry with high labour productivity will display better technical efficiency performance. However, it may not operate at a better operational scale than telecommunications industry with low labour productivity. Fourth, capital intensity which is represented by CapexRev is similar in both countries in the last year of the study. However, the pattern indicates that while it is relatively stable in Canada, it declined in Nigeria. This measure has a statistically significant negative influence on scale efficiency, implying that increasing the Capex per dollar of revenue diminishes performance and that enhanced performance depends on the degree of capacity utilization. Fifth, RGDPPC increased in both countries but Canada's display of higher RGDPPC may infer a higher disposable income and the affordability of telecommunications services. However, CRGDPPC was found to have a negative and insignificant influence on technical and scale efficiency, indicating that the telecommunications industry in countries with lower economic growth would display technical and scale efficiency performance that are similar to telecommunications industries in countries with higher economic growth. Inflation denoted by consumer price index has positive and significant effect on technical and scale efficiency, suggesting inflation drives performance enhancement. The level of development has an insignificant relationship with technical and scale efficiency, implying that the level of development in a country has unimportant influence on technical and scale efficiency of the industry.

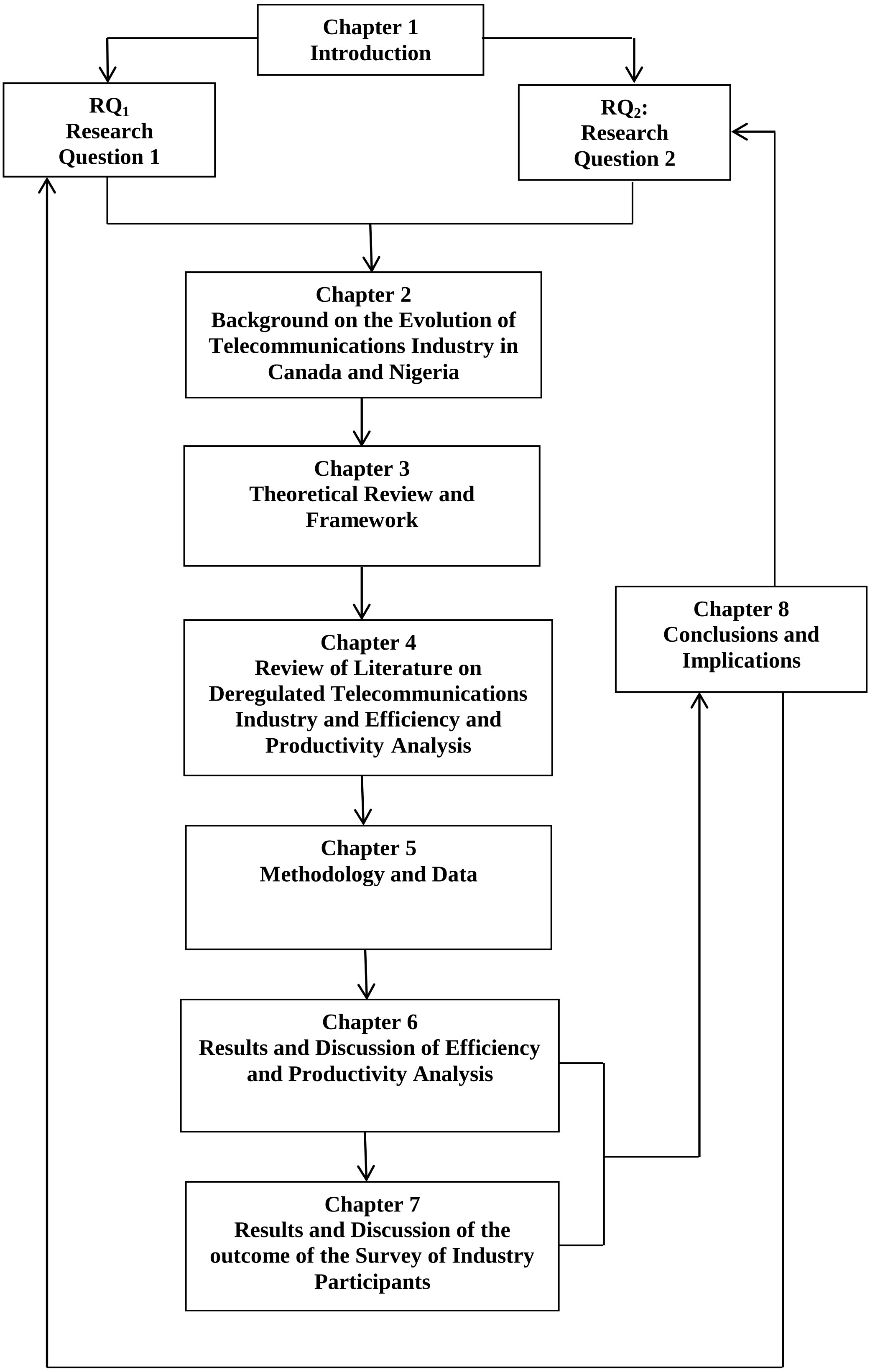
1.7 Significance of the research

Studies on telecommunications industry deregulation and its impact on performance exist but with a focus on countries other than Canada and Nigeria.

Because no current study exists on the efficiency and productivity performance of the industry in the two countries, this research fills a knowledge gap in literature and provides empirical evidence that adds to the understanding of the industry's performance. In addition, this research contributes to the knowledge of telecommunications industry performance in deregulated environments in three other ways. First, measuring efficiency and productivity performance of the industry over time and delineating the source of change yields information on trends in the performance of the industry and the source of cross-country differences in performance. In so doing, it provides telecommunications industry managers and regulators with information that could facilitate improvement of the industry. Second, the uniqueness of this research lies in the application of the structure-conduct-performance (SCP) model in examining the deregulation of telecommunications industry; it contributes to the SCP model narrative by seeking to confirm or disprove it through an exposition of the industry's structural change and influence on conduct and performance. Third, policies in favour of deregulation are embarked on with a view to promoting efficiency and increasing competition. However, deregulation does not always yield the presumed benefits that policy makers aspire to (Jurac, Vladimir, & Leos, 2004). This research contributes to the understanding of the relationship between deregulation and performance and increases stakeholders' knowledge regarding the evolving landscape prior to instituting policy actions that may impede existing deregulation or result in further deregulation of the industry. Therefore, government agencies (i.e., the regulators and/or policy makers) could use this research as empirical evidence when gauging their expectations of the industry and when formulating policies to move the industry in the direction of sustainable competition.

1.8 Structure of the research

The eight chapters in this research report all plausible concepts, phenomena and findings relating to the research (Figure 1.1). Chapter 1 introduces the research and deregulation milieu. It presents the research background, the motivation for engaging in the research, the purpose and objective of the research, the key research questions, an overview of the methodology, a summary of the findings, and the significance of the research by identifying the gaps filled and why the problem merited investigation. In addition, the chapter provides information on the structure of the research. Chapter 2 focuses on the evolution of the telecommunications industry in Canada and Nigeria. It describes and presents a snapshot of events that contributed to the industry's evolution in the two countries. In addition, the chapter provides an assessment of the industry and discusses the objectives of deregulation and the deregulatory issues experienced in the two countries of focus. Chapter 3 details the theoretical review and framework of this research. It conceptualizes regulation and deregulation. Predominantly, this chapter describes regulation, the rationale for regulating monopoly, forms of regulation and regulatory mechanisms (i.e., rate of return regulation, price cap regulation and earnings sharing regulation). In addition, the chapter conceptualizes deregulation and alternative expressions such as liberalization, privatization and commercialization as used in telecommunications research. The chapter discusses market structure vis-a-vis market structure continuum and deliberates on the theoretical underpinnings of market structure through a discussion of the Austrian school of thought, the Chicago school of thought, the post-Chicago school of thought, the contestable market phenomenon, the new empirical industrial organization (NEIO) theory, the SCP model and game theory. Furthermore, it presents the SCP model as the theoretical framework on which this research is based. Chapter 4 reviews the literature on deregulation and on telecommunications industry efficiency and productivity analyisis. It presents a review of studies on the impacts of deregulation on performance. It also presents the outcomes of empirical studies on telecommunications industry efficiency and productivity analysis. Chapter 5 covers the methodology and the data. It details the concept and measurement of efficiency and productivity, pinpoints various DEA models and discusses the use of MPI in decomposing and isolating the source of productivity change. In addition, the chapter discusses the Tobit model as a supplement to DEA-based efficiency analysis. Furthermore, this chapter elaborates on the empirical approach adopted, the model specifications, and the input and output selection. Additionally, the chapter discusses the data collection methodology, data issues, assumptions, and data treatment and ethical considerations in the conduct of the research to enhance its reliability and validity. Chapter 6 presents the results of the performance analysis in the form of partial factor analysis and total factor analysis of the efficiency and productivity of the industry. It identifies trends and patterns that relate to the research objectives and answers the research questions. The findings from using input-oriented DEA-based efficiency and an MPI analysis of 13 years of panel data involving 19 countries are presented in the chapter. Also, the chapter highlights changes and trends in efficiency and productivity as well the sources of the changes. In addition, the chapter considers the results of the second stage regression analysis and the Mann-Whitney test used to ascertain the statistical significance of identified efficiency and productivity differences between the two countries. Furthermore, the chapter discusses the sensitivity analysis performed on the DEA efficiency scores and also presents the result of the robustness check carried out on the censored Tobit model. Chapter 7 discusses the results of the survey questionnaires completed by industry participants. The chapter provides a discrete discussion of the analysed data, details the implications, and compares the findings with contemporary research that have examined telecommunications industry deregulation. Chapter 8 provides concluding details of the research and discusses the implications and meaning of the research results and their usefulness and contribution to the literature. The chapter discusses the research in a manner that presents the interpretation of the result as objective and worthy of further empirical inquiries.



Sources: Developed by the author for this research

Figure 1.1: Structure of the research.

Chapter 2
Background on the Evolution of the Telecommunications Industry in Canada and Nigeria

2.1 Introduction

The evolution of the telecommunications industry in Canada and Nigeria is articulated in this chapter. The first section of this chapter (Section 2.2) highlights the distinctiveness of the Canadian telecommunications industry deregulation and enunciated the two phases in its evolution. In addition, it gives a brief overview of the objective for deregulating the industry, and provides an assessment of the industry and deregulatory issues. The second section (Section 2.3) describes the stream of events that culminated in the deregulation of the Nigerian telecommunications industry. Specifically, it decribes the pre-liberalization, liberalization and post-liberalization eras, provides a basis for understanding the objectives for deregulating the industry, and presents an assessment of the industry and issues pertaining to the industry's deregulation.

2.2 Canadian telecommunications industy deregulation

2.2.1 Evolution of the Canadian telecommunications industry deregulation

Canada's telecommunications industry evolved from provincially held monopoly to one that is market driven. Events in the industry are categorized in two phases (CRTC, 2005): Phase one covers 1852 to the early 1980s; Phase two started in the mid 1980s with the introduction of competition in mobile cellular market. It continued with the introduction of Telecommunications Act of 1993 which set competition and efficiency as parameters for the industry. A summary of major developments in the industry is presented in Table 2.1.

2.2.1.1 Phase one

Phase one of the Canadian telecommunications industry which was defined by provincial/territorial monopolies and cross-subsidization covers the period between 1852 and early 1980s. With a service provider allowed in a particular region/territory, the Federal government required universal access and affordability, and initially applied rate-of-return regulation (ROR) but later changed to price cap regulation (PCR) to better protect customers (Gundy et al., 2007). Legislation in this phase included the Telegraph Act (1852), a Special Act (1880) and an amendment to the Railway Act (1906) to cover telephone services and a shared jurisdictional power (i.e., between the federal and provincial governments) over the industry (Table 2.1). Furthermore, in this phase the Department of Telecommunications assumed responsibility for framing Canada's telecommunications policy while the regulatory responsibility was delegated to the Canadian Radio-television and Telecommunications Commission (CRTC). Also, during this phase, *Bell Canada Special Act* was amended, and the 'obligation' to serve became mandatory for Bell Canada (CRTC, 2005; Industry Canada, 2006, p. 6.5). In addition, several aspects of the industry, including tariffs, the nature and mix of services, infrastructure use and business activities complementary to telecommunications became subject to regulation by the CRTC.

2.2.1.2 Phase two

Phase two, which overlaps with phase one, took roots in the late 1970s with the easing of price and entry controls in utility industries (i.e., energy, transportation, telecommunications etc.) (Industry Canada, 2008). In addition, this phase was shaped by the Supreme Court's ruling in 1989 that ceded jurisdictional powers over telecommunications carriers to the Federal government. Furthermore, this phase witnessed a series of deregulatory policy initiatives, a consolidation of telecommunications laws and the inclusion of 'forbearance' clause in the Telecommunications Act of 1993 (Minister of Justice, 2014, p. 21). The forbearance clause gives the CRTC the option to stay the application of regulatory provisions if doing so is consistent with Canadian telecommunications policy objectives. Also, in this phase, price cap regulation (PCR) replaced rate-of-return regulation (ROR). In addition, competition was introduced in the long distance sector, review of the implementation of the recommendations of the Telecommunications Policy Review Panel was carried out, and directives issued to the CRTC to allow the industry rely on market forces.

2.2.2 Objectives of telecommunications industry deregulation in Canada

Canada's telecommunications deregulatory policy was a response to the industry's changing landscape. It was instituted to curtail regulatory costs and make the industry competitive internationally (Industry Canada, 2006). However, the forbearance provision in the Telecommunications Act of 1993 requires but does not mandate competition when the competitive force is strong enough and protects consumers (CRTC, 2005). As set out in Industry Canada (2006, pp. 2.3), the objectives of Canada's telecommunications industry deregulation are to:

- i. Facilitate telecommunications development and affordability across Canada.
- ii. Enhance efficiency and competitiveness locally and abroad.
- iii. Foster reliance on market forces in the provision of services.
- iv. Protect the interest of users and respond to their economic and social requirements.
- v. Promote the use of Canadian transmission facilities.

2.2.3 Assessment of Canada's deregulated telecommunications industry

The Canadian telecommunications industry plays an important role in the life of Canadians and in the Canadian economy by linking the widely dispersed population and by yielding social and economic benefits for all regions (Statistics Canada, 2002). Unlike most countries where an incumbent national monopoly existed prior to deregulation, Canada had no national incumbent as monopolies were held provincially. Major players in Canada's deregulated telecommunications industry are: Rogers, Bell Canada, Telus and MTS Alstream. The industry also has some 43 independent firms providing services to rural and remote communities (OECD, 2002b). The industry is concentrated with five firms accounting for about 66% of industry revenue (Middleton, 2011). The services provided are wireline and mobile (i.e., wireless) which in 2013 accounted for 37% and 63% of subscriptions respectively; unlike wireline, the mobile sector is the least concentrated (Church & Wilkins, 2013). Furthermore, markets in Ontario, Quebec and British Columbia are more competitive than in provinces (e.g., Prince Edward Island, Saskatchewan, Newfoundland and Labrador) that delayed the introduction of competition (Statistics Canada, 2002). Prior to deregulation, the requirement for universal service preserved cross-subsidization. Since deregulation, the cross-subsidization of local and residential services by long distance and business customers has been eliminated (Lacobucci, Trebilock, & Winter, 2006). Also, increased competition in the deregulated environment has slowed price increases and profitability growth (CRTC, 2014). The industry has experienced growth with 99% of Canadian households subscribing to either a fixed or mobile service (Lacobucci, Trebilcock, & Winter, 2006). Also, the industry's contribution to GDP has is relatively stable at approximately 2% between 2001 and 2013 (Business Monitor International, 2009). The industry provides direct employment to 114,346 people and indirect employment to some 16,580 individuals (Industry Canada, 2006). Furthermore, Canada's average revenue per subscriber (ARPS) is relatively stable and the churn rate (i.e., the rate at which customers switch service providers) increased from an average of 1.57 in 2008 to 1.83 in 2011 but declined to 1.67 in 2012 (CRTC, 2013). The high churn rate is attributable to CRTC's mandated local number portability that has lowered customers' switching costs by allowing number retention in the event a customer chooses to change service providers (Statistics Canada, 2002). Clearly, no known empirical study provides an integrated assessment of the performance of the industry. By examining the trends in the efficiency and productivity of the industry, this research provides a basis for understanding how the industry has performed in the deregulated environment.

2.2.4 Deregulatory issues in Canada's telecommunications industry

The forbearance clause in the Telecommunications Act of 1993 may apply if doing so aligns with Canada's telecommunications policy objectives and protects customers, but the Act offers no guidance to aid its implementation and creates application ambiguity for the CRTC (Industry Canada, 2006, p. 2.10). There is the perception that the industry is reliant on market forces and that the forbearance clause could be removed. The view is that lack of guidance on the implementation of forbearance may increase the risk of cautious forbearance from regulation in competitive markets or too much regulation in markets where some regulation may be necessary but in which market forces could adequately complement or replace regulation (Industry Canada, 2006). Another issue is the requirement for network sharing and interconnection. The telecommunications industry is capital intensive and new entrants require access to incumbent networks to provide service to customers. Advocates of mandatory network access maintain it is uneconomical to duplicate telecommunications infrastructure and that mandated network sharing and access lowers entry barriers. However, opponents (i.e., carriers with established networks) were weary of granting access to new entrants that would compete with them (Industry Canada, 2006). The requirement that incumbents open their networks to competition generated complaints about network access and interconnection tariffs and necessitated CRTC regulation to require incumbents to implement ‘functional separation’ by splitting their businesses into retail and wholesale sectors and not engage in discriminatory practices that restrict competition from their network (Janisch, 2012, p. 775).

In Canada the regulatory policy that promotes universal access to telecommunications services and the ‘duty to serve’ which imposes obligations on firms in the industry to provide services to customers meant that service providers had to make services available to customers at a similar rate regardless of location. Supporters of service imposition obligation contend that it ensures geographically remote areas have access to services at affordable rates, but critics argue for its removal as customers could access services through multiple platforms (Ryan, 2012, pp. 521–22). Compounding the debate is the recognition that policies relating to universal services and obligations to serve result in cross-subsidizing rural customers and are inconsistent with competitive market ideals but they have ensured nearly 99% of Canadians in both rural and urban locations have access to telecommunications services (Rajabiun & Middleton, 2013). An important question is whether the duty to serve extends beyond the monopoly industry that necessitated its creation? Nonetheless, the debate is ongoing and no consensus has been reached (Ryan, 2012). Also, there are concerns regarding the conflicting objectives of the Telecommunications Act of 1993 that promotes increased reliance on market forces and the Broadcasting Act of 1991 which seeks to encourage Canadian values and talents but constrains competition (Anderson et al., 1998).

Table 2.1: Major developments in the Canadian telecommunications industry.

Dates	Activities
1852	• Passage of the first Telegraphs Act
1880	• Special Act passed by Parliament to give Bell Canada a Charter to provide telephone service throughout Canada; Bell Canada concentrated investments in Ontario and Quebec.
1902	• Bell Canada Special Act amended ▪ Imposes an obligation to serve on Bell Canada ▪ Forms the basis for Canada's universal service policy
1906	• Telecommunications Industry regulated by the Canadian Transport Commission • Amendment of Railway Act to cover telephone services
1969	• Establishment of Department of Telecommunications ▪ Telecommunications and broadcasting policy ▪ Radiocommunications policy and regulation ▪ Telecommunications and broadcasting services extension to remote areas ▪ Research and development
1976	• Canadian Radio-Television and Telecommunications Commission formed ▪ Telecommunications and broadcasting policy and regulation
1978	• Cost inquiry initiated to establish reporting mechanism for CRTC to identify cross-subsidization
1985	• Introduction of mobile wireless competition ▪ National license granted to Rogers Cantel (now Rogers Wireless) ▪ Regional license granted to each provincial monopoly ▪ CRTC resisted opening the long distance market to competition
1989	• Supreme Court gave the Federal government power over telecommunication carriers and provinces transferred their regulatory powers to the Federal government
1992	• CRTC introduced competition to public long distance services ▪ Requires open entry and equal access
1993	• Telecommunications Act passed ▪ Sets parameters for industry transition to competition
1994	• CRTC reviewed regulatory framework • Created framework that increased competition by reducing the number of services subject to regulation • Announced forbearance from regulation of wireless services
1995	• Announced forbearance from non-dominant carriers • Competitive wireless Personal Communications Systems licensed
1996	• National digital mobile license issued to Rogers Wireless and two new entrants (i.e., Microcell and Clearnet)
1997	• CRTC announced regulatory framework for competition in local telephone markets ▪ Mandated interconnection between local providers ▪ Identified essential services incumbent should make available to new entrants and set prices ▪ CRTC narrowed its regulation of incumbent local service providers ▪ CRTC forbearance from regulating long distance services and private line services
1998	• Competition in the public pay-telephone service market introduced through liberalization • Replacement of traditional rate-of-return with price cap regulation • Establishment of regulatory framework for international services

2000	• Telesat Canada's monopoly on satellite telecommunications carriage ended • Long distance competition introduced in areas served by Northwestel

2005	• Appointment of the Telecommunications Policy Review Panel
	  ▪ Review Canada's telecommunications policy framework
	  ▪ Make recommendations on how to make the industry internationally competitive

2006	• Telecommunications Policy Review Panel report made available to the Minister of Industry
	  ▪ Justifies reliance on market forces
	  ▪ Recommended the elimination of CRTC's economic regulation
	• Government issued directives to CRTC on the implementation of section 7 of the Telecommunications Act
	  ▪ CRTC to allow the industry to rely on market forces to the extent possible
	  ▪ Any regulation should be efficient and less interference with market forces required

Sources: Industry Canada (2006); Middleton (2011, pp. 69.2–3); OECD (2002, p. 9).

2.3 Nigerian telecommunications industry deregulation

2.3.1 Evolution of Nigeria's telecommunications industry deregulation

The telecommunications industry in Nigeria spans three eras. The major events are outlined in Table 2.2. The first era, pre-liberalization, pre-dates the country's independence and extends to periods after independence. The second era, liberalization, started in 1986. It was dominated by increased interests in the pursuit of privatization policies and the introduction of the Structural Adjustment Programme (SAP) (Jerome, 2008). Post-liberalization is the third era, which this research indicates is still evolving.

2.3.1.1 Pre-liberalization era

At independence in 1960, there were 18,724 telephone lines servicing a population of 40 million people in Nigeria (Oyatoye & Okafor, 2011). As illustrated in Table 2.2, this era witnessed heavy government involvement aimed at facilitating access. By 1985, the number of telephone lines increased to 200,000. However, the ratio of 1 telephone line for every 440 Nigerians (i.e., a teledensity of 0.23) was below the target of 1 telephone line for every 100 Nigerians (Ajiboye, Adu, & Wojuade, 2007). In this era, the Department of Post and Telecommunications (P&T) was split, and the telecommunications divisions merged with the Nigerian External Telecommunications Limited. The merger led to the emergence of Nigerian Telecommunications Limited (NITEL) which became the national monopoly. NITEL was tasked with providing efficient services, attaining scale economies, improving service affordability, harmonizing the planning and coordinating of internal and external telecommunications services, and rationalizing investment (Ajiboye, Adu, Wojuade, 2007). However, NITEL's inability to cope with population growth and its slow adoption of automatic switch exchange technology hampered sevice quality (Jerome, 2003; Oyatoye & Okafor, 2011).

2.3.1.2 Liberalization era

In the liberalization era, public faith in NITEL dwindled and the clamour for a different model became paramount. Although the Nigerian government initiated the move to privatize and commercialize state owned enterprises in 1986 as part of the structural adjustment program (SAP) for economic growth and development, deregulation of the telecommunications industry did not start until 1992 after the

Nigerian Communications Commission (NCC) Decree Number 75 was promulgated (Table 2.2). NITEL's monopoly ended in this era as new entrants – a second national carrier, five global systems for mobile communications (GSM) operators, and several code division multiple assess (CDMA) operators were granted operating licenses (Mughele, Olatokun, & Adegbola, 2012).

2.3.1.3 Post-liberalization era

The post-liberalization era started in 2006 upon the expiration of the five-year exclusivity period granted GSM operators. In this era, the unified license which authorizes firms to provide a group of services (i.e., mobile and fixed telephone, national long distance and gateway) in a region of the country or nationally was implemented (NCC, 2016b). This provision was meant to enable firms take advantage of new technology and be cost effective in providing services to customers (Omowunmi, Niran, & Oluseyi, 2009). Furthermore, the registration of subscriber identity module (SIM) card to customer's name became a strict requirement. In addition, mobile number portability (MNP) which gives customers the right to cancel a service with a provider and to migrate to a different network without losing their phone numbers was implemented. This allows customers more freedom and forces operators to reduce costs and improve service quality (Tiamiyu & Mejabi, 2012). Remarkably, competition in the industry was high at the start of this era but some providers unable to compete exited the industry thereby reducing competition.

2.3.2 Objectives of telecommunications industry deregulation in Nigeria

Deregulation was intended to address NITEL's inefficiency, improve teledensity and the sector's contribution to the economy (Hassan, 2011). Initially, the deregulatory agenda was focused on commercialising NITEL. It gravitated to divestment and eventual sale of NITEL. As indicated in Chidozie, Odunayo, & Olutosin, (2015, pp. 178-179), the motives for deregulating NITEL and for which the Nigeria Communications Commission (NCC) was established in 1992 were to:

i. Promote competition and facilitate telecommunication services provision.
ii. Protect the public (e.g., on prices, service quality etc.).
iii. Promote the entry of private entrepreneurs and investors to the telecommunications industry.
iv. Issue licenses to firms in a manner that is transparent and equitable.

v. Manage spectrum allocation to ensure its effectiveness and efficiency.
vi. Promote investment in the industry.

2.3.3 Assessment of Nigeria's deregulated telecommunications industry

Prior to deregulation, the industry was dominated by the state-controlled incumbent (i.e., NITEL). Since deregulation, competition has increased with the entry of new service providers, which has benefitted customers through lower prices (Hassan, 2011). The industry is concentrated and consists of two national carriers (i.e., NITEL and Globacom) and five firms with MTN Nigeria controlling the largest share of the market. Also, the industry is dominated by GSM service providers who account for 99.1% of the market while CDMA and fixed line/fixed wireless services account for 0.8% and 0.1%, respectively (NCC, 2016). In addition, some firms have operating license that allows them to participate across multiple spectrums. For example, NITEL and Globacom also offer GSM services. Furthermore, the CDMA operators offer fixed line/fixed wireless services, and one GSM operator (MTN) is in partnership with VGC Communications Limited that offers fixed line/fixed wireless services.

Teledensity which was approximately 1 in 2001 increased to 91.15 in 2013 and the industry's contribution to GDP reached 7.4% in 2013 (NCC, 2016a). However, the rapid subscriptions growth resulted in network congestion with negative effect on service quality, prompting the Nigerian Communications Commission (NCC) to impose fines on firms that failed to meet service requirements. Awoleye et al. (2012) noted that investment in the industry rose, but average revenue per subscriber (ARPS) declined (Pyramid Research, 2010); considering mobile number portability (MNP), the market has become competitive. The incidence of increased subscriptions and teledensity suggest improved performance from the view of the regulator but declining industry revenue shows otherwise from the perspective of the industry, thus generating some ambiguity in measuring the performance of the industry. This research will make it possible to draw definite conclusions about the performance of the industry. The use of aggregate measures in the efficiency and productivity analysis of the industry will enable policy makers and industry managers to have a similar understanding of the industry's performance. It will shed more light on the factors that may have contributed to or detracted from the performance of the industry and actions that could be taken to enhance performance.

2.3.4 Deregulatory issues in Nigeria's telecommunications industry

The process of deregulation and the sale of NITEL met with political and public resistance (Ariyo & Jerome, 2004). Also, NITEL's sale to private owners was hindered by disagreements between the Bureau for Public Enterprises (BPE) and the ministries responsible for NITEL (Otobo, 2002). In addition, the Nigerian Labour Congress, the union representing employees, voiced its objection through strikes and legal injunctions that were meant to frustrate the deregulation of the industry (Otobo, 2002). Other issues included the lack of transparency and the poor implementation of subscriber identity module (SIM) card registration (Okpanachi & Obutte, 2011), lack of robust legal institutions, and the inability to secure adequate finances (Omoleke & Adeopo, 2005).

Table 2.2: Major developments in the Nigerian telecommunications industry.

Dates	Activities
1851	• Postal branch of the British Post established
1886	• Telecommunications facilities established by the colonial administration
1960–85	• Telecommunications consisted of two departments: ▪ Posts and Telecommunications was responsible for internal communications ▪ Nigerian External Telecommunications (NET) was responsible for external communications
1984–85	• Decoupling of Posts and Telecommunications into two divisions ▪ Postal division ▪ Telecommunications division
1986	• Structural Adjustment Program introduced by the government ▪ Deregulation and privatization of SOEs started
1988–91	• Technical Committee on Privatization and Commercialization carried out a comprehensive review of NITEL
1992	• National Communications Commission (NCC) Decree Number 75 promulgated • NITEL commercialized as NITEL Plc., a public limited company ▪ NITEL Plc. was registered under the Companies and Allied Matters Decree of 1990
1998	• Amendment of NCC Act to strengthen the role and powers of the NCC
2001	• GSM license granted to MTN, Econet and M-Tel (a subsidiary of NITEL Plc.)
2002	• NITEL lost its monopoly of the industry when Globacom was granted a license to operate as the second national carrier
2003	• A more comprehensive Communications Act was passed • Implementation of National Telecommunications Policy • Globacom granted GSM license
2005	• Introduction of unified licensing
2008	• Etisalat granted GSM license

Sources: Onakoya, Tella, & Osoba (2012), Akinpelu & Ayokunle (2011) and NCC (2016b).

Summary

This chapter discusses the Canadian and Nigerian telecommunications industries and some of the events that shaped their evolution. Events in the Canadian industry occurred over two phases. Phase one was characterized by provincially held monopolies and cross-subsidization to attain government objective of universal service provision and affordable prices. However, due to the inadequate protection of customers through rate-of-return regulation (ROR), the Federal government changed the industry's regulatory mechanism to price cap regulation (PCR). Phase two was prominently influenced by a Supreme Court ruling in 1989 that gave the Federal government authority over the industry. In this phase, deregulatory initiatives were introduced, telecommunications laws consolidated and the 1993 Telecommunications Act that allowed the CRTC to forbear introduced. Nonetheless, the lack of clarity on the implementation of forbearance created an issue. The Nigerian telecommunications industry had a national monopoly but several policies adopted by the government shaped the industry's evolution. The pre-liberalization era was marked with government involvement and poor performance of the industry. The liberalization era started in 1992 with the establishment of the Nigerian Communications Commission (NCC). National monopoly ended in this erea with the introduction of competition in the industry in 2001. The competitive environment in the post-liberalization era has intensified due to shift toward unified licenses and mobile number portability (MNP), resulting in the less competitive firms exiting the industry. While the attainment of deregulatory objectives is ongoing, the issues highlighted include the lack of transparency and the inability of the legal system to deal with issues relating to the industry.

This chapter has shown that the overall policies adopted by the Canadian and Nigerian governments were aimed at promoting market forces and at facilitating the development and improvement of the industry. The next chapter (Chapter 3) presents the theoretical review and the framework of this research in order to understand how the industry in the two countries performed in the deregulatory environment.

Chapter 3

Theoretical Review and Framework

3.1 Introduction

This chapter provides a brief overview of regulation and deregulation. It details the rationale for regulation, forms of regulation and regulatory mechanisms. In addition, the chapter covers the basis for deregulation and discusses the different forms of deregulation and deregulatory mechanisms. Also, it elaborates on the theoretical underpinnings of market structure and crystalizes the conceptual model and theoretical framework for this research. The framework reveals linkages between structure, conduct and performance and illunimnates the role of government policies and external factors in determining events in the telecommunications industry.

3.2 Describing regulation

Regulation is a government way of inducing firms to act in consonance with its socio-economic pursuits. The premise is that it mitigates 'market failure' and confers maximum benefits to the public (James, 2000, p. 330). The concept of regulation in this research reflects market intervention carried out by governments for the attainment of economic (e.g., reduced price) and/or socially desirable goals (e.g., universal access).

3.2.1 Rationale for regulating monopoly industry

A monopoly occurs when a single firm provides a product or service for which there are no close substitutes (Joskow, 2007). It exists with utilities firms in industries such as hydroelectricity, transportation, energy and telecommunications which typically have 'monopoly power' that could be used to influence output and price (Yee, 2004, p. 485). Proponents of regulation believe it restricts firms' behaviour and prevents undesirable market outcome (James, 2000). Telecommunication industry regulation advocates cite 'public interest' doctrine and express that it improves the welfare of customers by eliminating inefficiencies and by correcting market anomalies and failures (Franco, 2004, p. 178). Another rationale for regulation is 'economic theory' (Church & Ware, 2000, p. 769) which is premise on redistributing economic wealth, restricting price and preventing the monopoly firm from arbitrary price increase (Kuo-Tai, 2012) and using entry barriers to protect incumbent firms so ‘scale’ and ‘scope’ economies are achieved (Hoffmann, 2008, p. 4). Another justification for regulation is ‘information asymmetry’ which is a situation where some market participants make suboptimal decisions due to lacking information possessed by others (Baron, 2010, p. 313). It is construed that regulation mitigates the occurrence of inadequate information and prevents irrational decisions from being made.

3.2.2 Forms of regulation

Regulation takes the form of ‘ex ante’ or ‘ex post’ regulation (Blackman & Srivastava, 2011, p. 30). With ‘ex ante’ regulation, the regulator reviews the structure of the industry, anticipates actions of industry participants and applies measures (e.g., price control, entry terms etc.) to redirect behaviours of market participants toward socially desirable goals. On the other hand, with ‘ex post’ regulation, the regulator uses fines and sanctions to deal with specific conduct and rule violation (Blackman & Srivastava, 2011, p. 31).

3.2.3 Regulatory mechanisms

A natural monopoly situation is expected to result in cost decrease due to spreading fixed costs over more units of output (Church & Ware, 2000). However, studies show that a monopolist possesses ‘market power’ and uses it (e.g., output restrictions) to cause consumers to pay more for the product or service (Uukkivi, Ots, & Koppel, 2012, p. 225). To prevent the abuse of power, underproduction, and inefficiency, mechanisms that have been used in telecommunications industry regulation includes: rate-of-return, price cap and earnings sharing.

3.2.3.1 Rate-of-return regulation (ROR)

Rate-of-return mechanism is used to cap a monopoly’s profit by limiting the return on investment (ROI) to a value considered ‘fair’ (Currier & Jackson, 2008, p. 262). Through rate of return, the regulator advises the monopoly on price that allows for recouping operating costs and a modest return on investment. According to Yee (2004), the unintended consequence of this mechanism is inefficiency as the monopoly is guaranteed a certain level of return on investment. Also, because the monopoly sees no incentive to contain costs, customers may end up paying more than they would in a competitive market (Majumdar, 2010).

3.2.3.2 Price cap regulation (PCR)

Price cap regulation was aimed at eliminating inefficiency and costs associated with rate-of-return regulation (Yee, 2004). It involves setting the maximum price for a product or service for a given period (e.g., 3–5 years.) and allowing it to rise and fall at a rate equal to the difference between the inflation rate and a factor (X) that is set in advance by the regulator. This shifts the burden of price variations to the monopoly (Currier & Jackson, 2008) and forces it to share any cost savings with customers through price adjustment (i.e., inflation adjusted prices) (Bernstein, 2000). With price cap regulation, the actual return on investment deviates from the forecast as the monopoly could set a price below or at a capped rate. Illustratively, if the inflation rate was 2.5% and the X-factor set at 3%, the monopoly will be required to reduce the price by 0.5% (2.5%-3% = -0.5%). However, when price cap regulation results in a lower rate of return, it provides no incentive for the monopoly to respond to higher product or service demand; thus constraining the drive for improved efficiency and innovation in the industry (OECD, 1995).

3.2.3.3 Earnings Sharing Regulation (ESR)

With earnings share regulation, the regulator specifies a target rate of return and earnings or profits for the monopoly. It also specifies the range (e.g., 10%–12%) where ‘no sharing’ of profits with customers is required. Although regulators require the transfer of all or part of the earnings above the specified range to customers through refunds and/or reduced price, the monopoly is allowed to increase price when earnings fall below the lower limit (Sappington & Weisman, 2010). Earnings share regulation diminishes technical efficiency and is considered an unviable regulatory mechanism (Majumdar, 1997).

3.3 Describing deregulation

Deregulation is often associated with ‘privatization’ (Doellgast, 2009, p. 4; Megginson & Netter, 2001, p. 321), ‘commercialization’ (OECD, 2003a, p. 13; Adeyemo, 2005, p. 224) and ‘liberalization’ (Bance, 2007, p. 331; Jho, 2007, p. 633). In the context of privatization, it projects delegating production decisions to private owner(s) and shifting ownership and control from government to the private sector (Megginson & Netter, 2001). Viewd Through the lens of ‘commercialization’, deregulation connotes reorganizing and making public enterprise less dependent on government subventions (Adeyemo, 2005). In the context of liberalization, deregulation is the removal of restrictions on entry, prices, output and profits (Williams, 2010) and/or using ‘market-driven’ policies to promote competition (Eckel, 2007, p. 78). In this research, deregulation is considered to be ownership transfer from government to the private sector and the lessening of government interventions; a description that has both theoretical and ideological meanings that traverse privatization, commercialization and liberalization. Studies show deregulation has positive impacts on the industry due to alterations in the number of participants and the nature of products/services offered (Rosenblut, 1998).

3.3.1 Rationale for telecommunications industry deregulation

Rate-of-return regulation, price cap regulation and earnings share regulation have been applied to restrict monopoly. However, the administrative cost and the fostering of the non-competitive environment in which they are applied removes incentive(s) for firms to improve performance (Yee, 2004). The rationale for the shift from regulation to deregulation is discussed under the following themes.

3.3.1.1 Increasing regulatory costs

Skyrocketing regulatory costs (e.g., ‘compliance’, ‘opportunity’, ‘defence’, and ‘administrative’) have created the demand for a shift in the regulatory approach so as to synchronize permitted conduct with public interest (Vance, 2012, p. 271). For governments, the desire to curtail the direct and indirect costs of regulation rationalizes the shift away from regulation. For firms, the shift is predicated on ‘unnecessary burdens’ of compliance that raise costs for firms and inhibit their competitiveness of (OECD, 2010, p. 11).

3.3.1.2 Political ideology

The rationale for deregulation has been examined through political views – the right wing (i.e., conservatives) and left wing (i.e., liberals) (Cabeza & Gomez, 2011). While the left wing favours regulation and government interventions, the right wing endorses ‘unfettered operation of markets’ (Larner, 2000, p. 6) and holds the view that government intervention in markets is fiscally imprudent, stifles innovation and erodes individual consumer choice and freedom. The political spectrum and philosophical constructs from which public officials emerge defines the level of support for deregulation.

3.3.1.3 Performance

Efficiency and productivity are vital to the long-run sustainability of an industry. Productivity measures output per unit of inputs (Coelli et al., 2005) while efficiency deals with how well resources are used to create value for customers by producing a mix of products/services that meets their needs (Treacy & Wiersema, 1993; Porter, 1996). Poor performance contributes to the decision to deregulate because entry barriers in monopoly industry and the guarantee of a particular level of return on investment contribute to inefficiency and inflate prices for customers (Baumol & Klevorick, 1970).

3.3.1.4 Addressing fiscal issues

Pressure to tackle fiscal issues is an impetus for deregulation. Deficit spending is addressed through reduction and/or removal of subventions granted to state owned enterprises (SOEs). Also, proceeds from deregulation are used to ameliorate government liquidity problems (Omoleke & Adeopo, 2005). In addition, deregulation generates revenue for government to enhance social programs (Abbott, 2013). Also, it is seen as a way of facilitating direct investment in infrastructure and a means for accelerating the attainment of salient economic growth objectives (Cabeza & Gomez, 2011).

3.3.1.5 Advancement in telecommunications, computer and information technology

Innovation in telecommunications, computer and information technology, including the shift from analogue networks to digital and satellite transmissions, are contributory to the industry's deregulation (Vogelsang, 2003). The advancement blurs the lines between telecommunications, computer and information technology and validates the quest for deregulation (Stolfi & Sussman, 2001). The innovation in network infrastructure and service delivery facilitates new service provisions and challenges the existence of the regulated monopoly provider.

3.3.1.6 Meeting the lending requirement of the World Bank and the International Monetary Fund

As a prerequisite for financial assistance, the World Bank and the International Monetary Fund (IMF) require structural reforms targeted at eliminating anti-competitive legislation and/or barriers to entering industries considered essential for economic growth and development (Adeyemo & Salami, 2008). Following the recommendations of two international financial institutions (i.e., World Bank and IMF), several countries have made telecommunications industry deregulation part of their reform for access to aid packages to shore up their economies and to address broader macroeconomic issues (Latipulhayat, 2010). A contemporary example is the Greece crisis within the European Union and the mandate for Greece to engage in economic reform and curtail deficits spending prior to bailout funds agreements with the IMF and the European Central Bank (Featherstone, 2011).

3.3.2 Forms of deregulation

Deregulation changes the competitive landscape and imposes an obligation on firms to operate efficiently. However, the degree of deregulation and the speed with which it occurs determines firms' response. Kim & Prescott (2005, p. 416) uses 'scope' and 'pace' to describe the elements of deregulation. While the former focuses on the degree of deregulation (low *vs.* high) and determines the level of competition and price, the latter centres on the speed (slow *vs.* fast) of deregulation and defines smoothness in the transition that firms have to make.

3.3.2.1 Frame-breaking

The 'frame-breaking' form of deregulation occurs when the 'scope' is high and 'pace' is fast and firms are expected to rely more on internal mechanisms (Kim & Presccott, 2005, p. 417). Although many business opportunities abound with the frame-breaking form of deregulation, the uncertainty associated with it requires that incumbent and new firms quickly adapt and leverage core competencies (Kim, 2002).

3.3.2.2 Metamorphic

The 'metamorphic' form of deregulation is known for its high 'scope' but slow 'pace' (Kim & Prescott, 2005, p. 418). Though the scope of deregulation is high, the slow pace reduces uncertainty and creates less urgency because market participants have time to adjust. Furthermore, the slow pace of deregulation does not lead to a rapid increase in competition as incumbent and potential entrants have time to assess deregulatory policies before taking actions. With this form of deregulation, firms rely on internal mechanisms as government regulation will not be quickly eliminated.

3.3.2.3 Piecemeal

The 'piecemeal' form of deregulation is characterized with low 'scope' but fast 'pace' (Kim & Prescott, 2005, pp. 418–19). The fast pace causes a quick introduction of competition and puts pressure on market participants to adapt. However, the slow scope does not allow competitive environment to be fully entrenched. Like the metamorphic form of deregulation, piecemeal allows firms to rely on internal mechanisms but with convergence among firms and retention of regulatory power by government (Udayasankar & Das, 2007).

3.3.2.4 Plodding

'Plodding' is a form of deregulation with low 'scope' and slow 'pace' (Kim & Prescott, 2005, p. 419). The low scope signals that deregulation is limited and that market opportunities are restricted; the slow pace indicates gradual deregulation and firms view it as less beneficial to institute internal mechanisms (Udayasankar & Das, 2007). Unlike the other forms of deregulation where reliance on internal mechanism is embraced, in order to accommodate reality, this form allows the regulatory agency to maintain significant control and to modify rather than outrightly eliminate regulation.

3.3.3 Deregulatory mechanisms

The mechanism used to deregulate an industry is dependent on government objectives (Hoffmann, 2008) and the nature of the monopoly – "private" or "public" (Blackman & Srivastava, 2011, p. 10). With a private monopoly, the direct introduction of competition is favoured. On the other hand, with a public monopoly, the approach could involve granting entry to private operators to compete with the public or state owned enterprise, transferring ownership of the state owned enterprise to the private sector and concurrently introducing competition and/or breaking up the state owned enterprise with monopoly power into several units (Alabi, Onimisi, & Enete, 2010; Megginson & Netter, 2001). As noted in Industry Canada (2008), transferring ownership from public to private retains the monopoly structure and may not benefit customers, but privatizing the state owned enterprise and introducing competition results in efficiency gains and benefits customers through reduced prices and better services.

3.4 Describing market structure

Market structure identifies an industry's nature and characteristics and is the 'consequence' and 'determinant' of competition (Boone & van Witteloostuijn, 2006, p. 409). It describes the organization and actions of market participants (i.e., buyers and sellers) and their relative competitiveness and ability to influence market price (Sigmund, 2008). 'Perfect' and 'imperfect' competitions are the two ends in the market structure continuum (Foshee, 2010, p. 68). The 'perfect' competitive structure is characterized by many sellers with no market influence but each exhibits 'price taking' behaviour due to the inability to control price (Julien, 2010, p. 661). The imperfect competitive structure embodies 'monopolistic competition', 'oligopoly' and 'monopoly' (Luo, 2009, p. 512) and is characterized by reduced competition and more market power concentrating in one firm or only a few due to decline in the number of participating firms, product differentiation and/or entry barriers as the structure trends from monopolistic competition to oligopoly and to monopoly.

Boone & van Witteloostuijn (2006, pp. 412–13) uses 'organizational density' (i.e., number of firms) and 'concentration' (i.e., size of firms) to categorize market structure in four. First is the 'fragmented' structure which is a structure that is accentuated in perfectly competitive market where power is dispersed and each participant adopts market price. In this market, easy entry and/or exit is the norm and each firm is a 'price taker' (Makowski & Ostroy, 2001, p. 480). Studies such as Makowski and Ostroy (2001) and Hayes (2008) show that due to product homogeneity, this type of industry is rivalrous, creating incentives for firms to be efficient and effective. Second is the 'uniform' market structure. This reflects monopolistic competitive industries where a number of firms offering similar but differentiated products compete (Chang, 2011). Firms in this industry produce similar or close substitute products but the uniqueness of each firm's products creates opportunity to earn above average market price (Carson, 2006). Given that there is a price range beyond which customers would switch to competitors, the desire to maximize profit causes firms to under produce, resulting in capacity underutilization and inefficiency (Lou, 2009). Third is the 'concentrated' market structure. This structure is exhibited in oligopoly markets where a handful of large firms competing with each other recognize their 'strategic interdependence' (Fuentelsaz & Gomez, 2006, p. 482). Church & Ware (2000) noted that collaboration among firms in oligopoly markets influences their behaviour and that agreeing to output restrictions increases each firm's profitability. Boopathi & Sujen (2012) indicates that firms in oligopoly market pay attention to rivals' reactions and struggle to choose between promoting self-interest and collaborating with others. Usually, firms are aware of anti-trust policies and express bans on colluding for the purpose of increasing price or engaging in any actions that reduces benefits for customers (Brock & Obst, 2009, p. 67). Nonetheless, there is also the understanding that the law does not directly forbid 'conscious parallelism' – a covert cooperation attained by matching rivals' actions especially if the firm making the initial move is the market leader in the industry (Dibadj, 2010, p. 590). Fourth is the 'dual' market structure, which is prevalent in markets where a dominant market participant allows smaller but specialized firms to operate in the market. This categorization does not directly refer to monopoly but the mention of market dominance suggests monopoly characteristic. An obvious assumption is that a monopoly often maximizes profits by charging the highest price but it faces an elastic demand (i.e., a downward sloping demand curve) and so would not always emphasize the highest price but will search for the best output and price combinations that maximizes profitability, causing it to give less consideration to the efficient use of resources (Rosenberg & Clements, 2000; Lee & Tollison, 2011)

3.5 Theoretical underpinnings of market structure

Several theoretical constructs have been used to explain firm behaviour and industry performance. One is the Austrian school of thoughts which holds that 'disequilibrium' and 'monopoly power' are normal in competitive markets (Leon, 2014, p. 8). This school of thought maintains that efficient resource allocation is attained via rivalry and that competition results in more efficient firm(s) dominating the industry and conferring benefits to consumers. The exit of inefficient firms may allow efficient ones to temporarily attain monopoly profits until their actions are copied by others. Another perspective is the Chicago school of thought which gained prominence in the 1970s and 1980s. The Chicago school asserts ideas similar to the Austrian school and cautions against market interference by government by maintaining that efficiency and benefits to customers are achievable if markets are left alone (Cook, 2002). The assertion from the perspective of the Chicago school is that with time highly efficient firms with low production costs will increase in size and market share, plausibly increasing market concentration (Bhandari, 2010), thus the motivation for others in the industry to seek efficient production methodologies to be competitive (Baker & Shapiro, 2008). Unlike the Austrian school, the Chicago school rationalizes why firms increase in size and why high profitability may not necessarily be due to market power but the result of operational scales, high efficiency and/or the effectiveness of a small group of firms (Shaik et al., 2009; Delvin, 2010). Given the Chicago school's rationale for market concentration and efficiency, it is possible that the increase in market concentration and power would result in monopoly profit for the incumbent (Cook, 2002). To curb this, the post-Chicago school evolved. Unlike the Chicago school, this holds a moderate view and concurs that market power emanates from barriers to entry and other forms of anti-competitive practices; hence its tolerance of some level of government interventions (Delvin, 2010).

Another view is the 'contestable market' phenomenon which was initiated by Baumol, Panza, and Willig in the 1980s (Bratland, 2004, p. 2; Amavilah, 2012, p. 2). As a theory in the field of industrial organization, contestable market is one in which 'entry is absolutely free, and exit absolutely costless' (Baumol, 1982, p. 3). Possessing some preconditions, contestability is found to apply in all types of market structures. According to Church & Ware (2000, p. 508), the first condition is that all incumbent firms and potential entrants are predisposed to the same technology; second is the absence of sunk costs due to recoverability of entry costs upon an entrant's exit from the industry; third is the lack of 'entry lag', meaning that a new entrant can produce at any level; fourth, the response time requirement of the incumbent firm is greater than the entrant's exit time requirement, implying that a new firm can enter an industry, sell at a price below what incumbent firm sells at, and exit in a ‘hit-and-run’ fashion with no cost to itself before the incumbent could initiate a response (Baumol, 1982, p. 4). Contestable market posits that a specific market structure does not necessarily yield a particular performance. Instead, the contestable nature of the market and the possible entry and/or costless exit of firms serves as a check to the conduct and behaviour of existing firms irrespective of the industry structure (Machaj, 2013). This construct is elaborated in Evenden & Williams (2000) who noted that the behaviour of existing firms does not preclude the potential impact of the behaviour of new entrants. In essence, potential entrants can enter an industry to tap profit opportunities and then exit when conditions change without incurring a loss. Although theorists of contestable markets hold that contestability and threats of new entrants motivate incumbents to pursue cost effectiveness and efficiency improvements, support for it has waned due to empirical limitations and the difficulty surrounding the determination of the degree to which markets are imperfectly contestable (Evenden & Williams, 2000).

Furthering the discussion on market structure and firms’ behaviour, Boopathi & Sujen (2012, p. 1) focused on the oligopoly market and used ‘game theory’ to explain how ambiguity surrounding the decisions firms face in choosing between promoting self-interest and cooperating with others can affect operational, investment and competitive strategies. Sirghi (2009, p. 260) elaborated on the game theory and describes how firms in oligopoly markets behave by first acknowledging their mutual interdependence followed by a consideration of their expected or anticipated behaviours. Thus firms may use resources unproductively, resulting in inefficiencies and higher prices for customers (Bompard et al., 2010). Game theory application extends to the new empirical industrial organization (NEIO) which was coined by Bresnahan in 1989 (Einav & Levin, 2010). NEIO premises that marginal costs are unobservable and impossible to be estimated directly and that each industry is unique and so assessing behaviours from a cross-sectional sample of industries is implausible (Parsons, 2007). Kadiyali, Sudhir, & Rao (2001, p. 167) present the three main considerations essential to NEIO applicability (i.e., demand specification, cost specification, and competitive interaction specifications). They noted NEIO provides adequate understanding of the competitive behaviour of firms in defined markets and industries rather than in cross-sectional studies across industries. Overall, NEIO is useful for approximating market power and marginal cost, but it relies on behavioural differences that exist when price taking firms and those with market power are subjected to new demand and/or cost requirements (Church & Ware, 2000).

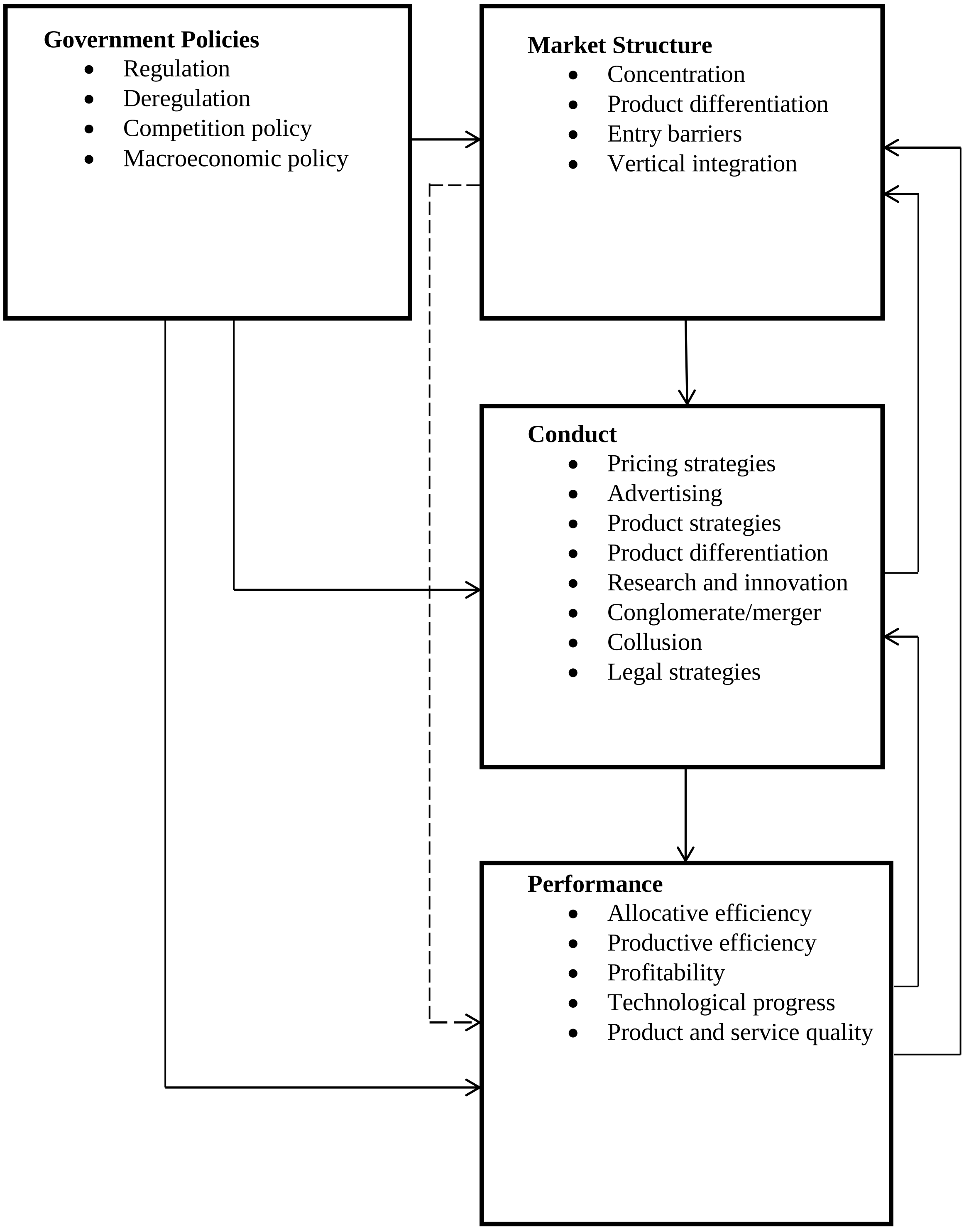
A model that has contributed to the understanding of market structure, level of concentration and performance is the structure-conduct-performance (SCP) model developed by Edward Mason and Joe Bain in the 1940s and 1950s (Nazari & Tajdini, 2011) and which is referred to as the 'Harvard paradigm' (Pope & Ma, 2008, p. 949). It assumes causality between industry structure, firm conduct and performance (Church & Ware, 2000). Originally applied to the study of the relationship between profitability and concentration in US manufacturing industries, it articulates that structure influences conduct which in turn determines performance. Within the context of SCP, structural variables which are observable and measurable include the number of market participants, product differentiation, entry barriers, and degree of market power (Wirth & Bloch, 1995; Tung, Lin, & Wang, 2010). The conduct variables are behavioural variables and include product strategies, advertising, pricing strategies, and research and innovation. The performance variables include productive and allocative efficiency, product and service quality, profitability and technological advancement (Wirth & Bloch, 1995; Tung, Lin, & Wang, 2010). Two constructs of the SCP model are discussed in Edwards, Allen, & Shaik (2006, p. 1). The first is the 'structure performance' model which premises that there is an inverse relationship between market concentration and level of market competition; the second is the 'efficient structure' model which rationalizes the dependence of a firm's performance on efficiency. Conceptually, the SCP hypothesizes that market power increases with concentration (Pope & Ma, 2008; Delvin, 2010) and that there exists a positive correlation between concentration, market power and profitability (Church & Ware, 2000). In the telecommunications industry, market power is increased due to barriers relating to high capital requirements, network effects, regulations and firm created barriers such as exclusive dealings and high switching costs. These barriers prevent or limit entry and concentrate market power in the hands of one (monopoly), two (duopoly) or a few (oligopoly) incumbent firms.

3.6 Building the theoretical framework for this research

The theoretical framework establishes the philosophical basis for the research and lays the foundation for conceptualizing the research (Berman, 2013; Imenda, 2014). The framework presented in Figure 3.1 is a product of a blend of several studies on the SCP paradigm. These studies were examined for relevance and applicability to the case being investigated but were found to need modifications to fit the research objective. In constructing the framework in Figure 3.1, the outcomes in Kadiyali, Sudhir, & Rao (2001, p. 164), Sahoo & Mishra (2012, p. 239) and Tung, Lin, & Wang (2010, p.1123) were amalgamated in ways that eliminated the deficiencies identified in each.

3.6.1 The structure, conduct and performance (SCP) framework

The SCP model presumes that structure shapes conduct which then influences performance. Tung, Lin, & Wang (2010) and Kadiyali, Sudhir, & Rao (2001) present a causal effect and flow from structure to conduct to performance but there exists the influence that conduct has on structure, performance on conduct and performance on structure. Figure 3.1 shows the interrelationship between structure, conduct and performance and depicts how governments through policies relating to regulation, deregulation, competition and the macroeconomy influence the SCP components. Broader macroeconomic objectives of government, policy shift from regulation to deregulation and the requirement to comply with anti-competitive 'ex ante' and 'ex post' regulations are essential to ensuring competition and altering firms' conduct and performance (Blackman & Srivastava, 2011, pp. 30–1; Garcia & Anson, 2012). This research recognizes the structural presumption in the SCP model and relies on the depiction in Figure 3.1 to fully capture the significance of the interdependent nature of structure, conduct and performance.



Source: Assembled from Kadiyali, Sadhir, & Rao (2001); Tung, Lin, & Wang (2010), & Sahoo & Mishra (2012, p. 239).

Figure 3.1: The refined SCP model.

3.6.2 Theoretical framework of this research

The underlying theoretical framework of this research is 'deductive reasoning' at a macro level and culminates in the use of 'middle-range' theory so that the observed phenomena are grounded in empirical evidence for easy generalization (Liehr & Smith, 1999, p. 81; Neuman, 2011, p. 69). The various layers used to frame this research are depicted in Figure 3.1. This framework relies on the SCP model that has been refined with the inclusion of government policies and also the identification of conduct and performance as having impacts on structure and vice versa. Government policies cut across economic and social objectives (Korsching, Sapp, El-Ghamrini, 2003; Williams, 2010) and broader macroeconomic policies directed at economic growth, job creation, wage increase and better trade policies influence government actions. Telecommunications industry promotes economic growth and satisfies government's macroeconomic objectives (Giray, 2007; Awoleye et al. 2012). However, the direction embraced (i.e., regulation *vs.* deregulation) influences the industry's structure, conduct and performance which in turn determines macroeconomic outcomes. In a monopoly situation, a firm makes decisions that maximize profitability with little attention to efficient resource utilization causing 'welfare' loss for customers (Round & Zuo, 2008, p. 33; Brock & Obst, 2009, p. 67) as 'wealth' is transferred from customers to the firm (Balasooriya, Alam, & Coghill, 2010, p. 370). On the other hand, in a deregulated and competitive situation, the lack of market power by firms stimulates effective resource use (Kalejaiye, Adebayo, & Lawal, 2013).

On the social front, telecommunications allow people to break distance and location barriers (Yilmaz, Haynes, & Dine, 2002) and enrich the experience and social wellbeing of those accessing the technology (Katz, 2009). The social policy regarding universal service provisions to a wider group (e.g., rural and remote areas) coupled with government investments through direct involvement in infrastructure results in social benefits (Williams, 2010; Rajabiun & Middleton, 2013). Universality hinges on scale and scope economies and favours the monopoly model but may undermine performance (Madden, Savage, & Ng, 2003). The competitive market structure is assessed using the number of participants, concentration, product differentiation, entry barriers and degree of vertical integration. To determine an industry's concentration, the Hirschman-Herfindahl index (HHI) index is used. The index is calculated by adding the squared market share of all firms in the industry.

The revised HHI merger guidelines by the US Department of Justice and the Federal Trade Commission (2010, p. 19) is shown in Table 3.1. Based on this widely accepted guideline, a high HHI indicates highly concentrated industry with a firm or a few firms having market power.

Table 3.1: Categorizing an industry using HHI.

Hirschman-Herfindahl index (HHI)	Level of Concentration
Less than 1500	Unconcentrated
1500–2500	Moderately concentrated
Greater than 2500	Highly concentrated

Source(s): US Department of Justice and the Federal Trade Commission (2010, p. 19)

Market structure reflects the level of industry concentration and is considered to have an influence on conduct and performance of firms in an industry. Since competition results from low levels of concentration, government and regulatory agencies have the tendency to intervene through policy change should there be evidence of high concentration and/or reduced competition. The intervention could change market structure variables and influence conduct and performance (Martin, 2012). Studying the effect of policy reform in the Mongolian mobile communications industry, Byambaakhuu, Kwon, & Rho (2014) describe the desire for increased competition as the basis for deregulating the industry. The study applies SCP framework and reckons that changes in market structure cause behavioural change among firms, and define firms and market performance. In their view, once operationalized, deregulation causes reconfiguration of structure, conduct change (e.g., investment in infrastructure) and performance augmentation.

Summary

Insights on regulation and deregulation have been provided in this chapter. The description of regulation depicts market intervention meant to mitigate monopoly firm from misusing market power. A common view is that regulation protects the general public and restricts the monopoly from arbitrary price increases. Rate-of-return regulation, price cap regulation and earnings share regulation have been used to regulate monopolies but are subject to criticism due to the high costs associated with monitoring compliance by firms in the industry and the need for the monopoly to constrain costs or to strive for an increased level of performance. Issues associated with regulation made the pursuit of deregulation apparent. The change in the competitive environment fostered by deregulation motivates firms in the industry to operate more efficiently. However, the degree of deregulation and the speed with which it occurs shape how firms respond in a deregulated environment. Hence the study of the Canadian and Nigerian telecommunications industries offers a good glimpse of deregulated environment.

In addition, this chapter discusses market structure and highlights how the organization, nature and competitiveness in an industry are affected by the number and size of market participants. Aside from the four predominant market structures (i.e., perfect competition, monopolistic competition, oligopoly, and monopoly) often discussed in the market structure continuum, this chapter presents an elaborate understanding of market structure and uses the four categorization in Boone & van Witteloostuijn (2006, pp. 412–413). The first is 'fragmented' industry structure which is tantamount to perfectly competitive market where each participant is obligated to comply with market dictates. The second is 'uniform' market structure and reflects monopolistic competitive markets in which firms profit by offering differentiated products but the underutilization of resources prevails due to profit maximization motives of firms in the industry. The third is 'concentrated' market structure. This foreshadows oligopoly situation with a small number of firms dominating the market. The fourth is the 'dual' market structure which is prevalent in markets with a dominant participant. The theoretical underpinning of market structure presents the review of industry structure and performance through a variety of perspectives (i.e., Austrian school, contestable market, Chicago school, post-Chicago school, game theory, NEIO and SCP) that show that views differ on why an industry could become concentrated and/or on how structure influence conduct and performance. This chapter also discusses the SCP model and conceptualizes it as the framework for understanding the performance of deregulated telecommunications industry. The next chapter (Chapter 4) provides a review of literature on deregulated telecommunications industry efficiency and productivity analysis. It details studies on deregulation and performance, highlights the results of deregulated utilities industries and directs attention to the efficiency and productivity studies on telecommunications industry.

Chapter 4

Review of Literature on Deregulated Telecommunications Industries and Efficiency and Productivity Analyses

4.1 Introduction

Chapter 3 discusses market structure and the theoretical framework for this research. Also, it was used to set the stage for understanding performance in deregulated environment. This chapter (Chapter 4) provides a review of relevant literatures on the outcome of industry deregulation. The chapter is organized as follows: Section 4.2 reviews prior studies on deregulation and performance; and Section 4.3 presents empirical studies on telecommunications industry efficiency and productivity analysis. Maintaining focus on the objectives of this research, the review of literature was carried out to identify gaps in existing studies and to serve as the basis for rationalizing the methodology used in the analysis of performance in this research. The chapter concludes with a summary.

4.2 Review of studies on deregulation and performance

The evaluation of the relationship between deregulation and industry performance is of interest because of the impact of deregulation on performance and policy implications. There is a plethora of studies on deregulation, but there is no consensus on its influence on performance. Comparing the average value of performance indicators five years before and after privatization, Jerome (2008) relied on profitability (i.e., return on assets [ROA], return on equity [ROE], and return on sales [ROS]), operating efficiency (i.e., net earnings per employee and revenues per employee) and capital expenditure to sales to analyze the performance of some privatized enterprises in Nigeria. The study found improvements in ‘allocative efficiency’ and ‘consumer welfare’ (p. 49). However, the study ignored the role of exogenous factors. Liu & Whalley (2011) examined the behaviour of firms through the lens of market concentration, investment and pricing, and showed that restructuring alone cannot prevent anti-competitive behaviour by operators with market power, thus highlighting the need for policy makers to pursue the introduction of competition and the disintegration of the dominant player in the industry during deregulation. La Porta & Lopez-de-Silanes (1997) examined the benefits of deregulation in Mexico and found that it has economic impact on some privatized enterprises' profitability, operating efficiency, capital expenditure, output and capital structure. Similar indicators were used in Boubakri & Cosset (1998) study of the financial and operating performances of 79 newly privatized firms in 21 developing countries. Focusing on profitability (i.e., return on sales [ROS], return on assets [ROA] and return on equity [ROE]), efficiency (i.e., sales efficiency – real sales/number of employees), net income efficiency (i.e., net income/number of employees), capital investment spending (i.e., capital expenditure/sales), number of employees, leverage (i.e., debt/total assets and debt/equity) and dividends (i.e., dividends/sales and dividends/net income), the study shows an increase in all areas of performance measures when ownership moved from public to private hands. Furthermore, using simple averages and Wilcoxon Z statistic test, the study establishes that privatization resulted in increased financial performance and that it was also responsible for the decline in leverage ratios. Extending the work of Boubakri & Cosset (1998) in the analysis of corporate governance and performance of newly privatized firms, Boubkari, Cosset, & Guedhami (2001) used performance indicators similar to the ones used in earlier studies. Focusing on profitability, efficiency, investment and output, the study applied descriptive statistics and regression model to show that economic reforms and corporate governance influence post-privatization performance of newly privatized firms, a hint that factors other than deregulation may play a role in post-deregulation performance.

Wei et al. (2003) studied the financial and operating performance of China's newly privatized firms. Relying on performance measures that include profitability (i.e., return on sales and net profit), output (i.e., real and nominal sales and real assets), employment, operating efficiency (i.e., sales efficiency – ratio of sales to number of employees), and leverage (i.e., debt-to-total asset), the research assessed performance three years before and after privatization and used Wilcoxon sign-rank test to examine if there is significant difference in performance. Furthermore, the study used regression analysis to understand the influence of some other variables on the pre and post-privatization performance of firms. The findings show that output, sales efficiency, real assets and profitability increased post-privatization. Similarly, in a comparison of the pre and post-privatization performance of partially privatized firms in India, after adjusting for changes in competition, Gupta (2002) itemized evidence of increased profitability, efficiency and productivity (i.e., ratio of sales revenue to labour), and return to labour (i.e., ratio of operating income to labour) of the firms examined.

Capital intensive industries appear to be of interest in most studies on deregulation. Delmas & Tokat (2005) apply DEA in the analysis of performance of deregulated electricity utility sector in the US and reported that deregulation has a negative impact on the efficiency of firms in the industry. However, the study only focused on the short-term impacts of deregulation and reviewed three years of data (1998–2001). Nonetheless, the study's finding that efficiency is affected by the level of fragmentation in the competitive environment adds value to the debate regarding industry concentration and efficiency. Jamasb et al. (2005) provides empirical evidence on the determinants of performance of electricity sector reform in developing countries. The study notes that deregulation increased operating efficiency but that the gains have not been passed on to customers effectively. Zhang, Parker, & Kirkpatrick (2008) examination of electricity sector reform in developing countries and the effects of privatization, competition and reforms reveal interesting dynamics. Using data from 36 countries from 1985 to 2003, the study relates that competition results in improved capacity utilization and labour productivity. However, it notes that situations involving privatization alone showed no evidence of improved performance. The lack of competition in situations involving privatization indicates no benefits accrue in the transfer of monopoly from public to private. Dempsey (2008) investigated impact of US airline industry deregulation and notes that it has benefitted customers through price reductions, but rising costs and excess capacity meant reduced profitability for firms in the industry. Although, deregulation has contributed to the growth in the industry, the increase in competition has resulted in consolidation and mergers and an increase in the level of concentration; a phenomenon considered necessary in order to leverage scale and scope economies for the attainment of increased efficiency and productivity (Scharpenseel, 2001). In the banking industry, Strahan (2003) notes that deregulation led to an increase in bank size and the ability to service more customers over a wider geographical area at lower prices. Nevertheless, the elimination of less efficient banks through mergers, acquisitions or outright bankruptcy raises the possibility of increased concentration and higher market power. Competition and increased levels of efficiency and productivity were evidenced in the Indian banking sector that showed increased productivity after deregulation (Casu, Ferrari, & Zhao, 2013). However, the recorded gain benefitted foreign banks rather than locally owned banks

The telecommunications industry is a capital intensive network industry that has gone through deregulation. The liberalization of the industry in China took the form of share issues on major stock exchanges instead of an outright sale of the state owned enterprises to private individuals (Zheng & Ward, 2011). The application of regression model in the study of the effects of liberalization on China's telecom industry showed improvements in the average revenue per user, average revenue per minute, industry concentration and number of subscribers. Focusing on Korea Telecom and the impact of competition on the efficiency of public enterprise in Korea, Lee, Park & Oh (2000) found significant improvements in a number of performance measures which led to the conclusion that significant improvements in performance is achievable only if markets are competitive. This finding is similar to Naessi & Neven (2005) who applied regression analysis in the examination of competition, regulation and privatization of telecommunications sector in Latin American countries and found a combination of decline in price and increase in labour productivity (i.e., number of lines per worker and revenue per worker), investment in infrastructure and higher teledensity when the industry became deregulated. In a multi-country analysis of telecommunications reform, achievement, and challenges in Indonesia, The Philippines, Thailand and Vietnam, Lee & Findlay (2005) found that Indonesia failed to attain the desired performance objective through partial privatization (i.e., public–private partnership) hence it embraced full deregulation and opened the industry to competition in 1999. This is buttressed by Li & Xu (2004) who used regression model to evaluate the impact of privatization and competition on telecommunications firms and reported that telecommunications firms in countries with full privatization have better performance than those in countries with partial privatization. Lee & Quayes (2005) applied the Cox proportional hazard model to shed lights on the relationship between public ownership and productive efficiency. Using teledensity, productive efficiency (number of lines per employee) and revenue per line, they suggested that ending state ownership of telecommunications improves productive efficiency. Hung & Lu (2007) did a comparative study of the performance of global telecommunications operators. Using inputs (i.e., total assets, capital expenditures and employees), and outputs (i.e., revenues, earnings before interest, taxes, depreciation and amortization

[EBITDA], EBIT and net income), they suggested that telecommunications firms could attain higher levels of efficiency by reducing input. Interestingly, the study found that publicly owned telecommunications firms were more efficient than privatized ones but quickly concludes that the reason for this observation was not clear, thus necessitating further empirical studies. Among empirical studies that present inconsistent results is Petrović et al. (2012). The study examined telecommunications industries in 22 European Bank for Reconstruction and Development countries and found that countries that exhibited greater deregulation had better performance, suggesting that differences in post-deregulation performance is attributable to country-specific differences and prevailing environmental factors in each country.

Overall, industry performance in deregulated environment has drawn much interest, but many of the studies on developed and developing countries present mixed results. While studies such as Fink, Mattoo, & Rathindran (2002) and Madden, Savage, & Ng, (2003) indicate improvement in performance, some show otherwise and infer that firms in non-deregulated environments display better performance (Hung & Lu, 2007) or no detection of difference in performance immediately following deregulation (Resende & Facanha, 2002). In general, two competing theories are dominant – 'market power' (MP) paradigm and 'efficiency structure' (ES) paradigm (Gajurel & Pradhan, 2011, p. 25). The former states that increased market concentration resulting from low competition leads to better profitability and performance. In contrast, the latter affirms no causality between market concentration and performance but that higher level of efficiencies explains better profitability and performance. Of particular significance is the discussion regarding the level of competition, market power and performance noted in Uukkivi, Ots, & Koppel (2012) and Gutierrez-Hita & Georgantzis (2012) that indicate market power prevails in an environment of low or absence of competition and so does inefficiency and poor performance but that deregulation fosters competition and results in improved performance.

Studies seem to converge in ascribing improved performance in deregulated environment to deregulation, but the degree of success and enumerated performance vary partly due to using inconsistent performance measures which makes it difficult for reliable conclusions to be drawn on the impact of deregulation. An example is Zhang, Tang, & He (2012) who investigated the impact of macro and firm-specific characteristics on the post-privatization performance of state owned enterprises in China. The study indicates no profitability improvement post-privatization but reported efficiency improvement. However, it relied on a simple partial measure of efficiency (i.e., sales per employee). Also, Cabeza & Gomez (2007) measured performance using profitability, productivity and efficiency ratios such as sales divided by number of employees and operating profit divided by the number of employees. The study did not show medium-term post-privatization improvement in firms' profitability but revealed significant improvements in the long term. Based on this observation, they asserted that there is need to consider longer time horizons when analyzing privatization process and its influence on firm performance. With the exception of Cabeza & Gomez (2007), other studies are silent on the time horizon (i.e., short term *vs.* long term) for attaining improvement in performance. Additionally, studies have used econometric analysis and regression models to provide useful insights on factors that affect performance, but the robustmess of the models used in several studies, including Boubakri, Cosset, & Guedhami (2001), is questionable due to inadequate provision for dealing with issues of correlation and bias. A major deficiency in these studies is their dependence on partial measures of performance which creates difficulty in identifying a benchmark without being impartial.

4.2 Empirical studies of telecommunications industry efficiency and productivity analysis

The evaluation of efficiency and productivity is necessary for an understanding of the performance of an industry prior to designing and implementing improvement measures. Studies have examined performance using frontier and non-frontier methods (Figure 4.1). Wallsten (2001) used a non-frontier econometric technique to investigate the effect of competition, privatization and regulation on telecommunications industry performance in 30 countries from Africa and Latin America from 1984 to 1997. It found that competition benefitted the industy and that privatization together with independent regulatory authority improves performance. Similarly, Wallsten (2004) examined privatized monopolies in developing countries and confirmed that reform improves performance but granting exclusivity shifts monopoly from public to private and decreases investment. Ros (1999) investigated telecommunications industry reform effect on network expansion and efficiency.

Using data from 1986 to 1995 and fixed effect model, the study finds that privatization and competition impoves labour efficiency (i.e., mainlines per employee) and that competition has no effect on network expansion. Also, it found that countries that have at least 50% telecommunications assets in private domain experienced higher teledensity, however the study maintains that no evidence of increased teledensity for countries with GDP per capita below $10 000. The research presents astonishing results but uses partial measure of performance (i.e., teledensity and labour productivity) as dependent variables in the model instead of aggregate measures which would have generated a robust result. Fink, Mattoo, & Rahindran (2003) applied econometric technique and assessed telecommunications reform in 86 developing countries across Africa, Asia, Middle East, Latin America and the Caribbean from 1985 to 1999. While the technique used does not capture the multifaceted reform process, the study concludes that teledensity and labour productivity increased but that complete liberalization (i.e., privatization and concurrent introduction of competition) increases teledensity and labour productivity by 8% and 21% respectively than reform involving privatization and delayed introduction of competition. Banker, Chang, & Majumdar (1998) also used non frontier econometric technique to examine economies of scope in U.S telecommunications industry between 1988 and 1992 and note that technology deployment contributed to cost reduction and improved performance. However, serial correlation in the Ordinary Least Square (OLS) used to regress the time series data may have biased the coefficients of the variables in the model.

The frontier approach in Erber (2005) took the form of parametric and involves stochastic production possibility frontier in the analysis of the efficiency of telecommunications industries in the US, UK, Germany, France and Netherlands. The study determined technology efficient frontier for each of the countries and measured inefficiency over time with reference to the frontier. Analyzing data from 1981 to 2002, it notes France and UK displayed better technical efficiencies. The study attributed efficiency differences to time lag in adopting technology but suggests observed differences diminished with time. However, the study's use of unbalanced data and dependence on a series of assumptions regarding the Cobb-Douglas function and translog function creates difficulty in generalizing the results. Supplementing stochastic frontier analysis (SFA) with data envelopment analysis (DEA), Li (2009) examines the efficiency and total factor productivity growth

(TFPG) of 22 mobile carriers across seven countries over 13 years (i.e., 1995–2007). The study shows that as the number of decision making units (DMUs) increases, DEA displays lower efficiency scores than SFA. Additionally, it examined productivity under both approaches and finds total factor productivity growth under DEA (5.6% per year) is higher than under SFA (2.2% per year). Also, the DEA approach showed that contribution from efficiency change (EC: 4.8% per year) surpasses contribution from technical change (TC: 1.1% per year) whereas the SFA showed contribution from technical change (TC: 2.2% per year) is greater than contribution from efficiency change (EC: 0.9% per year) hence the study's reasoning that efficiency and productivity scores are sensitive to methodlogy. Additionally, the study indicates reform influences the sector positively and that GDP growth enhances DEA technical efficiency and SFA technical efficiency whereas time trend has no consistent effect because it shows no influence on DEA technical efficiency but positively influences SFA technical efficiency scores. Seo et al. (2010) apply DEA and SFA in the investigation of market consolidation and productivity in US telecommunications industry. Focusing on 25 Incumbent Local Exchange Carriers (ILECs) over 10 years (i.e., 1996–2005), the study finds incidence of post-merger productivity deterioration under both methodologies but notes firms that consolidated alleviated productivity decline, insinuating increase in concentration enhances productivity. The study is fascinating in that it contradicts earlier study by Li (2009) that reported productivity increase. The controversy is compounded by findings in Resende (2008) who investigated the robustness of different efficiency measures: SFA, DEA, Corrected Ordinary Least Square (COLS), and a random effect model in the study of incentive regulation implementation in US telecommunications industry. The study's comparison of efficiency scores showed moderate level of consistency across the models, representing a departure from Li (2009) and others that seemed to indicate performance is sensitive to methodology.

The frontier approach in Diskaya, Emir, & Orhan (2011) involves non-parametric method (i.e., DEA) which was applied in a comparative analysis of the effect of the 2008 financial crisis on the technical efficiency of Turkish telecommunications industry and G8 countries. Using four inputs and three outputs and data from nine firms, the study concludes that the industry came out of the recession stronger. Furthermore, sample mean constant returns to scale technical efficiency (CRS TE) and variable returns to scale technical efficiency (VRS TE) declined in 2008 and 2009 but increased in 2010 and is higher than the mean score in 2007, implying improvement in efficiency over time. The productivity analysis showed that Turk Telecom experienced total factor productivity decline (1.7% per year) due to technological regress and efficiency retardation. Although, the overall sample displayed technological regress (1.67% per year), it attained total factor productivity growth mainly through efficiency improvement of 1.84% per year. However, the study's use of four inputs and three outputs suggests it needed at least 12 firms instead of 9 in the sample size to be empirically sound. In addition, no statistical tests was performed to determine if the efficiency and productivity scores of Turk Telecom is statistically and significantly different from those of firms in the G8 countries, nonethesless, the study provides useful basis for understanding the sources of efficiency and productivity performance. Applying DEA to study productivity change in telecommunications industries in 13 OECD countries from 1979 to 1998, Calabrese, Campsi, & Mancuso (2002) note total factor productivity growth averages 4.87% per year with technological change contributing the most (4.83% per year). The study also indicated efficiency could be improved through input-output mix rather than scale, however it inappropriately used number of mainlines rather than capital investment to proxy capital input (Coelli et al., 2005).

Utilizing two inputs and one output in the examinination of telecommunications industry in 11 European countries, Torres & Bachiller (2013) analyzed data from 1997 to 2005 and reported decline in technical and scale efficiency over the study period. Regressing efficiency scores in the second stage analysis, the study noted investment increased efficiency and that liberalization alone does not affect efficiency unless it is accompanied by increased competition which is consistent with Fink, Mattoo, & Rahindran (2003). Similar analysis by Gokgoz & Demir (2014) revealed decrease in mean technical and scale efficiency of European telecommunications industry. Commendably, the study examined industry data from 32 countries in Europe and utilized production and revenue approaches with three inputs and two outputs but the implied conclusion is not objective due to dependence on two years of data (i.e., 2010 and 2011) and lack of information on efficiency trends in the industry in each country. Usero, & Asimakopoulos (2013) investigated productivity change and its drivers among 23 leading mobile operators in Europe between 2008 and 2009 and finds that all except one experienced productivity decline. The study failed to decompose the productivity results and provides no analysis of the sources of the productivity decline thereby detracting from its practical implications. Petrovic et al. (2012) used DEA to examine 22 European Bank for Reconstruction and Development countries from 1998 to 2007. Relying on three inputs and one output, it found that the 10% per year total factor productivity growth was the result of technical change progression (TC: 9.4% per year) and efficiency change improvement (EC: 0.5% per year) but it failed to decompose the efficiency change into pure technical efficiency change (PTEC) and scale efficiency change (SEC) components which would have provided more insights on how the efficiency improvement was attained. Similarly, Petrović et al. (2011) examined the efficiency of 20 developing countries in Europe in 2002 and 2007. Employing three inputs and one output in the DEA, the study found that only four of the 20 countries in the study showed growth in performance score and rankings. Also, the study made broad statement that efficiency attainment in Estonia was due to good regulatory framework and that economic development does not determine events in telecommunications industry but it gave no empirical examination to support these statements. Prior studies (e.g., Li, 2009) proved otherwise. In addition, regressing efficiency scores against some environemental variables that proxy regulation and economic growth would have provided greater insights rather than the broad statement lacking empirical validity.

An integral study by Madden & Savage (1999) investigated telecommunications industry productivity, catching-up, and innovation in 74 countries. Applying the Malmquist Productivity Index (MPI) and relying on five years of data (i.e., 1991–95), the study reported that the average total factor productivity growth of 0.9% per year was due to technical change rather than efficiency change. Additionally, the study found that the category of industrialized countries displayed the highest total factor productivity growth (10.2% per year) due to technological innovation only and the deterioration in efficiency noted was caused by inappropriate scale. Developing European countries also experienced total factor productivity growth (8.9% per year) but was attributed to innovation and efficiency improvement. African countries as a group experienced total factor productivity decline (3.7% per year) due to technical change regress and efficiency retardation. Also, countries in the Western Hemisphere experienced total factor productivity decline (10.2% per year). While Asia and Middle East categories experienced total factor productivity growth (1.2% per year) which was attributed to technical change improvement (i.e., innovation) but the two regions experienced efficiency decline. Using Generalized Least Square, the study stated that market size and privatization positively influence innovation in the industry but that market concentration has no significant effect. The study is informative but telecommunications industry has changed since 1995, suggesting the need for a contemporary study with more recent data. Cabanda, Ariff, & Viverita (2004) apply DEA to study telecommunications industry in 39 countries from Africa, Americas, Asia–Paific, and Europe. Using 10 years of data (i.e., 1989 to 1998), it found total factor productivity declined in the sample of countries due to technological regress. While categorizing the data by region reveals Europe (1.293) experienced the highest total factor productivity growth followed by Americas (1.040), and Asia–Pacific (1.033), and Africa (1.003), the lopsidedness of input (i.e., two outputs) and output (i.e., four outputs) and the small samples in each category may have caused limited comparison and reduced the discriminatory power of the DEA. Nonetheless, the finding regarding the source of total factor productivity growth mirrors prior empirical findings (e.g., Madden & Savage, 1999).

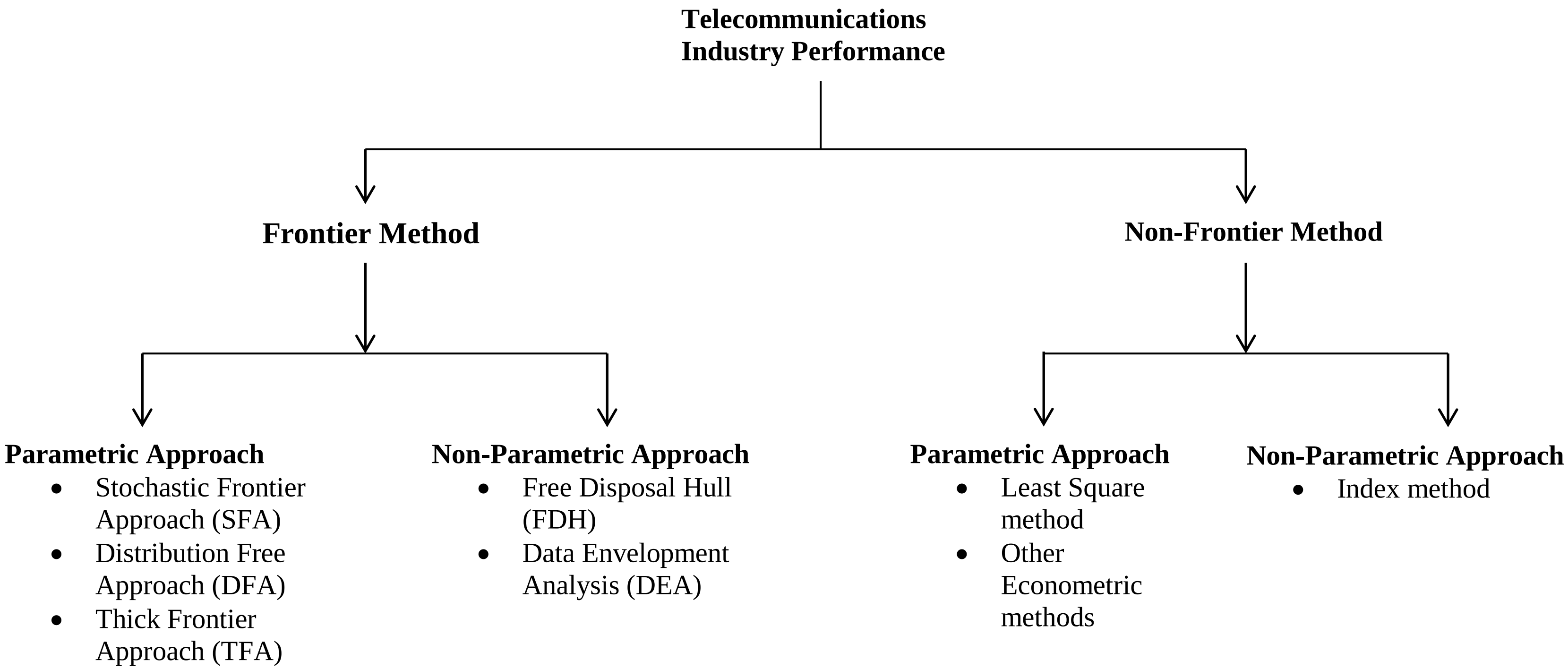
Hu & Chu (2008) used two-stage procedure to analyze the efficiency and productivity of 24 major telecommunications firms in Asia–Pacific over a five year period (i.e., 1999 to 2004). The study reports technical and scale inefficiency in all years in the sample of firms except KDDI of Japan and TNZ of New Zealand. Also, the second stage regression with Tobit model shows that the level of competition (i.e., HHI) has no statistically significant effect on efficiency but GDP per capita and scope and scale economies positively influence efficiency. In addition, the Mann-Whitney test relayed that wealthy countries in Asia–Pacific displayed better efficiency scores than less economically buoyant countries in the region which harmonizes with Cabanda, Ariff, & Viverita (2004). Furthermore, the study notes total factor productivity growth (0.2% per year) was due to 3.4% per year technological progress because efficiency deteriorated by 3.1% per year and was due to decline in pure technical efficiency (1% per year) and scale efficiency regress (2.2% per year). The study applied sound methodology and its findings would be generalizable had it investigated the industry in each country instead of a firm in the industry in each country; however, its finding on total factor productivity growth sources contradicts Diskaya, Emir, & Orhan (2011) but supports Calabrese, Campsi, & Mancuso (2002) and Madden & Savage (1999). Also, Tsai, Chen, & Tzeng (2006) study of global telecoms looks at data on 39 firms categorized into three regions (i.e., America, Asia–Pacific, and Europe). Utilizing three inputs and three outputs, the study found that Asia–Pacific region (0.7783) displayed better efficiency, followed by Europe (0.7597) and America (0.7043) but the Mann-Whitney test shows the performances are not statistically significantly different. Furthermore, the study notes that as a group, state owned telecom firms displayed higher efficiency (0.7649) than privatized firms (0.7419) due to their scale and scope of services but this difference is not statistically significant based on the Mann-Whitney test result. However, the finding that state owned firms performed better than privatized firms contradicts conventional assertions and studies that show deregulation enhances performance (e.g., Wallsten, 2004; Torres & Bachiller, 2013) but aligns with studies that indicate no performance benefits from deregulation. Like Tsai, Chen, & Tzeng (2006), Hung & Lu (2007) examined efficiency of 36 global telecom operators from three regions (i.e., America, Asia–Pacific, and Europe). Using three inputs and four outputs, the study noted that firms in Europe displayed superior efficiency (0.9720) than the other two regions (America: 0.8480; Asia–Pacific: 0.9340). In addition, the study examined performance and signals that state-owned telecom are more efficient (0.9690) than privatized ones (0.9050) but there is no statistically significant difference in their pure technical efficiency, suggesting the technical inefficiency is scale related. Also, the study noted that operational scale has influence on efficiency and that consolidating small operators improves scale and efficiency. Although similar to Tsai, Chen, & Tzeng (2006) in methodology, the divergence in findings may be due to differences in the number of inputs and outputs and sample of firms studied. Nevertheless, the notion of consolidation noted in the research seems to ignore the underlying premise for deregulation which is to increase competition and reduce market power.

Moshi, Mwakatumbula, & Mitomo (2013) studied telecommunications industry productivity in 30 African countries from 2000 to 2009 and made use of two inputs and a single output in the DEA. The mean efficiency scores in the sample showed inefficiency but the industry experienced 18.7% per year total factor productivity growth which was mainly due to 21% per year technical change progression as the efficiency change deteriorated (1.9% per year). The retardation in efficiency change was caused by inappropriate scale (SEC decline: 1.9% per year) and marginal improvement in pure technical efficiency change (0.1% per year). In the second stage analysis, the study found that revenue, subscriptions, Internet users, level of competition, international operators, and time trend positively influence productivity growth but that the presence of regulatory agency and GDP per capital declines productivity, a finding inconsistent with Li (2009) which indicated that GDP drives efficiency and Hu & Chu (2008) that expressed that GDP per capital positively influence efficiency. Country specific study carried out by Banker et al. (2010) apply DEA to study technological progress and productivity growth in US mobile telecommunications industry. Covering 16 firms in the industry over a three year period (i.e., 2000 to 2002), the study reported no significant improvement in the relative efficiency of the industry but noted that the industry experienced 13% productivity growth mainly due to technological progress. Because the study utilized four inputs and two outputs, its sample size of 16 firms suggests it met the minimum sample size requirement of eight however, to yield more robust results the study could have used the maximum of 24 allowed by the DEA and an elongated study period beyond three years. Nonetheless, the study is insightful and identifies technological progress as the source of productivity. In addition, the second stage OLS regression analysis finding that national operators with larger market share displayed superior productivity growth than regional service providers seems to imply providers with larger operational scale and scope perform better. On the contrary, Moreno, Lozano, & Gutierrez (2013) indicated competition has not made firms efficient and that increased market share detracts from efficiency, however it investigated 26 firms over a longer period (i.e., 1997 to 2007) rather than 16 over three year period in Banker et al. (2010) and relied on single input and single output in the DEA. Assessing the efficiency performance of 10 telecommunications service providers and 23 service circle areas, Sharma, Momaya, & Manohar (2010) depended on a single input and two outputs in the DEA and found that technical inefficiency resulted from pure technical inefficiency (PTIE) and scale inefficiency (SIE) but pure technical inefficiency contributed mostly to the technical inefficiency. Mohamad (2004) examined the pre-reform and post-reform productivity of Malaysia telecommunications industry. Using six years of data (i.e., 1996 to 2001) and four inputs and one output, the results showed CRS technical efficiency and VRS technical efficiency improved. In addition, the research identified that the total factor productivity growth was the result of technical change progression of 42.1% per year with minute contribution from efficiency change improvement (1% per year).

An overview of prior studies on telecommunications industry efficiency and productivity presented in Table 4.1 shows several apply DEA with a handful utilizing SFA. The findings in many of these studies reveal operating in deregulated environment improves performance over time and that inefficiency is caused by pure technical inefficiency and inappropriate scale while productivity decline is caused by either the inadequate utilization of technology or inefficiency and/or both. Nonetheless, not all agree that deregulation leads to efficiency and productivity improvements. Also, among studies that indicated deregulated environment results in performance improvement, there seems to be controversy on the source of efficiency improvement with some (e.g., Calabrese, Campsi, & Mancuso, 2002; Naimy & Merheb, 2014) indicating managerial effectiveness is allocating inputs as responsible for increased efficiency but others (e.g., Hung & Lu, 2007) signifying operational scale as the source. Also, the review shows disagreement on the source(s) of productivity growth with some (e.g., Hu & Chu, 2008; Moshi, Mwakatumbula, & Mitomo, 2013) expressing technological progress as responsible for productivity growth but Diskaya, Emir, & Orhan (2011) attributed the growth in productivity to efficiency gains whereas Petrović et al. (2012) findings appear to indicate technical and efficiency change progressions as respondsible for total factor productivity growth. From the foregoing, it is apparent that a study is needed to clarify the sources of efficiency improvement and/or productivity growth. In addition, the review shows detailed attention has not been paid to the telecommunications industry in Canada and Nigeria, showing the need for a methodological examination of the industry in the two countries.

Summary

Reviewing the literature on telecommunications industry deregulation and performance, it is pertinent to note that studies on the phenomenon have largely ignored Canada and Nigeria thus revealing a gap and presenting an opportunity to comparatively examine the case of Canada and Nigeria. Also, the literature review shows that majority of the studies demonstrates that deregulation contributes to improved performance but studies also exist that contradict this assertion, making it difficult to ascertain the impact of deregulation on performance. A study of the case of Canada and Nigeria will contribute to the understanding of telecommunicatons industry performance in deregulated environment. Furthermore, the review of literature showed that efficiency and productivity are often used to evaluate telecommunications industry performance but the findings in these studies are not easily generalized to fit the case of Canada and Nigeria, however, while the findings in these studies may serve as useful benchmark in construing the experience of Canada and Nigeria, literature elucidation provided the impetus and direction for this research. The next chapter (Chapter 5) discusses the methodology and data. It details the methodological approach of this research, highlights efficiency and productivity measurement techniques, inputs and outputs selection, sample size, data collection and treatment, and ethical considerations that guided the conduct of this research.



Sources: Adapted from Resende (2008) & Coelli et. al. (2005)

Figure 4.1: Telecommunications industry performance measurement techniques.

Table 4.1: Measurement of firm's performance.

Research	Industry	Method	Input	Output	Findings
Bollou & Ngwenyama (2008)	Telecommunications industry in six African countries, 1995–2002	Time series DEA Regression	Investment in ICT Number of staff	Revenue from ICT Number of Internet users Number of lines Total telephone traffic Number of cellular phones	Growth in TFP has slowed in all countries studied
Cabanda, Ariff, & Viverita (2004)	Examine productivity, efficiency and technological progress in 39 samples of global telecommunications in Africa, Asia–Pacific, the Americas and Europe, 1989–1998	Uses DEA-type Malmquist Productivity Index to determine performance	Capital investments Number of employees	Total telecom services revenue Total fixed line International outgoing telecom minutes Teledensity	Order of productivity growth is Europe, the Americas and Asia–Pacific. Technological progress rather than efficiency changes is highly correlated with the increased TFP growth Africa shows a greater potential for telecommunications productivity growth Low innovation is the cause of decline in overall TFP across the sample studied.

Calabrese, Campisi, & Mancuso (2002)	Telecommunications industries in 13 OECD countries, 1979–1998	DEA Cobb-Douglas production function ANOVA	Labour (number of full time staff) Number of lines in operation	Telecommunications revenue	Technological change is the most important factor in the sectors' improvement Slight inefficiency exists in the industry Source of inefficiency lies in input-output utilization rather than the size of the operation
Cho & Park (2011)	109 firms in the mobile content industry in Korea	Input oriented DEA Principal component analysis Regression	Total assets Operating costs Number of employees Number of years in operation	Revenue	Of the 109 examined, only 11 are determined to be efficient; there exists varying levels of efficiency among them
Hu & Chu (2008)	24 telecom firms in APEC member economies, 1999–2004	DEA Tobit regression Malmquist Productivity Index	Number of staff employed (full and part-time) Total fixed assets	Fixed line and non-fixed line revenues	Technical efficiency is attributed to economies of scale and scope rather than competition
Hung & Lu (2007)	36 global leading telecommunications firms	Input oriented DEA	Total assets Capital expenditures Number of employees	Revenues (includes consolidated subsidiaries) EBITDA EBIT	Holding the input ratios constant, telecom operators can generate the same level of output with less inputs Inefficiency is mainly due to technical inefficiency

				EAT	Operational scale has influence on efficiency
Li (2009)	22 carriers in telecommunications firms, 1995–2007	Output oriented TFP SFA DEA	Labour costs Material costs Capital costs Capital quantity	Operating revenue	Performance sensitive to method Higher technical efficiency, innovation, and total factor productivity
Majumdar (1997)	45 local operating companies in the US telecommunications industry, 1988–1993	Input oriented DEA	Number of switches Number of lines Number of employees	Local calls Inter-LATA toll calls Intra-LATA toll calls	Regulation results in inefficiencies PCR as a replacement to ROR has a positive but lagged effect on technical efficiency ESR found to be detrimental to technical efficiency
Moreno, Lozano & Gutierrez (2013).	Assessment of US wireline telecommunications industry Incumbent Local Exchange Carriers, 1997–2007	Dynamic DEA Multiple Regression	OPEX	Telecommunications revenue	Findings show no clear relation between size and efficiency
Moshi, Mwakatumbula, & Mitomo (2013).	30 African telecommunications industry, 2000 to 2009	DEA Malmquist Productivity Index Regression	Number of full time staff Telecommunications investment	Telecommunications revenue Number of telephone subscription (fixed and wireless) Number of Internet	Productivity improvement mainly from technological progress and less from technical efficiency. Improving technical efficiencies will enhance productivity

				users	Competition and increased subscriptions have positive impact on productivity
Naimy & Merheb (2014)	16 mobile telecom operators in Middle East	Input oriented DEA Partial Factor Productivity	Total number of employees Total assets Capex	Total Revenue EBITDA	Seven operators were found to be operating; nine while 9 were not The most efficient was in Turkey
Oh, Lee, & Heshmati (2008)	580 Japanese manufacturing industries, 1993–2003	Input oriented TFP Time Trend General Index Chained-Multilateral Index	Capital stock Labour Material Production costs	Gross production	Higher return to scale for larger plants Higher technical change and productivity growth for larger plants
Petrović, Gospić, Tarle & Bogojević (2011).	Telecommunications industries in 20 developing (transition) countries, 2002–2007.	DEA Composite indicators	Total subscribers Total number of employees Annual telecommunications investment	Telecommunications service revenue	Countries that progressed had effective telecommunications policies. Progress in one dimension (e.g., regulatory reform), does not imply better performance in other dimensions (e.g., economic efficiency)
Papadimitriou & Prachalias (2009)	18 telecom operators; 15 from the European Union, 1 each from Africa, Asia and South	Output oriented DEA	Staff Investments	Revenue	Total productive efficiency improved over time

	America		Marketing expense Traffic of fixed telephony Traffic of mobile telephony		
Sharma, Momaya, & Manohar (2010)	10 telecommunications service providers in India	Input oriented DEA	Capital employed	Number of subscribers Total value of output	Industry growth driven by competition Tremendous scope for improvement in resource utilization in less efficient firms
Torres & Bachiller (2013).	Comparative analysis of the efficiency of 11 European privatised public telecommunications operators, 1997–2005	DEA Regression	Number of employees Total assets	Operating revenues	Concluded that privatisation is positively related to efficiency and that firms do not show the same degree of response to the liberalisation
Tsaia, Chenb, & Tzeng (2006).	Examined productivity efficiency of 39 leading global telecom companies as ranked in Forbes 2000	DEA	Total assets Capex Number of employees	Revenue EBITDA EBIT	No significant difference in regional performances Asia–Pacific telecom firms' performance better than Europe but superior to America

Chapter 5
Methodology and Data

5.1 Introduction

The literature review in Chapter 4 presents efficiency and productivity as measures used in the determination of performance in deregulated environments. This chapter (Chapter 5) presents information on the methodology and data in this research. Two phases were involved in the conduct of this research. The first was the secondary data analysis to yield information on the efficiency and productivity of the telecommunications industry and the use of Tobit regression to understand the impact of external factors on efficiency performance. The second entailed the analysis of the results of survey questionnaire completed by industry participants. The remainder of the chapter is organized as follows. Section 5.2 details the concepts and measurement of efficiency. Section 5.3 discusses the productivity concept and productivity change measurements. Section 5.4 explains the second stage econometric regression involving the Tobit model and highlights the variables used in the model. Section 5.5 sheds lights on the case study as the empirical approach adopted in this research. Section 5.6 details the model specification. Section 5.7 discusses the inputs and outputs selection and sample size. Section 5.8 describes the data collection. Section 5.9 highlights the data treatment. Section 5.10 narrates the data analysis approach used in this research. Section 5.11 provides information on the ethical considerations adhered to in this research. The chapter concludes with an integrated summary.

5.2 Efficiency concept and measurement

5.2.1 The efficiency concept

Efficiency refers to the use of economic resources in ways that mitigate waste. It relates to the use of inputs in producing outputs and is achievable by minimizing inputs or by maximizing outputs (Norman & Stoker, 1991; Kumar & Gulati, 2008). Thus, a firm that wants to attain efficiency would use its resources to produce a high amount of outputs at low costs. Referencing Farrell (1957), Coelli et al. (2005, p. 51) note that a firm's efficiency consists of technical efficiency (TE) and allocative efficiency (AE). Whereas technical efficiency demonstrates the production of the maximum output from input and is measured on a scale of 0 to 1, allocative efficiency reveals the use of an optimal input mix given a particular price and technology constraint. The combination of technical and allocative efficiency results in ‘economic (i.e., cost) efficiency’ (CE) (Coelli et al., 2005, p. 51). Furthermore, technical efficiency is subject to managerial decisions and is attained when it is not possible for a firm to raise output without increasing at least one of the inputs. But allocative efficiency is attained when the mix of inputs (e.g., capital and labour) is optimized to meet organizational objectives (e.g., profitability) (Kumar, 2013, p. 150).

5.2.2 Measurement of change in efficiency

According to Kumar (2013, p. 150), both ‘parametric’ and ‘non-parametric’ approaches are applied in studies relating to efficiency. A parametric approach is Stochastic Frontier Analysis (SFA) which allows for the statistical testing of hypotheses relating to differences in technical efficiency scores (Seo et al., 2010, p. 275). The SFA model originally advanced by Aigner et al. (1977) and Meeusen & Van den Broeck (1977) describes a production function with error term and allows for the estimation of the ‘least cost’ function for the industry with the best performing firm (Ariss, 2008, p. 934). Its drawback is that any difference between the actual and the potential output is ascribed to inefficiency. Also, it neglects any unobserved and omitted variables and ‘stochastic noise’, thus resulting in higher inefficiency scores (Gatto, Liberto, & Petraglia, 2011, p. 961). Other parametric approaches – the Distribution Free Approach (DFA) and the Thick Frontier Approach (TFA) – have also been used to evaluate efficiency. DFA was introduced by Berger (1993) and is less dependent on the ‘distributional assumptions’ than SFA. It contains one-sided error term representing cost inefficiency but makes no assumption about the specific distribution for the inefficiency (Wagenvoort & Schure, 1999, p. 8). TFA, which was developed by Berger and Humphrey (1991; 1992), assumes that aside from inefficiency that results in deviation from the frontier, deviation is also caused by measurement errors or factors beyond management control. Starting with average costs, it identifies two ‘thick frontiers’, one for the lowest and one for the highest average costs quartile of firms (Wagenvoort & Schure, 1999, p. 9; Kumbhakar & Lovell, 2000, p. 176). To detect inefficiency level, the average inefficiency of the highest quartile firms is computed in comparison to the two ‘thick frontiers’ (Wagenvoort & Schure, 1999, p. 9). Firms that are located on the lower quartiles are considered relatively efficient while those on the top quartile are considered inefficient. Although TFA allows for the avoidance of the restrictive assumption essential in the other approaches, its major drawback is that its reliance on ‘average production’ and output performance tends to ignore (i) small efficient firms when considering the case involving increasing returns to scale (IRS) and (ii) large efficient firms when considering the case involving decreasing returns to scale (DRS) (Wagenvoort & Schure, 2005, p. 5).

Non-parametric approaches used to measure efficiency include Free Disposal Hull (FDH) and Data Envelopment Analysis (DEA). FDH was introduced in 1984 by Deprins, Simar & Tulkens. As an alternative to DEA, it does not require ‘convexity’ but assumes the free disposability of inputs and outputs (Simar, 2007, p. 184). Some shortcomings of FDH are its sensitivity to the number of observations in the dataset, the distribution of the observations, and the number of inputs and outputs. Commenting on the shortcomings, De Borger et al. (1994) stated that a larger sample size increases the possibility of efficiency notation and that having more inputs or outputs in the analysis results in greater possibility for efficiency. Data Envelopment Analysis put forward in 1978 by Charnes, Cooper and Rhodes (CCR) for evaluating profit and non-profit organizations is an extension of the single input–output approach introduced by Ferrell in 1957 for determining efficiency relative to a production frontier (Haridasan & Venkatesh, 2011; Hadad et al., 2013). DEA relies on the input and output parameters of the decision-making units (DMUs) to generate efficiency frontier on which DMUs are assessed (Amindoust, Ahmed, & Saghafinia, 2012). A DMU can be an entity, a business firm, any organization or unit that converts inputs to outputs (Cooper et al., 2001, p. 220).

In DEA applications, attention is drawn to ‘radial’ and ‘non-radial’ characteristics of DEA models (Avkiran, Tone & Tsutsui, 2008, p.128). The former is ‘unit invariant’ which implies that a change in the unit of measurement does not change the efficiency value (Coelli et al., 2005, p. 57). Furthermore, Avkiran, Tone & Tsutsui (2008) noted that while the use of ‘radial’ measure of efficiency relies on finding the proportional amount by which all inputs will have to decrease without diminishing the current output level, the ‘non-radial’ (also known as the slack-based measurement[SBM]) focuses on identifying the maximum rate of input reduction (p. 128). DEA can be input or output oriented (Coelli et al., 2005). The input oriented

DEA focuses on minimizing inputs in generating a given level of output (Hung & Lu, 2007). It directs attention to the inputs required to yield observable outputs and makes possible the evaluation of inputs reduction tolerable without a negative effect on outputs (Milana & Zeli, 2002). Output oriented DEA emphasizes maximizing outputs generated from specified level of inputs (Kim, Kim, Shin, 2014). When an input-oriented DEA is used, any inefficient DMU receives a score below 1 but when an output-oriented model is used, the inefficient DMU receives a score that is greater than 1.

In practical terms, DEA measures the relative efficiency for a given number of DMUs by comparing each DMU’s input and output data with others. It operates on the assumption that efficiencies cannot be greater than 1 and DMUs with values of 1 are efficient. Thus, performance is measured with respect to the efficient or best performing DMU (Charles & Kumar, 2012) and is based on the distance from the frontier or envelopment surface (Nigam, Thakur, & Singh, 2009). Norman & Stoker (1991, p. 179) distinguish DMUs by efficiency scores under the following groupings:

- Robustly Efficient Units: Efficient DMUs that also serve as benchmark for peers. These DMUs are considered effective in utilizing resources.
- Marginally Efficient Units: DMUs considered efficient due to CRS technical efficiency score that is equal to 1. However, these DMUs do not serve as benchmarks for others in that they may possess distinctive characteristics that differentiate them from peers and risk being inefficient with a slight change in inputs or outputs. In addition, inefficient DMUs under CRS but with VRS technical efficiency score of 1 are included in this category.
- Marginally Inefficient Units: DMUs with efficiency scores greater than 0.9 but less than 1. They could become efficient with a slight adjustment to their inputs or outputs.
- Distinctly Inefficient Units: DMUs with efficiency scores of below 0.9. These DMUs would have difficulties becoming efficient.

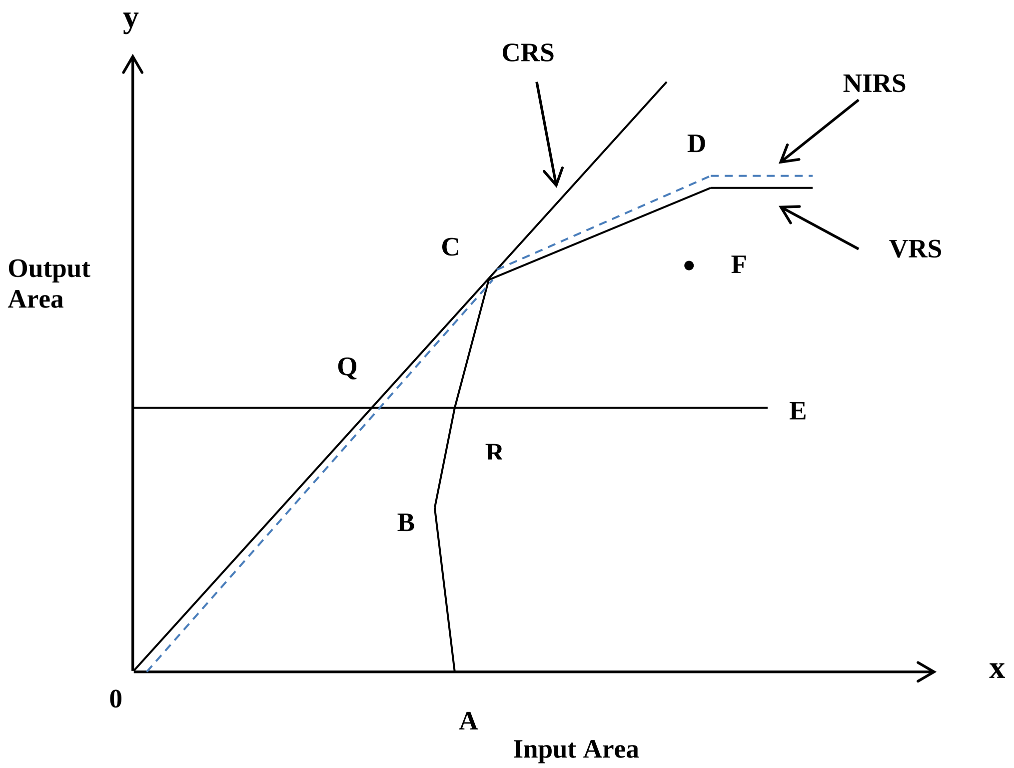
Although DEA is sensitive to outliers and sample size, it does not require a specific assumption relating to inputs (e.g., minimization of cost) and outputs (e.g., maximization of profit) (Kong & Tongzon, 2006; Charles & Kumar, 2012). Other advantages of DEA as outlined in Cronin & Motluk (2007, p. 47) are its ability to:

i. Accommodate multiple inputs and outputs;
ii. Decompose efficiency into technical, allocative, and scale efficiencies;
iii. Measure efficiency without needing price information; and
iv. Calculate relative efficiency by establishing a reference point of potential efficiency for DMUs.

In addition, Cronin & Motluk (2007) noted that DEA can be sensitive to outliers and data errors caused by measurement or reporting errors, suggesting the need to be meticulous when entering input and/or output data.

DEA models are developed based on the envelopment surface. According to Nigam, Thakur, & Singh (2009), the first approach is constant returns to scale (CRS), which assumes a direct relationship between input and output parameters and that all DMUs operate at optimal level such that a 1% increase in input will result in equivalent increase in output (Hu & Chu, 2008; Kim, Kim, & Shin, 2014). However, several factors such as management and internal constraints, government policy and regulation, and market structure may affect a DMU's scale of operations thus using constant returns to scale when not all firms operate at optimum scale could result in biased technical efficiency scores. The second approach is the Banker, Charnes and Cooper (BCC) model which adds 'convexity assumption' to the DEA to permit piecewise estimation of the envelopment surface (Banker & Morey, 1986, p. 1164). This allows variable returns to scale (VRS) with the supposition that operational scale influences the relationship between input and output such that a 1% increase in input could yield an output level that is greater than or less than 1%. Therefore, the use of variable returns to scale in determining technical efficiency removes scale bias as it compares inefficient DMUs to those similar in size (Coelli et al., 2005). Commenting further, Ngwenyama & Morawczynski (2009) note that scale efficiency occurs when the value of scale efficiency is 1 and technical efficiency under constant returns to scale is equal to the technical efficiency under variable returns to scale but that scale inefficiency is exhibited when scale efficiency is less than 1 and technical efficiency under constant returns to scale is less than technical efficiency under variale returns to scale. The third approach is non-increasing returns to scale (NIRS) which emphasizes that operational scale affects efficiency and the relationship between input and output (Hung & Lu, 2007). In addition, the nature of returns to scale (RTS) (e.g., increasing returns to scale [IRS] *vs.* decreasing returns to scale [DRS]) is determined by comparing the technical efficiency under non-increasing returns to scale to that under constant returns to scale. A DMU exhibits increasing returns to scale if it is scale inefficient and the technical efficiency under non-increasing returns to scale is equal to the technical efficiency under constant returns to scale but displays decreasing returns to scale if the technical efficiency under non-increasing returns to scale is greater than the technical efficiency under constant returns to scale (Ngwenyama & Morawczynski, 2009).

Figure 5.1 illustrates the efficiency measurement described in Hung & Lu (2007, p. 1121). It is a simplified input-oriented DEA that uses a single input to generate a single output. The constant returns to scale (CRS) represented by 0C is based on the assumption that all DMUs are operating at optimum scale and that the technically efficient DMU will have efficiency score of 1 and lie on point C. The other DMUs (i.e., B, E and D) operate outside the efficient frontier and are considered inefficient. The variable returns to scale (VRS) is represented by ABCD and the DMUs that lie on points B, C and D have score of 1 each and are considered efficient while the DMU on point E is not. Also, the non-increasing returns to scale (NIRS) is represented in Figure 5.1. To understand the level of a target DMU's scale inefficiency that results from increasing returns to scale or decreasing returns to scale, the technical efficiency score under non-increasing returns to scale and variable returns to scale are compared; any variation in the two as demonstrated by point E indicates increasing returns to scale and means the DMU is too small, suggesting that its efficiency could be increased through an operational size increase. But decreasing returns to scale occur if the two are equivalent, as shown in point F; implying the DMU is too large and its efficiency could be increased through operational size decrease.



Source: Hung & Lu (2007, p. 1121).

Figure 5.1: Simplified input-output DEA.

As pointed out in Martin & Roman (2006), DEA model selection may be influenced by data availability, industry characteristics and market structure. The mathematical notations for the input-oriented DEA are based on the measures and the approach for evaluating performance in Cooper et al. (2007, p. 154), Nigam, Thakur, & Singh (2009, pp. 43–44) and Hung & Lu (2007, p. 1122) and are expressed as:

$$\sum_{r=1}^{s} \mu_r y_{rj} \leq \sum_{i=1}^{m} v_i x_{ij} \quad (5.1a)$$

Maximization results in:

$$\sum_{r=1}^{s} \mu_r y_{r0} \quad (5.1b)$$

Subject to:

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0,\ j = 1, \ldots\ldots, n;\ \text{Where: } \mu_r;\ v_i \geq 0 \qquad (5.1c)$$

$$\sum_{i=1}^{m} v_i x_{i0} = 1 \qquad (5.1d)$$

As specified in Hung & Chou (2013, p. 35), the ratio of the output to input is less than or equal to 1, but as indicated in (5.1d), if input is set at 1, the efficiency score will reflect the weight of output shown in (5.1b). Consequently, when either of the optimal solutions (i.e., μ_r or v_i) is 0, the solution 'degenerates' such that a DMU that seems efficient may actually be inefficient due to using too much input (Hung & Chou, 2013, p. 35).

Cooper et al. (2007, p. 154) introduces a 'non-Archimedean element' (ε) smaller than any positive number (i.e., $\varepsilon > 0$). This constraint is written as:

$$0 < \varepsilon \leq \mu_r \text{ and } 0 < \varepsilon \leq v_i$$

The value of ε is infinitesimally small and specified to range between 10^{-5} and 10^{-6} (Hung & Chou, 2013). This infinitesimally small number is used to multiply the input slack (s_i^-) and output slack (s_r^+) to yield solution weights that are all positive in all input and output variables to create the 'dual' form (p. 35). According to Cooper et al. (2007, p. 154), the linear programming for the duality mode results in an equation which when applied to each of the DMUs produces an efficiency frontier that 'envelopes' a 'production possibility set'. The linear programming duality mode is expressed as:

$$\text{Min } \theta_0 - \varepsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_i^+ \right) \qquad (5.2)$$

Where:

j = number of DMUs being compared

θ = efficiency rating of DMUs being evaluated using DEA

y_{rj}= value of output r by DMU j

x_{ij}= value of inputs i used by DMU j

y_{r0}= value of output by the DMU being evaluated

x_{i0}= value of inputs by the DMU being evaluated

i = number of inputs used by DMU

r = number of outputs generated by DMU

μ_r = coefficient or weight assigned by DEA to output r

υ_i = coefficient or weight assigned by DEA to input i

s_i^- = input slack and represents the excess amount of input that resulted in inefficiency of the DMU

s_r^+ = the output slack and represents the shortfall amount of output that resulted in inefficiency of the DMU

λ = the optimal set of weights that satisfy the constraints and results in efficiency score identified as θ

The DEA model applies an efficiency rating of $0 \leq \theta \leq 1$ to demonstrate an efficiency rating of between 0% and 100%. According to Abokaresh & Kamaruddin (2011), a DMU is considered strictly efficient if and only if θ = 1 and $s_i^- = s_r^+ = 0$ for all values of i and r; and a DMU is considered weakly efficient if θ = 1 and $s_i^- \neq 0$ and/or $s_r^+ \neq 0$.

The Charnes, Cooper and Rhodes version of the model relies on constant returns to scale which assumes a proportionate increase (decrease) in outputs if inputs increase (decrease) by a certain quantity (Charles & Kumar, 2012). The duality mode is:

Subject to:

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{i0} \qquad \text{where: } i = 1, 2, \ldots.., m \qquad (5.3a)$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{r0} \quad \text{where: } r = 1, 2, \ldots\ldots s \qquad (5.3b)$$

$$\lambda, s_i^-, s_r^+ \geq 0 \qquad (5.3c)$$

The Banker, Charnes and Cooper model as shown in (5.4c) adds ‘convexity constraint’ to the Charnes, Cooper and Rhodes model (Charnes, Rousseau, & Semple, 1996, p. 5) and relies on variable returns to scale with the notion that changes in inputs may not result in proportional change in output (Hung & Lu, 2007; Kontodimopoulos et al., 2011). The duality mode is:
Subject to:

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{i0} \quad \text{where: } i = 1, 2, \ldots.., m \qquad (5.4a)$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{r0} \quad \text{where: } r = 1, 2, \ldots\ldots s \qquad (5.4b)$$

$$\sum_{j=1}^{n} \lambda_j = 1, \text{ and } \lambda, s_i^-, s_r^+ \geq 0 \qquad (5.4c)$$

5.3 Productivity concept and measurement

5.3.1 The productivity concept

Productivity is the ratio of outputs to inputs and is used to measure the amount of output generated per unit of input (Coelli et al, 2005; Nigam, Thakur, & Singh, 2009). Productivity could be attained through input minimization or output maximization. Its measurement yields information on how well a DMU uses inputs to generate output (Jaforulla & Whiteman, 1999; Kumar, 2013).

5.3.2 Measurement of change in productivity

Productivity measurement gives information on the sources of productivity differentials between DMUs and from one period to another (Cvetkoska, 2011). As noted in Nigam, Thakur, & Singh (2009), productivity change could be ascribed to differences in production technology, production process efficiency and environmental conditions. A productivity measurement approach includes partial factor productivity, multifactor productivity and total factor productivity (Coelli et al., 2005). Partial factor productivity determines output that results from an input without considerations for usage interdependence among outputs (Manonmani, 2014). It is expressed as output per unit of labour, output per labour hour or any other outcome that represents an output and input ratio (Coelli et al., 2005). However, its use is limited due to outcomes that improperly represent productivity when the direction of at least two partial measures of productivity conflict with each other (Lee, Park & Oh, 2000).

Multifactor productivity is suitable in situations involving a single output but multiple inputs (Subhash & Kankana, 1996). It focuses attention on how inputs are employed and measures the growth in output that could not be linked to labour and capital growths but ‘disembodied’ technological changes such as improvement in labour quality and business processes (Acheson, 2011, p. 68). However, like partial factor productivity, it fails to capture all inputs (OECD, 2001). Total factor productivity (TFP) identifies the increase in outputs that are not attributable to or accounted for by an increase in input but to changes in technology (Bollou & Ngwenyama, 2008; Lam & Shiu, 2008). It considers aggregate input in determing productivity change and is viewed as a better measure when performing comparisons across DMUs and/or a productivity of particular DMU over a given period of time (Coelli et al., 2005). Because it reveals the ratio of total output to total input, given equality in inputs, a DMU with higher total factor productivity will have greater output than that with a lower total factor productivity (Syverson, 2011).

Uri (2001) discusses stochastic frontier analysis (SFA) in productivity change measurement and notes productivity is affected by technical inefficiency and that the degree of inefficiency shown varies in magnitude depending on the distance below the frontier. A frontier approach is practical in situations involving individual and aggregate data and disentangles technological change (technical change [TC]) and technical efficiency (TE) which typically are sources of productivity growth (Gatto, Liberto, Petraglia, 2011). Another method used in productivity change analysis is ‘econometric’ which is a non-frontier and parametric approach (Uri, 2001, p. 169). This approach came to light through the separate works of Aigner et al. (1997) and Meeusen & Van den Broeck (1977) which integrates efficiency change into a model of productivity growth (Uri, 2001). In addition, Coelli et al. (2005) identify indices, which are non-frontier, but non-parametric approach for measuring productivity. The 'Fisher Index' is used when input and output quantities and prices are known. Its simplicity and non-requirement for a benchmark makes it appealing, but it fails to identify the sources of productivity change (Subhash & Kankana, 1996, p. 1660). Another index is the Törnqvist Productivity Index (TPI) which measures price and quantity change over time (Dumagana & Ballb, 2009; Diewert & Fox, 2010; Barcenilla-Visus et al., 2013).

The Malmquist Productivity Index (MPI) which requires finding the 'geometric mean' of two Malmquist indexes is also utilized in productivity change measurement (Fare et al., 1994, p. 66). This approach signifies the ratio of efficiency measures from one time period to another or between two different observations for the same period (Emrouznejad et al., 2011). As indicated in Li (2009), comparing inputs from two different time periods and identifying the maximum factor by which the input from one period could be decreased without negative impact on output was conceived by Malmquist and was put forth in 1953. However, the work of Caves, Christensen and Diewert (CCD) (1982) extended the Malmquist input index to the productivity measurement now known as the MPI. It entails decomposing total factor productivity into technical change (TC) and efficiency change (EC) (Sung, 2012, p. 491). The technical change provides information on productivity growth resulting from technological innovation while the efficiency change measures the contribution from efficiency improvements (Mohamad, 2004, p. 326). Like DEA, MPI could be input or output oriented (Kim, Kim, & Shin, 2014). The input-oriented form is akin to DEA (Kim, Kim, & Shin, 2014; Mathur, 2007) in that it estimates the minimum input necessary to produce a particular output while the output-oriented MPI provides information on the maximum output a given level of input could generate.

The notation M_t and M_{t+1} used in Usero & Asimakopoulos (2013, p. 2921) reveals the two Malmquist indices used to generate MPI.

$$M_t = \frac{D_i^t\ (X^{t+1}, Y^{t+1})}{D_i^t\ (X^t, Y^t)}$$

and

$$M_{t+1} = \frac{D_i^{t+1}\ (X^{t+1}, Y^{t+1})}{D_i^{t+1}\ (X^t, Y^t)}$$

In an input-oriented MPI, between two periods (i.e., period *t* and *t+1*) the geometric mean of the two indices above results in MPI (Kim, Kim, & Shin, 2014, p. 59) and is depicted below:

$$M_i^{t,t+1}\ (X^t, Y^t, X^{t+1}, Y^{t+1}) = \left[\frac{D_i^t\ (X^{t+1}, Y^{t+1})}{D_i^t\ (X^t, Y^t)} \quad \frac{D_i^{t+1}\ (X^{t+1}, Y^{t+1})}{D_i^{t+1}\ (X^t, Y^t)}\right]^{1/2}$$

Where:

(X^t, Y^t) and (X^{t+1}, Y^{t+1}) are input and output vector at period *t* and *t + 1*.

D_i^t and D_i^{t+1} are the distance function at *t* and *t + 1* when technology (T) is considered as reference point in period *t*.

$D_i^t\ (X^{t+1}, Y^{t+1})$ is the distance function that measures the maximum proportional change in output that is necessary to make (X^{t+1}, Y^{t+1}) feasible relative to technology in period *t*.

$D_i^{t+1}\ (X^t, Y^t)$ is the distance function that measures the proportional change in output that is necessary to make (X^t, Y^t) feasible in relation to technology *t + 1*.

With the initial level of total factor productivity estimated under CRS, an MPI above 1 indicates a total factor productivity increase from period *t* to period *t + 1* and implies the input required to produce the output decreased between period *t* and *t + 1* (Calabrese, Campisi, & Mancuso, 2002; Kim, Kim, & Shin, 2014). Additionally, provided cross-sectional data (e.g., Liu et al., 2014) and time series data (e.g., Kong & Tongzon, 2006) are available, the above MPI can further be broken down into efficiency change (i.e., ‘catching up’) and technical change (i.e., ‘innovation’) (Fare et al., 1994, p. 66) to determine source of productivity change. The decomposed MPI shown in Kim, Kim, & Shin (2014, p. 59) is represented as:

$$M_i^{t,t+1}(X^t, Y^t, X^{t+1}, Y^{t+1}) = \frac{D_i^{t+1}(X^{t+1}, Y^{t+1})}{D_i^t(X^t, Y^t)} \left[\frac{D_i^t(X^{t+1}, Y^{t+1})}{D_i^{t+1}(X^{t+1}, Y^{t+1})} \frac{D_i^t(X^t, Y^t)}{D_i^{t+1}(X^t, Y^t)} \right]^{1/2}$$

= Technical Efficiency change x Technological change

= Effch * Techch

= EC * TC

Furthermore, efficiency change could be broken into the pure technical efficiency change (PTEC) index and the scale efficiency change (SEC) index

$$\text{Technical Efficiency Change index} = \frac{V_i^{t+1}(X^{t+1}, Y^{t+1})}{V_i^t(X^t, Y^t)} \left[\frac{V_i^t(X^t, Y^t)}{D_i^t(X^t, Y^t)} \frac{V_i^{t+1}(X^{t+1}, Y^{t+1})}{D_i^{t+1}(X^{t+1}, Y^{t+1})} \right]$$

EC = PTEC * SEC

The Malmquist productivity index (MPI) is expressed as:

MPI = PTEffch * SEffch * Techch

MPI = PTEC * SEC * TC

5.4 Second stage econometric regression model

Regression model which is considered 'econometric' (Green, 2003, p. 7) is used to account for the influence of environmental factors outside management control on performance (Moreno, Lozano, & Gutierrez, 2013; Sung, 2012). This non-frontier parametric approach is based on the representation of DEA scores as a function of environmental variables in a process referred to as 'second stage analysis' (Kontodimopoulos et al., 2011, p. 982). The approach was first applied by Ray (1991) but has been subject to debate. Notably, model choice(s) vary by study and there is no general consensus on the most appropriate model as the choice of model depends on the underlying assumption(s). Models that are acceptable and that have been utilized include Tobit (Li, 2009; Hu & Chu, 2008), Generalized Least Square (Ng, 2012; Moshi, Mwakatumbula, & Mitomo, 2013), multiple regression (Moreno, Lozano, & Gutierrez, 2013), Ordinary Least Square (Banker & Natarajan, 2008; Yadav & Katib, 2015) and Logistic (Kumar & Gulati, 2008). Simar & Wilson (2007; 2011) expresss concern relating to possible serial correlation of estimated efficiency scores and Coelli et al. (2005) and Ramalho, Ramalho & Henriques (2010) caution that the second stage results could be biased if variables (i.e., inputs and outputs) used in the DEA model in the first stage highly correlate with independent variables in the second stage analysis. Nevertheless, several studies (e.g., Banker & Natarajan, 2008; Ramalho, Ramalho, & Henriques, 2010) favour its use (Simar & Wilson, 2011).

Studies (e.g., Banker & Natarajan, 2008; Hoff, 2007; McDonald, 2009) seem to indicate no significant difference in values generated using Tobit and other regression models (e.g., OLS) when investigating the influence of environmental variables on performance. However, the underlying assumption on which this assertion lies has been challenged by Simar & Wlson (2011) with an inference that OLS is inadequate. Also, Wooldrige (2002) notes the inability of OLS to handle the confinement of efficiency scores to 0 and 1 results in inconsistent estimates. Similar to Ngwenyama & Morawczynski (2009) and following the recommendation in Hoff (2007) and Coelli et al. (2005), the censored Tobit model is deemed appropriate in this research because the distribution of efficiency is restricted to 0 and 1 (i.e., identified inefficiency is denoted by 0 and efficiency is denoted by 1). The Tobit model was suggested in Tobin (1958) as a model that integrates probit analysis and multiple regression. The standard censored Tobit model is expressed in Wooldrige (2002, p. 519) as:

$$y*_i = x_i\beta + u_i$$

Where u_i / x_i ~ Normal (0, σ^2) and $y_i = \max(0, y*_i)$

For panel data, the applicable model is pooled Tobit model (Wooldrige, 2002, p. 538) which is stated as:

$$y_{it} = \max(0, x_{it}\beta + u_{it}) \text{ for t = 1, 2, 3, ……, T}$$

Where u_{it} / x_{it} ~ Normal (0, σ^2)

In a two-stage analysis involving telecommunications industry, independent variables vary by study but include GDP growth (OECD, 2001; Li, 2009), population (Moshi, Mwakatumbula & Mitomo, 2013; Li & Xu, 2004) and GDP per capita (Fink, Mattoo, & Rathindran, 2002; Moshi, Mwakatumbula & Mitomo, 2013). Other independent variables that have been utilized are teledensity, (Ospina, 2002; Fink, Mattoo, & Rathindrin, 2003), years in deregulation (Ospina, 2002; Moshi, Mwakatumbula & Mitomo, 2013), level of concentration (HHI) (Usero & Asimakopoulos, 2013; Hu & Chu, 2008), average revenue per subscriber (Lee & Quayes, 2005; Karamti & Kammoun, 2011), labour productivity (subscriptions per employee) (Li & Xu, 2004; Lee & Levendis, 2006), and Capex per employee (Ng, 2012). The independent variables used in the second stage analysis in this research are: Change in real GDP per capita (CRGDPPC) which is used to capture economic growth and wealth effect on affordability of telecommunications product and services; HHI which highlights the level of competition in the industry and reflects deregulatory impact on industry competition; capital expenditure to revenue ratio (CapexRev) which is a proxy for capital intensity and measures investment in technology and network infrastructures; subscriptions to employment ratio (SubEmp) which represents labour productivity; revenue to subscriptions ratio (RevSub) which is an industry specific variable that captures the financial viability of the industry; number of years in deregulation (NYRS) captures the number of years the industry has been deregulated; consumer price index (CPI) reflects the influence of inflation in the economy; dummy variable is applied to the level of development (LDev) to capture the influence of the level of development. The dummy is equal to zero if the country is a developing country and one if it is a developed country.

The model is explicitly expressed as:

$$E_{i\,t} = \beta_0 + \beta_1\, NYRS_{i\,t} + \beta_2\, SubEmp_{i\,t} + \beta_3\, RevSub_{i\,t} + \beta_4\, CapexRev_{i\,t} + \beta_5\, CRGDPPC_{i\,t} + \beta_6\, HHI_{i\,t} + \beta_7\, CPI_{i\,t} + \beta_8\, LDev_{i\,t} + u_{i\,t}$$

Where:

E: represents the efficiency performance of the industry

i: represents the cross sectional individual countries under study

t: represents the time series and covers period from 2001 to 2013

β_0: is the intercept which is a constant

u_{it}: is the error term that denotes the unobserved factors that affect the dependent variable.

5.5 The empirical approach for this research

Case study is an approach used in conducting empirical research and has gained wide appeal. A case study research aims at understanding ‘bounded’ system such as an event or a process (Creswell, 2012, p. 465). Compared to other approaches (e.g., surveys, experiments, histories and archival analysis), a case study is appropriate when the researcher is seeking answers to ‘what’, ‘how’ or ‘why’ questions, has little control over the events, and focuses on phenomenon or events that are contemporary and within a particular context (Yin, 2003, pp. 1 & 6). It sheds more light on a problem and allows an in-depth understanding of the issue being studied. Case study research could be a single case or multiple cases and may include either quantitative or qualitative data or both (Yin, 2003; Gerring, 2004). Unlike the single case, multiple cases allow for a deeper understanding of the similarities and differences between cases and within and across cases (Baxter & Jack, 2008). Although the nature of the case and the boundary could be limited by the researcher when deciding what to/not to include in the study thus creating difficulty in generalizing the research findings (Brown, 2008; Beins, 2009), using multiple cases increases the prospect for generalization (Yin, 2003) and has been applied in performance analysis and in-depth exploration of the telecommunication industry by Debnath & Shankar (2008), Lam & Shiu (2008), Barcenilla-Visus et al. (2013), Moshi, Mwakatumbula, & Mitomo (2013), Resende & Facanha (2002) and Calabrese, Campsi, & Mancuso (2002).

This research explores the performance of telecommunications industry in deregulated environment, thus a multiple case study approach has been adopted to understand the phenomenon. The multiple cases cover two countries and use a comparative format that involves describing, explaining and evaluating the cases of Canada and Nigeria. According to the World Bank classification, Canada is an OECD member country and is considered a high income country while Nigeria is considered middle income country (The World Bank, 2016). A comparative approach is suitable when dealing with two or more cases (Goodrick, 2014) and where there exists interest in discovering empirical relationships among variables that help confirm or disprove a theory (Lijphart, 1971). In addition, it provides deep insight and uncovers how similar and dissimilar the cases are in relation to the events being investigated with the potential for generalization of 'how' or 'why' a policy intervention succeeds or fails (Goodrick, 2014, p. 2). Multiple cases involving cross-country analysis have been carried out using this approach in Madden, Savage, & Ng (2003) examination of the productivity growth in 12 Asia–Pacific telecommunications service providers from 1987 to 1990 and in Mariscal (2004) study of Mexican telecommunications industry reform in comparison with Brazil, New Zealand and the US. In these studies, it was noted that each country exhibited unique characteristics that could be considered to have emanated from deregulation. Given the research objectives (see Chapter 1) this research lends itself to a comparative approach of inquiry. Additionally, it is not uncommon for countries to adopt different approaches in tackling similar policy issues (Iwuagwu, 2014). Thus, the comparative approach illuminates the rationale for certain actions and the impacts in a way not possible from studying a single case.

For a thorough understanding of the deregulatory milieu using the experience of a developed country and a developing country, this research broadly considers high income countries and middle income countries but specifically draws attention to Canada and Nigeria. These two countries were chosen because they are English speaking and the researcher was born and raised in the latter but lives and work in the former. Additionally, both have exposed the telecommunications industry to market forces. Hence, the comparative analysis isolates similarities and differences in events that culminate in policy shift, including trends in performance. Furthermore, the industry is constantly changing and deregulatory events are still manifesting in both countries. Therefore the research results which shed light on each country's experience provide a basis for learning from each other and for the knowledge gained to be extended to other sectors of the economy. Also, analyzing the two countries comparatively reveals factors affecting deregulation outcomes and gives policy makers better information for adjudging current policy effectiveness and in designing and implementing news ones. Canada and Nigeria have both deregulated their telecommunications industries. However, differences exist in the level of overall industry performance and regulatory frameworks. A comparative analysis highlights these differences while their similarities in these areas and with other high income countries and middle income countries provide a basis for drawing inference(s).

As identified in Cameron (2011, p. 96), case study research may entail 'mixed methods' and combines elements of 'qualitative' and 'quantitative' data that enriches the understanding of the research problem than either type alone. However, it requires bridging through integration and linkages to maximize the benefits (Creswell, 2012, p. 536). Considering the merits of this approach, this research adopts a mixed methodology and diversifies data sources such that they do not share the same or similar weaknesses (Farquhar, Ewing, & Booth, 2011). The procedure applied is similar to Serebrisky (2012) and involves two phases to provide a holistic view and an in-depth understanding of the event under study. The first phase entails using secondary data in a two-stage efficiency and productivity analysis. The efficiency and productivity analysis provides information relevant to answering the research questions RQ_1 and RQ_2. The second phase is complementary and entails gathering primary data from industry practitioners through a survey questionnaire developed for this research. To ensure reliability, secondary data were sourced from the World Bank, the ITU, the OECD Communications outlook, regulatory agencies, statistics bureaus, annual audited financials statements of telecommunications firms, and published academic journals. Information was collected on industry revenue, concentration, subscriptions, teledensity, employment and capital expenditures. The survey questionnaires were completed by practitioners with management responsibilities and knowledge in the areas of inquiry to extend the inquiry beyond

DEA efficiency and productivity analysis and to reflect industry practitioners' perspectives in the research outcome.

5.6 DMU and model specification

A DMU is a business, firm, organization or unit that uses inputs to generate outputs (Cooper et al., 2001, p. 220). In this research, the industry itself rather than individual firms is considered to be the DMU. The industry reflects the performance of all firms and maintains the research focus enunciated in Chapter 1. Also, treating industries as DMUs is a common practice in the field of inquiry and has been applied in prior empirical studies (e.g., Sharma, Momaya, & Manohas, 2010; Gokgoz & Demir, 2014). To avoid issues relating to non-homogeneous DMUs in DEA, Dyson, Allen, Camanho, Podinovski, Sarrico, & Shale (2001) suggest that DMUs with comparable processes and similar products be utilized; a condition satisfied in this research by considering the telecommunication industry in each country as DMU. Also, DEA results could be biased if homogeneous DMUs in non-homogeneous environments are evaluated (Dyson et. al., 2001). To address this, it is recommended that DMUs operate under similar environmental condition (Dyson et. al., 2001) or that environmental variables be accommodated in the DEA through a two-stage DEA analysis where the efficiency scores in the first stage DEA is regressed against the environmental variables (Haas & Murphy, 2003; Ralmalho, Ralmaho, & Henriques, 2010). To ascertain homogeneity in environment, all DMUs in this research were from countries with deregulated telecommunications industry. Also, the two-stage analysis procedure was employed to allow correction of the efficiency scores for the influence of environmental variables.

No general consensus exists among researchers on the most appropriate approach to adopt when engaging in efficiency and productivity DEA (Kumar, 2013, p. 151). Thus, the methodological approach is subject to data availability and relevance, and ease of application (Martin & Roman, 2006). Like Torres & Bachiller (2013) and Banker et al. (2010), this research adopts input-oriented radial DEA. It accommodates multiple inputs and outputs and allows for cross-country comparison irrespective of any dissimilarity in input and output combinations. Also, it allows inputs and outputs to be considered as a group (Delmasi & Tokat, 2005), thus preventing each country from being the benchmark on the basis of a single input and a single output which is a problem often associated with partial measures of performance (Serebrisky, 2012).

Furthermore, a radial form of DEA removes the shortcomings of 'proportionality' loss associated with the 'non-radial' (i.e., slack base measurement) and allows for the evaluation of change in efficiency over a period of time (Avkiran, Tone, & Tsutsui, 2008, p. 130). The rationale for adopting input-oriented DEA is that it fits situations involving managers having control over inputs (Coelli et al., 2005), thus the input-oriented DEA in this research is suitable because managers in the industry have control over input use relative to outputs. The CRS DEA assesses the overall efficiency but the pure technical efficiency (i.e., VRS TE) and scale efficiency are also assessable. VRS technical efficiency produces better results (Petrović et al., 2011) and is used to eliminate the bias associated with CRS technical efficiency that all DMUs operate at optimal scale (Hung & Lu, 2007). Although incorporating weight restrictions would have introduced human dynamics and forced the DEA to reflect efficiency scores that are different from DEA without restrictions, it would have contradicted the estimation of efficiency using data obtained from DMUs (Forsund, 2013). Hence the DEA in this research did not include weight restrictions. The benefit is that weights generated by the model are impartial due to no exposure to subjective value judgements regarding the importance of inputs and outputs (Liu, 2009). In addition, using DEA without weight restrictions is acceptable and has been applied in Naimy & Merheb (2014). Because non-bootstrapped DEA is determinstic and lacks statistical basis, Simar and Wilson (2007) proposed bootstrapped DEA to correct for possible bias in the DEA efficiency scores. However, the bootstrapped DEA is saddled with "dimensionality" problem and its statistical significance is dependent on the sample size (Adler & Yazhemsky, 2010, p. 277). Also, Banker and Natarajan (2008) show that regressing the non-bootstrapped DEA against environmental variables yield consistent results. While non-bootstrapped DEA is used in this research, its robustness was checked through a sensitivity analysis involving variations in inputs and outputs mix.

Three alternative approaches are available for constructing efficiency frontiers (Estache, Rossi, & Ruzzier, 2004, p. 287). The first is referred to as 'single period' analysis which involves establishing a frontier in each period under investigation and computing the efficiency of each DMU relative to the frontier established in each period. The merit lies in its flexibility in estimating efficiency scores rather than the approach involving a grand frontier which is sometimes overstated due to the effect of technological progress over time (Kumar, 2013). Also, establishing a frontier in each period permits technical progress and regress and allows variability in computed efficiencies such that a DMU that is efficient in one period may not be efficient in another period thereby eliminating error persistence that might affect efficiency scrores over time (Kumar, 2013). The second approach is the ‘multiple period’ which involves treating the panel data as a single cross-section such that each DMU in each period under investigation is considered an independent observation. With this approach, a master frontier (i.e., single best practice frontier) is established and computed efficiency scores of each DMU in each period are evaluated against this master frontier. Although this approach allows each DMU to be evaluated against the same benchmark, the assumption that the technology used by the main frontier does not change is not tenable. The third approach, the ‘intermediate’, relies on window analysis and was proposed by Charnes et al. in 1985 (Estache, Rossi, & Ruzzier, 2004, p. 287). It requires selecting a window width prior to the efficiency analysis. However, Estache, Rossi, and Ruzzier (2004) notes that it is problematic because the window width determined by trial and error results in efficiency scores that vary by the window width and increases the risk of biased efficiency estimates should the specified window width be inappropriate (Maidamisa, Ahmad, & Ismail, 2012).

Similar to Lavado (2004), this research adopts the ‘single-period’ approach with a frontier constructed in each of the 13 years under investigation after which the efficiency of each country in each year is evaluated relative to the frontier. Also, unlike the multi-period approach, the single-period approach allows for productivity change measurement. To evaluate the total factor productivity change (TFPC), an input-oriented DEA based MPI was used. Using DEA-based MPI allows for the source of productivity to be identified through decomposition into technical (i.e., technological) change (TC) and efficiency change (EC) (i.e., ‘catching-up’) (Fare et al., 1994, p. 71). Technical change provides insight on productivity growth/decline resulting from technological progress/regress while efficiency change measures the contribution from efficiency gains/deterioration (Mohamad, 2004, p. 326). Consistent with prior research, the DEA efficiency results are supplemented with a censored Tobit model in the second stage analysis. As noted in Section 5.4, no consensus exists regarding the choice of model in the second stage regression analysis but studies gravitate toward the Tobit model due to its ability to handle censored data with values between 0 and 1, and it is touted as yielding consistent and more reliable regression estimates (Tupper & Resende, 2004).

5.7 Inputs–outputs specifications and sample size

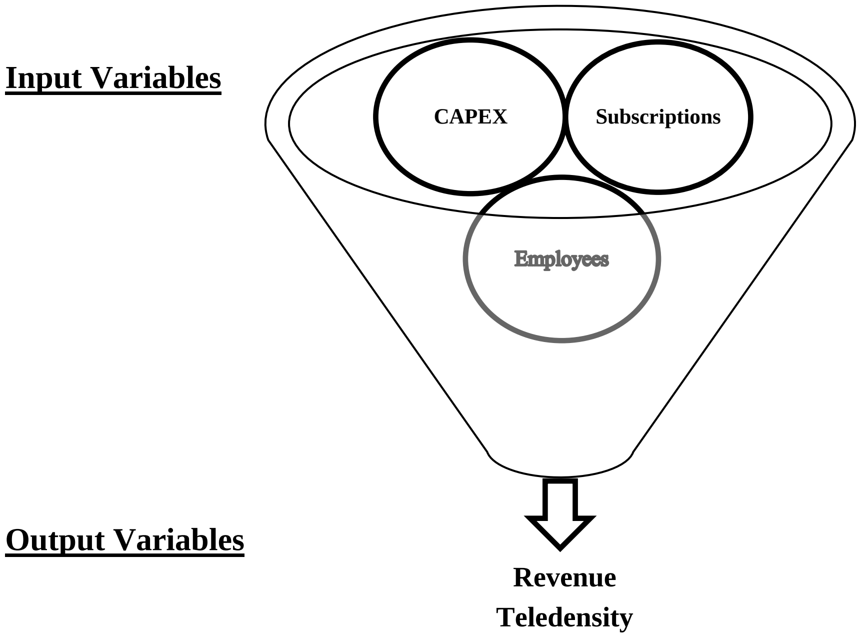
DEA is sensitive to sample size and input and output specifications. As noted in Industry Commission (1997), large sample size results in reduced efficiency score but provides greater scope for DEA in finding similar peers. On the other hand, small sample size may inflate efficiency sores. A rule of thumb is that sample size be at least equal to the product of the number of inputs and outputs. Another rule of thumb is that the sample size be at least three times the sum of inputs and outputs (Cooper et al., 2001; Kumar, 2013; Naimy & Merheb, 2014). As applied in studies by Hadad et al. (2013), Li (2009), Lu & Hung (2008) and Halkos & Tzeremes (2007), this research utilizes three inputs and two outputs. The use of three inputs and two outputs suggests a minimum sample size of 6 and a maximum of 15 is sufficient. The data from a sample of 19 countries (HICs, 10; MICs, 9) is greater than the maximum that could have been used. This may result in reduced efficiency scores but it provides the DEA with better explanatory power and latitude in determining efficiency scores. Also, it prevents artificial inflation of efficiency scores if data on fewer countries were used. Another benefit of using a sample of 19 countries over the 13-year period is that it generates adequate panel data essential for the censored Tobit regression analysis. For the second phase involving the survey of industry participants, purposive sampling was used to recruit participants. This resulted in a total of 37 (Canada: 5; Nigeria: 32) participants who took part in the survey. Concerted effort made to collect data from more participants proved abortive. The difficulty experienced in the collection of primary data reflects the small sample size. Although, a larger sample size would have been preferred, the sample size of 37 is considered satisfactory in that it falls within the sample sizes of 19 participants in Serebrisky (2012) and 50 in Ross & Bamber (2009). In addition, the core of the thesis is the analysis of the efficiency and productivity of telecommunications industry using DEA. The primary data was meant to complement the DEA efficiency and productivity results.

The inputs selected harmonize with Naimy & Merheb (2014) and Petrović et al. (2011) and include annual capital expenditures (Capex), yearly subscriptions (SUB) and employment (EMP) (Figure 5.2). Capital input provides insight regarding the cause of inefficiency. Using both too much capital for a given level of output, and capital with an inappropriate mix of other inputs may suggest inefficiency. The absence of accord on capital input treatment results in variations across researches. For example, Torres & Bachiller (2013) use total assets, Hu & Chu (2008) apply fixed assets (i.e., total assets less current assets), and Bollou & Ngwenyama (2008) and Gokgoz & Demir (2014) embrace capital expenditures (Capex). To mitigate the influence of financial reporting differences across countries in the treatment of capital, this research uses Capex to proxy capital inputs.

Another prevalent input is the number of lines available which is proxied by subscriptions (Lee, Park, & OH, 2000; Gokgoz & Demir, 2014). Under the assumption that subscriptions are active and in use by customers, this research considered subscriptions as input though the possibility exists that some lines may have been deactivated. Nonetheless, deactivated lines are often a minute proportion of the total subscriptions and customers who deactivate line(s) from a particular service provider usually switch to a different service provider in a phenomenon called ‘churning’ (Jadhav & Pawar, 2011, p. 17). Also, several studies, including Gokgoz & Demir (2014), Petrović et al. (2011) and Usero & Asimakopoulos (2013), lend support to subscriptions as input. In addition, it is appropriate to use subscriptions because operators and regulators measure the ratio of industry revenue to subscriptions when assessing competitive pressure, affordability and accessibility of telecommunications services (ITU, 2014)

An important input used to generate output is labour, hence the use of employment as an input is ideal. Total industry employment, number of full time employees and the total number of hours employed are commonly used to reflect labour input. While the total number of hours employed is considered the most suitable and preferred proxy for labour input (Coelli et al., 2005), the lack of data on this measure necessitated reliance on industry employment with the recognition that firms in the industry contract out work and this may result in understated employment. On the contrary, some countries may report aggregate post and telecommunications employment and overstate employment. Nonetheless, the use of persons employed is suitable as it eliminates measurement issues relating to the accuracy of hours worked and whether the individual is part-time or full-time. Also, its use as proxy for labour input is widely accepted and has been applied in prior studies (e.g., Lu & Hung, 2008; Sung, 2012).

The output selection proved difficult as some studies (e.g., Cho & Park, 2011; Moreno, Lozano, & Gutierrez, 2013) relied on a single output (e.g., revenue) and expressed operators' view of performance as operators usually focus on revenue increase to attain better profitability (Moshi, Mwakatumbula, & Mitomo, 2013). However, others (e.g., Cabanda, Ariff, & Viverita, 2004) expressed the operators' and policy makers' views of performance and utilize multiple outputs (e.g., revenue) and one or more variables relating to the level of coverage (e.g., teledensity). As shown in Figure 5.2, this research utilizes two output variables (i.e., revenue and teledensity) and harmonizes with prior research (e.g., Petrović et al., 2011). Because the industry's aggregate revenue was used for each country in each period, it is possible that some operators may report revenue unrelated to telecommunications which may lead to overstated revenue. Recognising inflationary impact, adjustment was made to account for differences in consumer price index (CPI) over the 13-year period between the countries and the data treatment is presented in Section 5.9. Teledensity, which accompanies revenue as an output variable in this research is a popular measure of telecommunication services diffusion and is based on subscriptions per 100 inhabitants (Meso et al., 2009). Higher teledensity reflects increased subscription levels and connotes increased availability of telecommunications services. Incorporating teledensity as an output embeds policy makers' view of performance (Moshi, Mwakatumbula, & Mitomo, 2013) and is similar to the approach in Cabanda, Ariff & Viverita (2004).



Source(s): Developed for this research

Figure 5.2: DEA input and output variables.

5.8 Data collection

5.8.1 Quantitative data collection

To meet the research objectives, the quantitative data on each of the 19 countries were obtained from secondary sources such as: International Telecommunications Union (ITU), the World Bank, the OECD communications monitoring report, bureau of statistics, regulatory agency's published information and published empirical research. The information extracted covers 2001–13 and consists of Capex, subscriptions, employment, revenue, teledensity, HHI, GDP and population. The two-stage efficiency and productivity DEA with a Tobit model requires quantitative panel data. Panel data allow several analyses that are not possible with cross-sectional or time-series data, but a concern is potential 'hererogeneity bias' which is a situation where some of the effects that exist in a cross-section or time series are not captured by the explanatory variables thus resulting in inconsistent parameter estimates (Hsiao, 2003, p. 8). Another concern is 'selectivity bias' which may occur when the selection constituting the panel is not random but based on preconceived characteristics (Hsiao, 2003, p. 9). In spite of these concerns, panel data are widely used in empirical research and have been applied in Li (2009) and Petrović et al. (2012). The panel data in this research consist of 247 observations from 19 countries (N = 19) over a 13-year period (T = 13) with each observation representing the industry in each country in a given year. Using panel data provide more information and generate better efficiency estimates of the regression parameters with less restrictive assumptions. In addition, the increased data points in the panel data generate high degree of freedom and reduce the potential for collinearity among the explanatory variables thereby contributing to the robustness of the model in yielding better parameter estimates (Hsiao, 2003). The time period of 2001 and 2013 is inclusive and contributes to mitigating 'statistical noise' (Kong & Tongzon, 2006 p. 2309). Furthermore, the panel data which rely on observations from each country over a period of time allow for statistical inferences to be made (Hsiao, 2003). Additionally, the 13-year period is consistent with Cabanda, Ariff, & Viverita (2004), Moshi, Mwakatumbula & Mitomo (2013) and Petrović et al. (2012) and is longer than time periods used in Usero, Grigorios, & Asimakopoulos (2013) and Gokgoz & Demir (2014).

In deciding the primary data to collect for this research, consideration was given to participants from the industry, regulatory angency, and service recipients. Because the research focuses on productive use of inputs in generating outputs, surveying service recipients was deemed unsuitable. Hence, the research sought to data from participants from the industry and regulatory agency. The primary data gathered through the survey questionnaire also yielded quantitative data. The 'purposive sampling' method used to recruit participants is a non-probability technique effective in research requiring information from individuals with particular expertise and knowledge (Beins, 2009, p. 130). In recruiting participants, information (names, addresses, telephone numbers etc.) on telecommunication firms in the industry were gathered to initiate a conversation on the research and to establish a commitment from potential participants. A questionnaire was used to gather information from the participants (Appendix 11). To incorporate the perspective of regulators, the CRTC and the NCC were contacted but the CRTC declined outright to participate as a matter of policy (Appendix 15), and three staff from the NCC who participated were unwilling to recommend others to participate. One of the three who participated did so reluctantly and was perceived to be under the influence of a personal relationship with the researcher. For these reasons, a decision was made not to include the regulatory agency in the survey.

The survey questions were the outcome of the literature review and a pilot study. The pilot study was conducted to determine the feasibility of the survey instrument (Leedy & Omrod, 2013). The pilot study carried out prior to the implementation of the survey questionnaire uncovered areas needing refinement. It exposed weaknesses relating to the structure and interpretation of the questions and the evaluation of the responses. The information gathered from the pilot study was used to refine the survey instrument and procedure. Guidelines in Ghauri & Gronhaug (2010) were adhered to in constructing the questionnaire so as to eliminate leading questions that would cause participants to answer in a particular direction. The questionnaire was deployed and retrieved between April 2014 and November 2014. It consists of 20 questions and gathered information on the description and understanding of (i) the driving forces and reasons for deregulating the industry; (ii) the extent to which the structure, conduct and performance of the industry has been influenced in the deregulated environment; and (iii) the strategic implications of industry trends. In addition, the questionnaire incorporated the question classifications in Ambrose & Anstey (2010). Thus, the questionnaire consisted of five sections – deregulation, structure of the industry, conduct of firms in the industry, performance, and background. Each survey questionnaire took approximately 30–45 minutes to complete and contained closed-ended and open-ended questions intended to answer research questions RQ_1 and RQ_2 and achieve the main research objectives. The individuals who completed the questionnaire were asked to identify others in the same firm and/or industry who were prime candidates to participate in the research. Relying on referrals, other potential participants were contacted and invited to participate in the study but many declined. In spite of the recruitment constraint, the research approach adopted allowed for the research questions to be answered and for the research objectives to be realized.

5.8.2 Qualitative data collection

The open-ended questions in the survey questionnaire allowed participants to express their unbiased views, thus permitting the gathering of qualitative data. Another method that could have been used to gather qualitative data is an interview (Ghauri & Gronhaug, 2010). However, particpants contacted were not willing to be recorded. The inability to conduct a face-to-face interview did not affect the outcome of this research because questions that would have been asked in an interview were in the questionnaire. The open-ended questions placed no constraints on participants and allowed them to provide answers according to their thoughts but it did not lend itself to follow-up questions that would have permitted the researcher to probe participants further on their responses.

5.9 Data treatment

5.9.1 Primary data treatment

The primary data was collected using the questionnaire and consists of quantitative and qualitative data. Each questionnaire was coded and the quantitative data entered in an Excel spreadsheet according to the sections in the questionnaire. The quantitative data were subsequently analyzed using STATA 14.1 which is a statistical analysis program used to generate descriptive statistics. The qualitative data which provides information that augments the quantitative data were reviewed, categorized and organized into meaningful themes relevant to the research questions.

5.9.2 Secondary Data Treatment

To ensure comparability among countries, Capex and revenue data were expressed in US dollars. Using a common currency unit is indispensable in cross-country research and has been applied in Petrović et al. (2011) who examined the benchmarking of telecommunications in developing countries using US dollars for the revenues and investments for each country. The US dollar is adopted because it is a major trading currency in international markets. It is not uncommon to experience missing data when compiling panel data for cross-country analysis. Thus, the relatively small amounts of missing data were approximated. The practice of estimating missing data is appropriate and has been used in OECD (2013) and is consistent with practices in empirical research (e.g., Dedrick, Kraemer, & Shih, 2013; Petrović et al., 2012; Petrović et al., 2011). Also, HHI information was calculated to reveal the level of concentration and industry structure (Ertl & McCarrell, 2002). The HHI was calculated using the sum of the square of the market share of each firm in the industry. Where market share information was not available, the HHI from published empirical research was considered adequate.

This research adjusted for any price change that may have occurred to inputs and output over the 13-year period under investigation. To adjust Capex, revenue and GDP for price changes, GDP deflator and CPI were consisdered. GDP deflator reflects change in price and quantity of goods and services produced in an economy. CPI measures price changes of a given market basket of goods and services purchased by consumers (Csipak & Zuccaro, 2014). While both methods reflect inflationary trends, the CPI has a wide appeal and, unlike the GDP deflator, it has a less varied yearly structure (Litra, 2009). Using 2010 as the base year, the impact of inflation on revenues and Capex were eliminated by deflating using CPI as suggested in Coelli et al. (2005) and applied in Majumdar (1994) and Byambaakhuu, Kwon, & Rho (2014). However, it is possible that eliminating the impact of price change may inadvertently diminish genuine price increase that resulted from improved product and service quality (Greenlees & McClelland, 2011). Nonetheless, the base year of 2010 allowed for constant dollar expressions and eliminated plausible influence of inflationary price changes on the efficiency and productivity measurement variables. In addition, the GDP data obtained from the World Bank database were in current dollars (i.e., nominal amount) and were converted to real GDP using the yearly GDP deflator.

5.10 Data analysis

5.10.1 Analysis of primary data

The analysis of the primary data was done in the following order: background and profile of participants; deregulation; structure of the industry and level of competition; conduct of firms in the industry; and performance. The analysis of quantitative data from completed questionnaires entailed 'inferential statistics' which typically rely on sample information in making inferences about the population (Charles & Mertler, 2002, p. 189). For a meaningful description, the analysis also involved presenting the data in tabular form with numerical measures. The analysis of the qualitative data took the form of inferences and quotes to avoid diluting the significance of participants' views. In addition, the analysis and discussion integrates the quantitative and qualitative data in ways that preserve participants' anonymity and contribute to meeting the research objectives.

5.10.2 Analysis of secondary data

The industry data gathered reflects information on all firms in the industry. Thus the analysis of the secondary data involves 'descriptive statistics' which is appropriate when information on the entire population is gathered and it is possible to analyze the population parameter (mean, standard deviation etc.) (Charles & Mertler, 2002, p. 188). Research on the telecommunication industry use a variety of data analysis methods involving descriptive analysis (Tuman, 2007; Cabeza & Gomez, 2011), regression (Banker, Chang, & Majumdar, 1998; Akhtar, 2009), DEA (Rosende & Facanha, 2002; Sharma et al., 2010; Gokgoz & Demir, 2014) or a combination of methods (Hu & Chu, 2008; Banker et al., 2010; Usero & Asimakopoulos, 2013). The analysis involved financial and non-financial variables and focuses on partial factor analysis (PFA) and total factor analysis (ToFA). The partial factor analysis measures are revenue, Capex to revenue, revenue to employment, Capex, Capex to subscription, revenue to subscriptions and the nonfinancial measures are subscriptions, subscriptions to employment, subscriptions per 100 inhabitants (teledensity) and industry concentration level (HHI). The ToFA concentrated on technical efficiency, pure technical efficiency and scale efficiency scores of the industry and the productivity change over time. This was attained using productivity improvement management-DEA software Version 3.0 which was developed by Emrouznejad & Thanassoulis (2011) and was used in an empirical study by Haruna & Maishanu (2013). STATA 14.1 which was used for the descriptive statistical analysis, censored Tobit model and Wilcoxon Rank-Sum (Mann-Whitney) statistical test is popular statistical analysis software.

Additionally, the MPI used to generate total factor productivity growth (TFPG) was decomposed into its components. The decomposition of MPI under constant returns to scale relies on the FGNZ index (Fare et al., 1994, pp. 66–7) which bases productivity change on the geometric mean of two MPIs. The approach yields total factor productivity by decomposing MPI into technical change ('innovation') and efficiency change ('catching-up') and measuring their distances relative to the frontiers. As noted in Ray & Desli (1997, p. 1033), the FGNZ index correctly shows the shift in technical efficiency under constant returns to scale. However, if scale effect exists as pronounced in variable returns to scale, FGNZ index will fail to account for 'autonomous' shift in the frontiers and will yield inconsistent results as it does not indicate how optimal output changes due to technical change provided the inputs is constant. In view of this, this research utilizes Ray and Desli's Malmquist index for the measurement of total factor productivity under variable returns to scale condition. Unlike the FGNZ index, Ray and Desli's index removes potential understating or overstating of technical change by not relying on shifts in benchmark technology but on shifts in best practice technology (Lovell, 2003). Furthermore, compared to the FGNZ index under constant returns to scale, Ray and Desli's index allows for the measurement of technical change by the ratio of variable returns to scale distance functions. While this affects the scale efficiency change, the pure technical efficiency change value is unaltered (Ray & Desli, 1997).

The analysis presents the data in tabular and graphical forms with numerical measures (i.e., mean, standard deviation etc). As demonstrated in Hung & Lu (2007, p. 1125), the Wilcoxon Rank-Sum (Mann-Whitney) test, which is a non-parametric test, was performed to determine if a difference in the performance (CRS TE, VRS TE, SE and TFPC) of the two countries exists. If differences exist, the test allows for the statistical significance to be determined. This test, like the Kruskal-Wallis test, accommodates two population groups to be tested, does not place normal distribution restrictions on the population, and has been used in empirical studies that have carried out intra and inter-country telecommunication industry performance comparisons (e.g., Tsai, Chen, & Tzeng, 2006; Hung & Lu, 2007; Lam & Shiu, 2008). The analysis and discussion of the quantitative data and key findings are discussed using 'descriptive' and 'inferential' statistics in ways that allow the results to be presented objectively (Creswell, 2012, p. 182).

5.11 Ethical considerations

Because human participants were involved, this research sought ethics approval from Human Research Ethics Committee at the University of Southern Queensland and was granted full approval on 19 November 2013 (Appendix 14). In compliance with this approval, participants were asked by letter to consent to participate voluntarily (Appendix 13). Through a participant information sheet (Appendix 12) that accompanied the questionnaire, participants were informed about the research objectives and the purpose for which the data was being gathered and their right to withdraw from the research. In addition, the privacy, anonymity and confidentiality of participants were ethical requirements that this research complied with through the avoidance of intruding questions not related to the research and by ensuring that any features that may identify participants were removed. Coding and aggregate reporting of data were also used to ensure anonymity. Furthermore, the confidentiality of participants was maintained by ensuring that completed questionnaires and consent forms were stored in a secure cabinet and electronic copies password protected and only accessible to the researcher.

Summary

This chapter elaborated on parametric and non-parametric approaches used to measure efficiency and productivity. The comparison of stochastic frontier analysis (SFA) and data envelopment analysis (DEA) techniques in performance analysis showed that either method is suitable but that the choice of method depends on the researcher and data availability. The adoption of DEA and MPI and the use of the Tobit model in the second stage analysis in this research are consistent with methodological approach in prior researches. Additionally, the case study approach provided a basis for understanding the phenomenon being studied. Furthermore, the survey questionnaires completed by industry participants complement the efficiency and productivity analysis and allowed the perspective of industry experts to be reflected in the outcome of this research. In particular, this chapter explained the approach and methodology of this research, the data gathering, issues and treatment, analysis of data, and the measures taken to ensure validity, reliability and consistency with prior empirical research in the area of inquiry. The next chapter (Chapter 6) presents the data analyisis and interprets the results of the analyzed data. Focusing on the research objectives established in Chapter 1, it details the theme(s) and identifies trends and patterns that relate to the research objectives.

Chapter 6

Results and Discussion of Efficiency and Productivity Analysis

6.1 Introduction

Chapter 5 describes the methodology adopted in this research. Chapter 6 details the results of the DEA and discusses the efficiency and productivity performance of the telecommunications industry. The chapter consists of five main parts after this introduction. Section 6.2 presents the descriptive statistics (mean, standard deviation, and maximum and minimum) of the data. Section 6.3 briefly discusses the performance analysis in this research. Section 6.4 is the analysis of the partial measures of performance. Section 6.5 is on the DEA efficiency and productivity and discusses the sources of efficiency and productivity change. Section 6.6 discusses the Mann-Whitney (Wilcoxon Rank-Sum) test carried out to examine any statistical differences between the efficiency and productivity performance of the industry in the two countries. Section 6.7 presents the analysis and discussion of the censored Tobit model and provides an understanding of the effect of environmental factors on efficiency. Section 6.8 presents specifications and estimation method change carried out to ascertain the robustness of the model. The chapter concludes with a summary.

6.2 Descriptive statistics of inputs and outputs

Table 6.1A presents the share of total Capex, subscriptions, employment and revenue for the two countries and country categories (i.e., HICs, MICs and OECD). The table shows that in 2001 Capex in HICs constituted 73% of the total in the panel data but declined to 67% by 2013. For MICs, it increased from 27% to 33% in the same period. For OECD member countries, Capex declined from 80% in 2001 to 70% in 2013. Concentrating on the two countries of focus, the table reveals that Canada accounted for 2% of total Capex in 2001 and 4% in 2013 while the amount accounted for by Nigeria was relatively stable at 1%. Furthermore, in 2001 HICs accounted for 59% of subscriptions and MICs 41%, but by 2013, HICs subscriptions as a percentage of the total declined to 24% while MICs rose to 76%. Noticeably, Canada's share of total subscriptions decline by 1% while Nigeria's share increased from almost 0% in 2001 to 3% in 2013.

Table 6.1A also shows HICs total share of industry employment declined from 45% to 24% in the study period, and a similar pattern was exhibited by the OECD category. Meanwhile, MICs percentage of employment rose from 55% of total employment in 2001 to 76% in 2013. The table also shows Canada's share of total employment declined from 2% in 2001 to 1% in 2013, but Nigeria's share of total employment doubled in the same period. Furthermore, HICs share of revenue declined from 83% in 2001 to 73% in 2013 but it rose in MICs from 17% to 27%. In addition, the table indicates that Canada and Nigeria experienced an increased share of total revenues. However, while Nigeria displayed a pattern similar to MICs, Canada exhibited a pattern that deviated from HICs and OECD.

Table 6.1A: Percentage distribution by categories.

	Capex (%)		**Subscriptions (%)**		**Employment (%)**		**Revenue (%)**	
	2001	**2013**	**2001**	**2013**	**2001**	**2013**	**2001**	**2013**
HICs	73	67	59	24	45	24	83	73
MICs	27	33	41	76	55	76	17	27
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Canada	2	4	2	1	2	1	2	3
Nigeria	1	1	0.07	3	3	6	0.06	1
OECD	80	70	65	29	48	27	88	77

Source(s): Author's calculations

Table 6.1B presents the descriptive statistics of the inputs and outputs in the panel data. The table indicates an average Capex of $10,741 million for the sample with a standard deviation of $17,964 million. The median Capex is $5,068 million which indicates that half of the countries in the sample engaged in Capex spending above $5,068 million. The sample mean subscriptions and employment are 151,734 thousand and 328,114. The average revenue for the sample is $63,107 million with a standard deviation of $111,874 million and a median of $29,943 million. Teledensity average 103.36 for the sample and the median and standard deviation are 111.33 and 48.96 (Table 6.1B). Also, the table shows that the sample of countries in HICs and OECD have a higher Capex average (HICs: $14,639 million; OECD: $12,855 million) and a higher median (HICs: $7,093 million; OECD: $6,309 million) than the average ($10,741 million) and median ($5,068 million) for the sample panel data and the MICs sample average of $6,410 million and median of $3,494 million, but with higher standard deviations. Average subscriptions for the sample of countries in HICs (97,904 thousand) and OECD (94,150 thousand) is below the panel data average (151,734 thousand) and MICs (211,544 thousand). The mean employment in MICs (449,480) is higher than the overall sample average (328,114), HICs (218,884), and OECD (203,357). Additionally, the average revenue for the countries in MICs ($30,051 million) is below the overall sample average ($63,107 million), HICs ($92,857 million) and OECD ($81,271 million). The teledensity average for the sample of countries in HICs (137.63) and OECD (128.74) are higher than the average for MICs (65.29) and the panel's overall sample average (103.36) (Table 6.1B).

For Canada, the average Capex of $7,099 is below the panel's average ($10,741) and the average for the sample of countries in HICs ($14,639) and OECD ($12,855), but above the average displayed by MICs ($6,410) (Table 6.1B). Also, the table shows average subscription in Canada is 39,030 thousand with a standard deviation of 5,090 thousand. Average employment is 117,268 with a standard deviation of 3,005. The mean and median revenue are $34,153 million and $36,621 million and the standard deviation is $6,394 million. The mean teledensity in Canada is 117.88 (Table 6.1B). In the case of Nigeria, Table 6.1B shows average Capex of $2,825 million which is 40% of Canada's average of $7,099. The average subscription of 52,044 thousand is 1.3 times the average for Canada but with a standard deviation of 44,710 thousand which is 7 times that of Canada. The average employment is 403,516 with a standard deviation of 107,852. The average revenue of $8,176 million is 24% of Canada, but with a standard deviation of $4,949 million which is 77.4% of the $6,394 million displayed by Canada. The average teledensity of 37.51 is lower than Canada's average of 117.88.

Table 6.1B: Descriptive statistics.

	Input 1 Capex (USD millions)	Input 2 Subscriptions (thousands)	Input 3 Employment	Output 1 Revenue (USD millions)	Output 2 Teledensity
All 19 Countries (247 observations)					
Mean	10,741	151,734	328,114	63,107	103.36
Median	5,068	71,494	147,994	29,943	111.33
STD	17,964	242,429	467,493	111,874	48.96
Maximum	130,030	1,496,098	3,273,000	524,896	193.77
Minimum	239	867	7,459	607	0.74
High Income Countries (10 countries; 130 observations)					
Mean	14,639	97,904	218,884	92,857	137.63
Median	7,093	50,133	116,019	39,838	139.35
STD	23,018	114,176	302,782	144,268	25.50
Maximum	130,030	443,931	1,423,900	524,896	193.77
Minimum	400	4,111	7,459	2,717	54.78
Middle Income Countries (9 countries; 117 observations)					
Mean	6,410	211,544	449,480	30,051	65.29
Median	3,494	79,314	193,682	17,053	67.12
STD	7,697	321,379	577,319	36,084	39.79
Maximum	43,665	1,496,098	3,273,000	184,596	157.78
Minimum	239	867	52,895	607	0.74
OECD Countries (12 countries; 156 observations)					
Mean	12,855	94,150	203,357	81,271	128.74
Median	6,309	62,417	116,529	33,618	131.53
STD	21,393	105,020	278,711	134,183	32.31
Maximum	130,030	443,931	1,423,900	524,896	193.77
Minimum	400	4,111	7,459	2,717	33.73
Canada (13 Observations)					
Mean	7,099	39,030	117,268	34,153	117.88
Median	7,143	38,559	116,997	36,621	117.24
STD	2,265	5,090	3,005	6,394	10.85
Maximum	11,449	45,446	124,652	41,924	131.36
Minimum	3,709	31,775	111,338	24,649	102.23
Nigeria (13 Observations)					
Mean	2,825	52,044	403,516	8,176	37.51
Median	3,036	41,975	462,115	6,926	29.98
STD	985	44,710	107,852	4,949	31.63
Maximum	3,908	127,607	485,177	17,335	91.15
Minimum	1,339	867	193,682	607	0.74

Source(s): Author’s calculations

6.3 Measures of performance

This research focuses on the performance of telecommunications industries in deregulated environement. The assessment has two parts. First is the partial measure of performance (PMP). It involves evaluating each of the single performance measures. Second is ToFA which utilizes aggregate measures in the DEA of the efficiency and productivity.

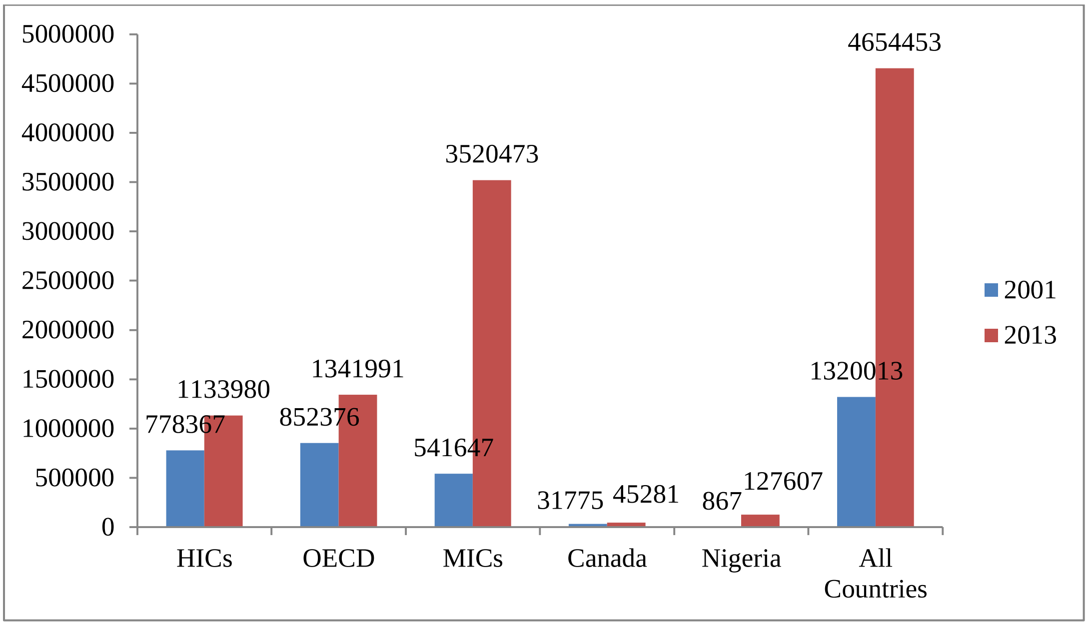
6.4 Partial measure of performance (PMP)

Partial measure of performance is a useful tool that provides insights on the performance of an industry. Its advantage is that it is simple to calculate and easy to comprehend (Serebrisky, 2012). Partial measure of performance involves using ratios (e.g., of input to output). However, using it in situations involving multiple inputs and outputs ignores potential interactions between the multiple inputs and outputs, resulting in misleading performance assessment (Serebrisky, 2012). Nonetheless, it has been used in empirical research to evaluate the performance of industries such as transportation (Serebrisky, 2012) and telecommunications (ITU, 2003). In the partial measures of performance analysis carried out in this research, the measures used are similar to ITU (2003) and include average revenue per subscriber (ARPS), teledensity, subscriptions to employment (SubEmp) ratio, revenues to employment (RevEmp) ratio, revenue to subscriptions (RevSub) ratio, capital expenditure to revenue (CapexRev) ratio, and capital expenditure to subscription (CapexSub) ratio and the level of competition (HHI).

6.4.1 Subscriptions and teledensity.

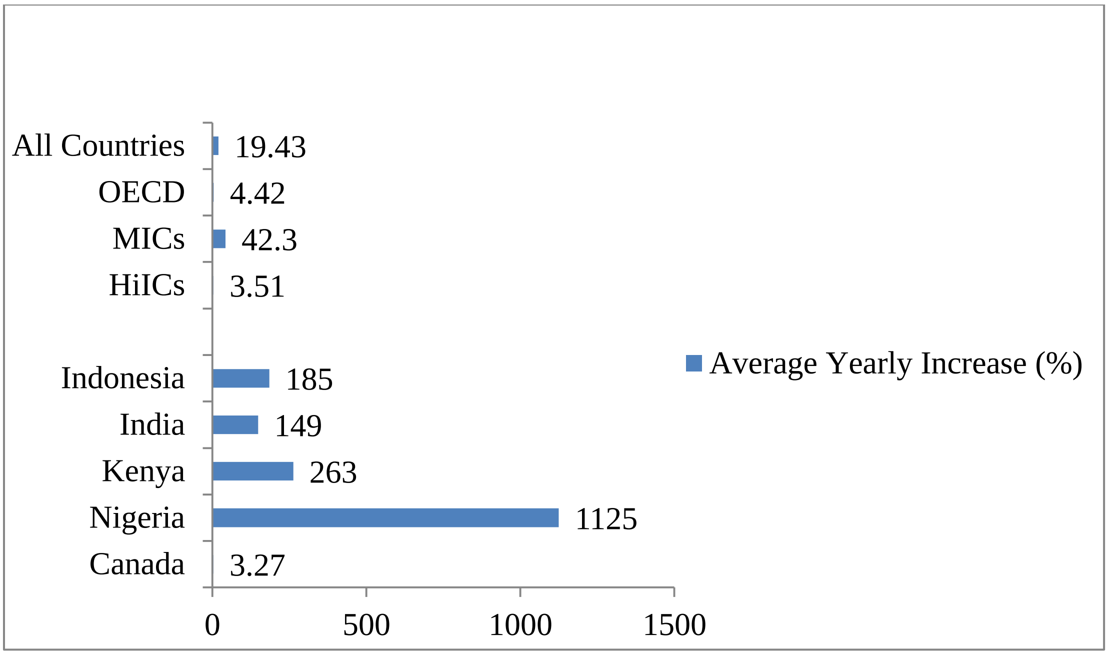
6.4.1.1 Subscriptions

Subscriptions in Canada increased from 31,775 thousand in 2001 to 45,281 thousand in 2013 (Figure 6.1A) which is a 42.5% rise or an average of 3.26% in each of the 13 years in the study but is less than the average increase in OECD (4.42%), HICs (3.51%), MICs (42.3%) and panel data (19.43%) (Figure 6.1B). In Nigeria, subscriptions rose from 867 thousand in 2001 to 127.6 million in 2013 (Figure 6.1A) representing average yearly increase of 1124% (Figure 6.1B) which is 345 times the average yearly percentage increase in Canada. Other countries with high average yearly growth rates are: Kenya (263%), Indonesia (185%) and India (149%); all are MICs (Figure 6.1B). Canada was deregulated in 1985 and Nigeria in 1999, hence, the enormous subscriptions increase in Nigeria may be due to the later deregulation of the industry. This finding harmonizes with Herath (2012) who stated telecommunications subscriptions tend to increase post-deregulation and linked subscriptions increase in several countries (e.g., India and Sri Lanka) to deregulation. The subscriptions pattern in Canada and Nigeria shown in Figures 6.1C and 6.1D reveal declining wireline subscriptions but rising wireless subscriptions, suggesting subscribers' migration from wireline to wireless services. Assuming that subscription is the yardstick used to evaluate the industry, the data indicates that average yearly subscriptions growth in Nigeria is slowing, as it did in Canada, but the cushion for growth makes the industry outlook superior to Canada which is trending towards stagnation and negative growth. The implication for Canada's saturated and Nigeria's declining growth market is that competitive intensity among telecommunications firms would increase.



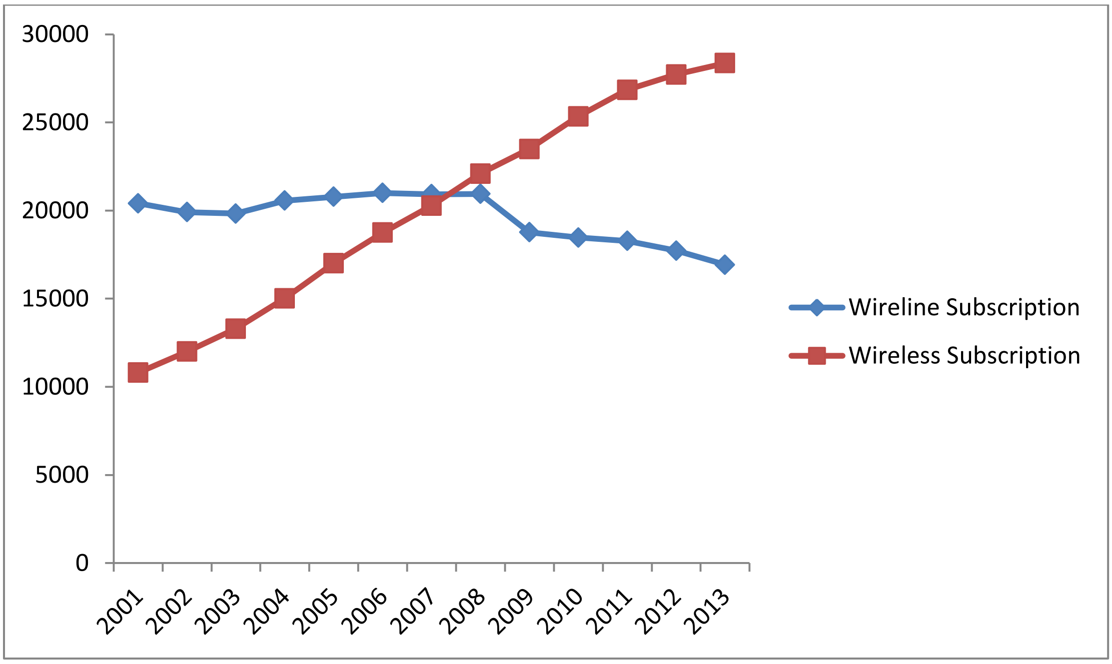
Source(s): Developed by the author for this research

Figure 6.1A: Subscriptions change (in Thousands)



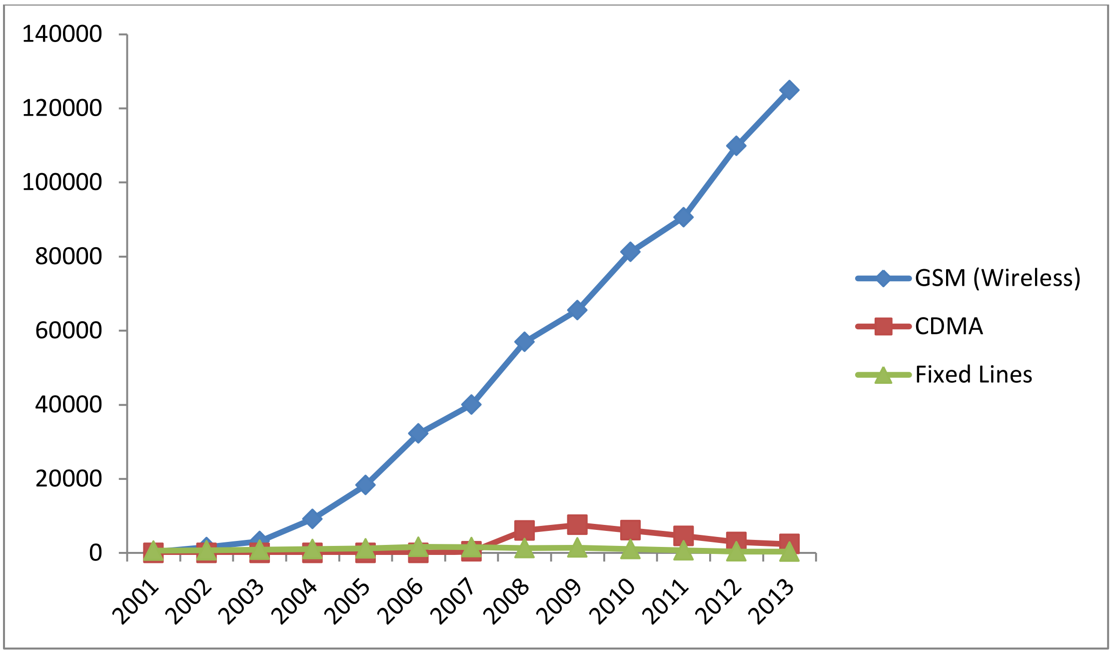
Source(s): Author's calculations

Figure 6.1B: Average yearly increase in subscriptions **(%)**



Source(s): Developed by the author for this research

Figure 6.1C: Wireline and wireless subscriptions in Canada (in Thousands).



Source(s): Developed by the author for this research

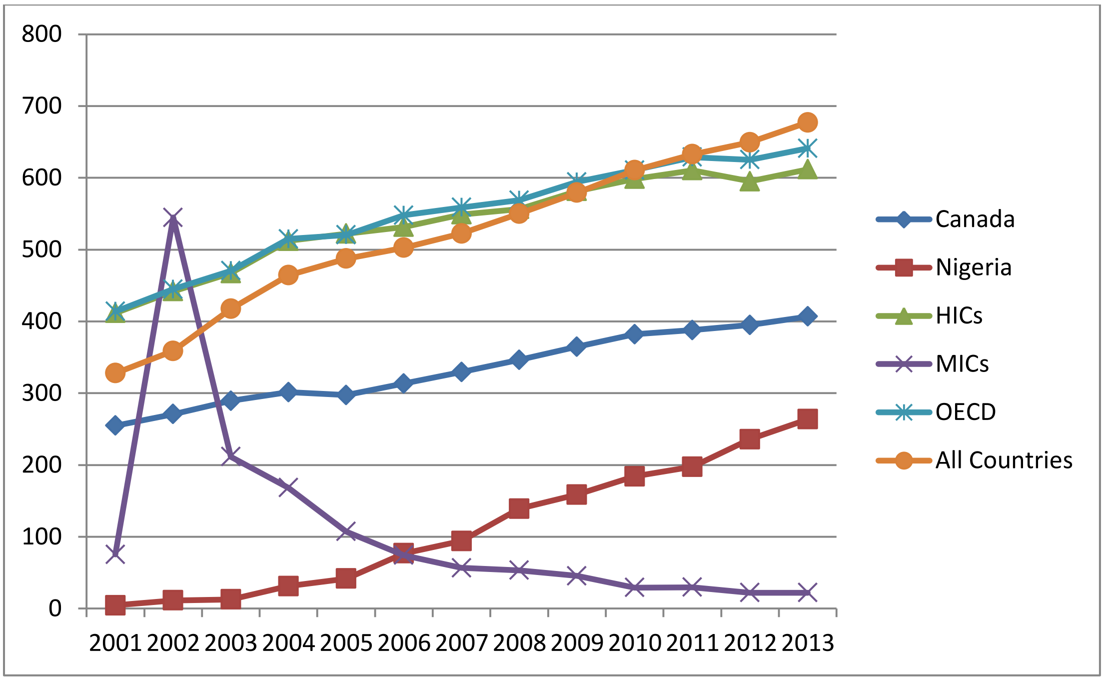
Figure 6.1D: GSM, CDMA and fixed line subscriptions in Nigeria (in Thousands)

6.4.1.2 Teledensity

Teledensity depicts the number of lines available per 100 inhabitants (Batuo, 2015). Teledensity in Canada was 128.81 in 2013 and 91.15 in Nigeria (Appendices 1D and 1N). Canada's average teledensity of 117.88 is below the average for HICs (137.63) and OECD member countries (128.74) but higher than the MICs (65.29), Nigeria (37.51) and the panel dataset (103.36) (Table 6.1B). Canada's teledensity average of 117.88 is higher than the median of 111.33 for the panel dataset, suggesting that Canada performed better than half of the countries but this teledensity performance is below the median displayed by HICs (139.35) and OECD member countries (131.53). Nigeria's mean teledensity of 37.51 is below half of the countries in the study. The low teledensity in Nigeria indicates low levels of phone lines per capita and/or low levels of access to telecommunications services probably due to limited infrastructure and the lateness in deregulating the industry. Canada has a higher teledensity, signifying a higher level of access to telecommunications services. The finding of higher teledensity in Canada is consistent with Li & Xu (2004) who noted that industrialized and wealthier countries with stable economy tend to have higher teledensities than countries with less stable economy. Furthermore, higher teledensity suggests greater access to telecommunications services. Thus, the difference in teledensity levels between the two countries may signal differences in level of access to telecommunications services. Care should be exercised in the use of teledensity as a performance measure. Wallsten (2001) used it with an interpretive caution, noting that using the number of lines per capita to access industry performance may result in wrong conclusions due to the multiple line subscriptions held by some individuals. Although teledensity as the only measure of performance should be interpreted with caution, Nigeria is yet to attain one telephone line per inhabitant (teledensity: 91.15), indicating growth potential for firms in the industry. On the other hand, Canada's high teledensity suggests limited growth opportunities.

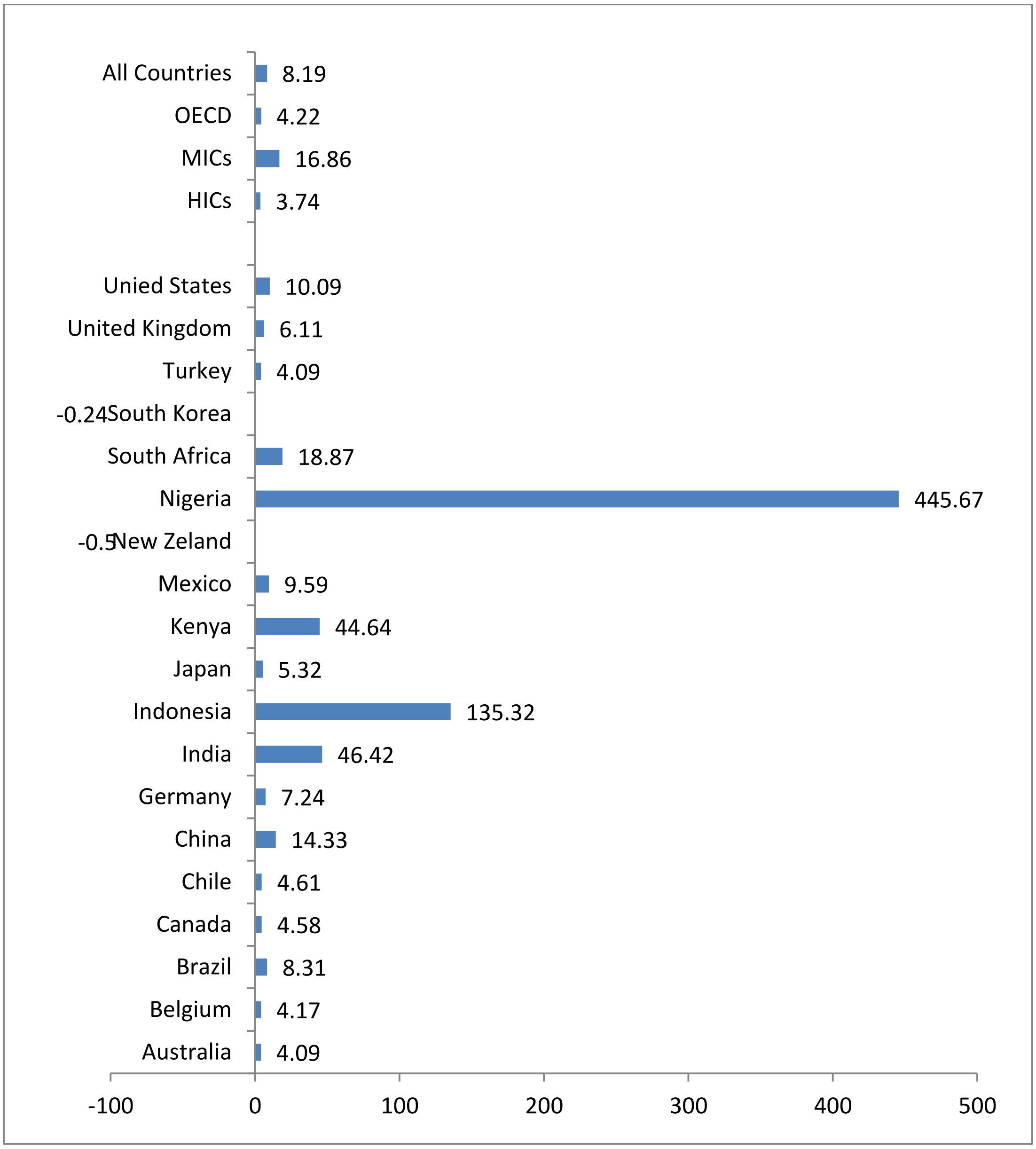
6.4.2 Subscriptions to employment ratio

Subscription to employment (SubEmp) ratio is considered a measure of labour productivity (Dabler, Parker, & Saal, 2002). Appendices 1D and 1N shows upward trends in subscriptions in Canada and Nigeria, however, employment in the Canadian telecommunications industry is relatively constant, increasing by a modest 7,500 (7.28%) over the 13-year period which is an average of 0.56% per year. In addition, Appendix 1D reveals that SubEmp which was 301 in 2001 peaked at 412 in 2008 but declined to 362 in 2009. Since 2010, it has continued to rise. Appendix 1N shows 483,801 employments in 2013 in Nigeria, an increase of 149.8% over the 13-year period. Figure 2A depicts the SubEmp trends. It reveals an upward trend for the categories of countries except MICs. SubEmp in Nigeria was four in 2001 but rose to 264 in 2013 (Table 6.2B). The SubEmp growth in Nigeria is 97 times that in Canada (Figure 6.2B), suggesting greater labour productivity growth in Nigeria. However, on average, the 112 SubEmp in Nigeria is smaller than the average for Canada (334), HICs (538), OECD (550), MICs (483) and the overall average (512) (Figure 6.2C). Countries that have SubEmp comparable to Canada are Australia (320) and United S (386), but Australia has a standard deviation similar to Canada while the US has a larger standard deviation (Table 6.2A). In addition, the coefficient of variation (CV) for Canada is 15% and 81% for Nigeria, suggesting a high variability in SubEmp in the case of Nigeria. Furthermore, Canada's average SubEmp (334) is three times that of Nigeria but it lags behind most HICs and OECD countries and is comparable to Australia (320), India (387) and US (386) (Figure 6.2C).



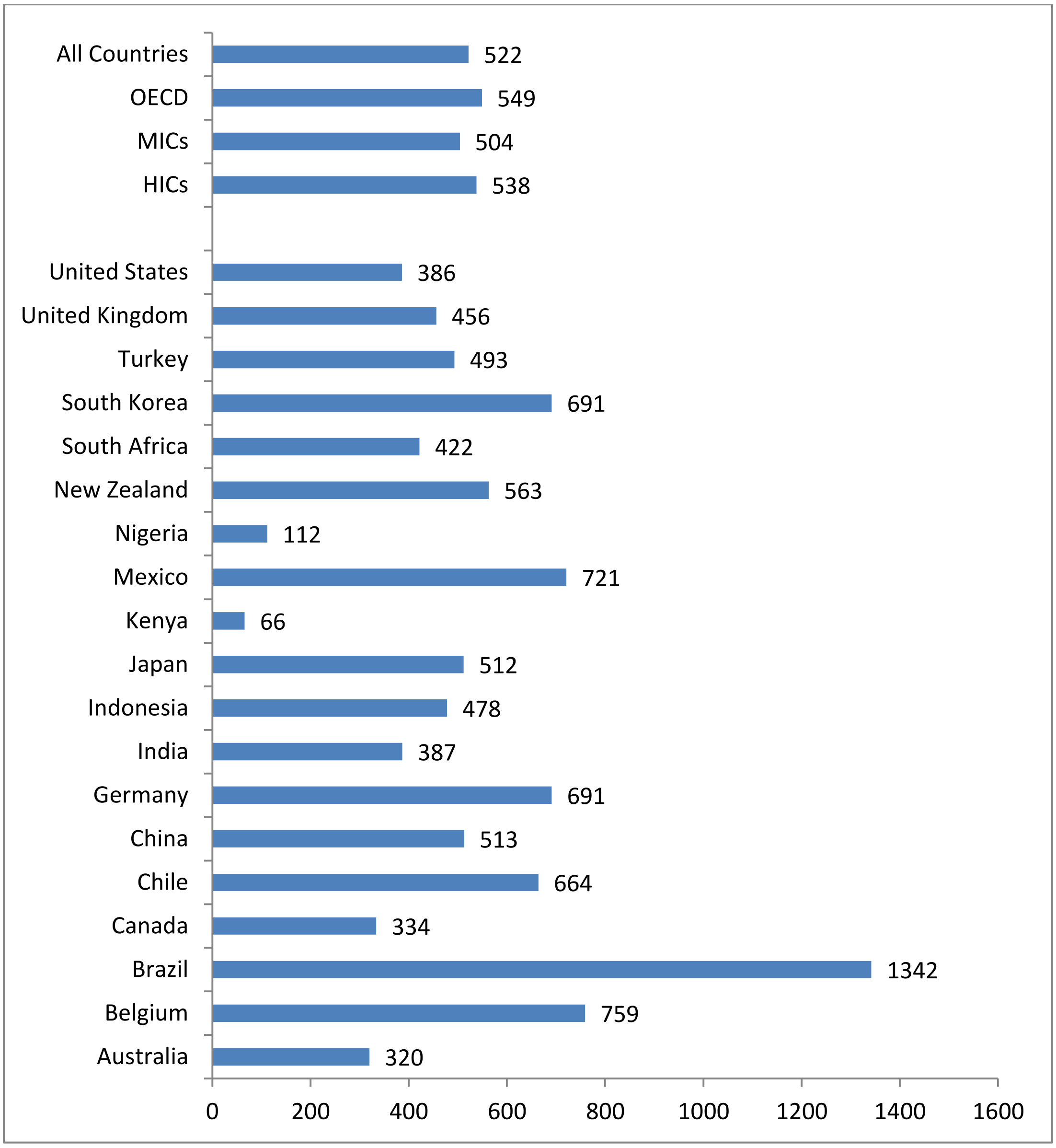
Source(s): Developed by the author for this research

Figure 6.2A: Subscriptions to Employment trends.



Source(s): Author's calculations

Figure 6.2B: Subscriptions to employment growth by country and category (%).



Source(s): Author's calculations

Figure 6.2C: Average subscriptions to employment by country and by categories.

Table 6.2A: Summary of partial measures of performance analysis.

	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscriptions Ratio (USD)	Capex to Revenue Ratio	Capex to Subscriptions Ratio (USD)	Capex to Employment (USD)
All 19 Countries (247 observations)						
Mean	522	257,598	536	0.23	122	45,965
Median	506	266,715	530	0.19	92	47,861
STD	312	177,305	349	0.30	220	32,855
Maximum	1,594	632,676	1,614	4.50	3,152	251,741
Minimum	4	3,135	26	0.03	4	1,025
High Income Countries (HICs) (10 countries; 130 observations)						
Mean	538	381,725	770	0.18	136	65,284
Median	546	387,585	764	0.17	121	62,621
STD	178	109,912	275	0.06	62	19,131
Maximum	909	632,676	1,614	0.38	406	128,883
Minimum	225	163,645	246	0.09	54	29,925
Middle Income Countries (MICs) (9 countries; 117 observations)						
Mean	504	119,679	276	0.29	106	24,499
Median	448	63,765	233	0.21	42	14,052
STD	412	129,543	212	0.42	313	31,609
Maximum	1,594	514,284	1,072	4.50	3,152	251,741
Minimum	4	3,135	26	0.03	4	1,025
OECD Member Countries (12 countries; 156 observations)						
Mean	549	351,218	698	0.18	124	60,319
Median	545	356,427	672	0.16	109	58,483
STD	180	125,043	303	0.07	67	23,191
Maximum	915	632,676	1,614	0.50	406	128,883
Minimum	225	96,550	160	0.03	11	5,121
Canada (13 observations)						
Mean	334	292,339	870	0.20	179	60,788
Median	330	314,051	883	0.20	184	61,257
STD	50	59,681	71	0.04	44	20,122
Maximum	407	360,475	963	0.30	284	98,314
Minimum	255	199,469	759	0.14	109	31,664
Nigeria (13 observations)						
Mean	112	19,026	390	0.72	444	7,627
Median	94	15,020	300	0.31	93	7,988
STD	91	9,753	336	1.17	874	3,366
Maximum	264	37,512	1,068	4.50	3,152	14,105
Minimum	4	3,135	53	0.18	11	2,759

Source(s): Author's calculations

Table 6.2B: Summary of percentage change in partial measures of performance.

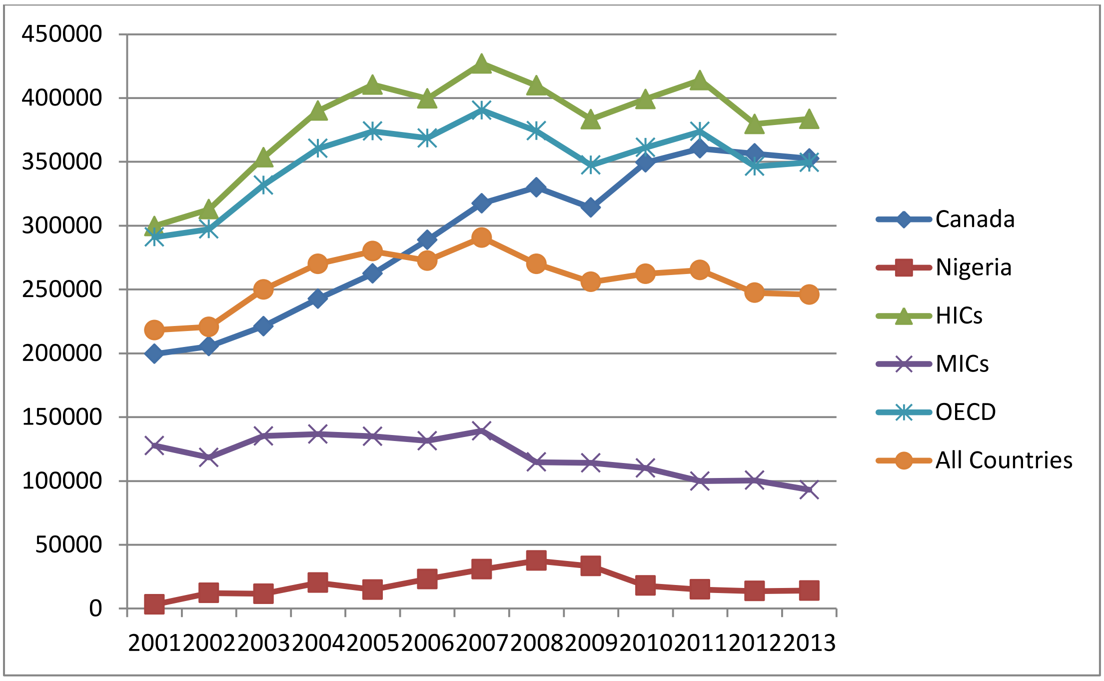
	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscriptions Ratio (USD)	Capex to Revenue Ratio	Capex to Subscriptions Ratio (USD)	Capex to Employment (USD)
			All 19 Countries (247 observations)			
Year 2001	328	218,205	687	0.53	355	65,277
Year 2013	677	245,968	406	0.19	79	45,978
Overall Increase (%)	106.50	12.72	-40.89	-63.95	-77.72	-29.57
Yearly Increase (%)	8.19	0.98	-3.15	-4.92	-5.98	-2.27
			High Income Countries (10 countries; 130 observations)			
Year 2001	412	299,675	805	0.24	185	67,801
Year 2013	612	383,631	672	0.20	135	75,194
Overall Increase (%)	48.63	28.02	-16.49	-14.08	-27.03	10.90
Yearly Increase (%)	3.74	2.16	-1.27	-1.08	-2.08	0.84
			Middle Income Countries (9 countries; 117 observations)			
Year 2001	235	127,683	556	0.86	545	62,473
Year 2013	750	93,010	110	0.18	17	13,516
Overall Increase (%)	219.20	-27.16	-80.17	-79.19	-96.82	-78.37
Yearly Increase (%)	16.86	-2.09	-6.17	-6.09	-7.45	-6.03
			OECD Member Countries (12 countries; 156 observations)			
Year 2001	414	291,054	770	0.27	195	74,240
Year 2013	641	349,482	597	0.19	117	66,278
Overall Increase (%)	54.82	20.07	-22.37	-29.54	-40.22	-10.72
Yearly Increase (%)	4.22	1.54	-1.72	-2.27	-3.09	-0.82
			Canada (13 observations)			
Year 2001	255	199,469	783	0.25	193	49,093
Year 2013	407	352,521	867	0.22	187	76,086
Overall (%) Increase	59.55	76.73	10.77	-12.31	-2.86	54.98
Yearly Increase (%)	4.58	5.90	0.83	-0.95	-0.22	4.23
			Nigeria (13 Observations)			
Year 2001	4	3,135	700	4.50	3,152	14,105
Year 2013	264	14,057	53	0.21	11	2,890
Overall Increase (%)	5793.67	348.42	-92.39	-95.43	-99.65	-79.51
Yearly Increase (%)	445.67	26.80	-7.11	-7.34%	-7.67	-6.12

Source(s): Author's calculations

The results show that SubEmp in the deregulated environment increased in Canada and Nigeria, but the pattern varies, confirming findings in Dabler, Parker & Sall (2002) that labour productivity improvement is not consistent across countries. Labour productivity increase in the Nigerian telecommunications industry shows steady rise which is not unusual after deregulation and affirms the observation in Wallsten (2001) of increased labour productivity following deregulation. In general, there is evidence of increased SubEmp in the two countries, but it is higher in Canada. Labour productivity in the industry in Canada is almost three times that in Nigeria which suggests better deployment and utilization of labour. Nevertheless, the increase in SubEmp in both countries is consistent with Ros (1999) who discusses that deregulation is associated with increased lines per employee. Also, the finding of lower SubEmp in Nigeria compared to Canada is consistent with Lee & Quayes (2005) who investigated global evidence of post-privatization of the telecommunications sector and found that SubEmp in South Asia is less than that in more developed OECD countries. The general increase in SubEmp could be attributed to investment in advanced technology and automated systems that allow the industry to be more productive by maintaining employment growth at a lower rate than growth in subscriptions; a finding that harmonizes with Carbone (2006). Nonetheless, caution should be exercised when using SubEmp to measure performance. As observed in ITU (2008), it is not uncommon for telecommunications firms to outsource or contract out tasks thereby understating total employment which may result in inflated SubEmp ratios. Also, this measure ignores differences in input prices and does not consider the substitution of one input for another (Serebrisky, 2012). Therefore, in comparison to Canada, the lower SubEmp in Nigeria may have been due to the substitution of labour for capital as labour costs are lower in Nigeria than in Canada and may not suggest ineffective use of labour or poor performance.

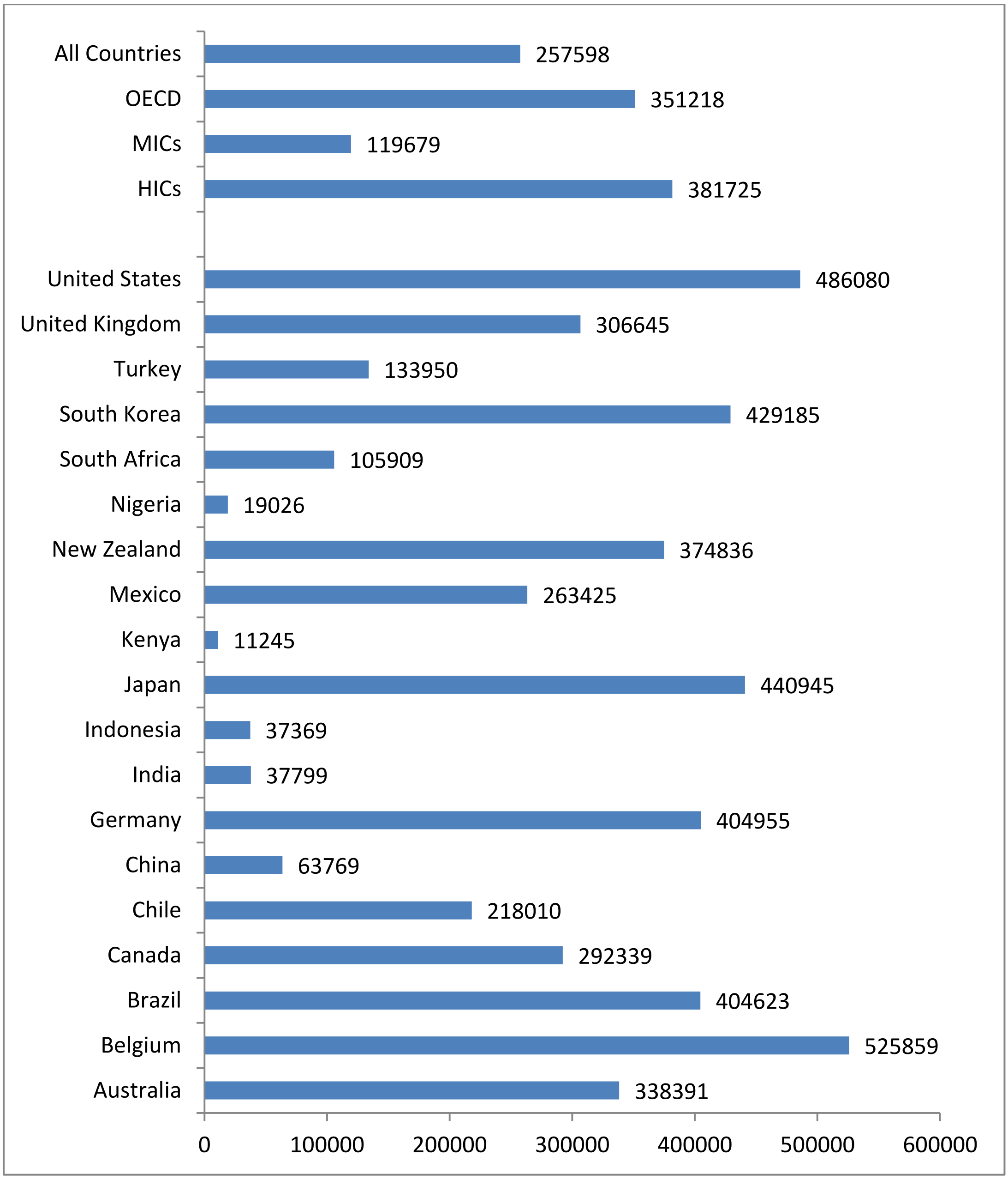
6.4.3 Revenue to employment ratio

Figure 6.2E displays the average revenue to employment (RevEmp) ratio. Average RevEmp in Canada is $292,339, which is comparable to the sample average but only 77% of the average in HICs, 83% of the average in OECD and 2.4 times that in MICs. The $19,026 average for Nigeria is 6.5% of Canada’s average (Figure 6.2E). The trend in RevEmp is shown in Figure 6.2D. RevEmp declined in the last three years of the study in Canada, Nigeria, and the categories of countries. Overall, all except MICs exhibited higher RevEmp in 2013 than in 2001. In 2001 RevEmp in the Canadian telecommunications industry was 64 times that in the Nigerian telecommunications industry but declined to 25 times by the end of the study period, indicating that RevEmp is growing faster in Nigeria than in Canada. In addition, Figure 6.2F which depicts the growth in RevEmp over the study period reveals 0.98% overall growth in RevEmp for the panel data, 5.9% and 26.8% growth in Canada and Nigeria, respectively, thus pointing to increased labour productivity in the study period. The results show that the Canadian telecommunications industry displayed higher RevEmp than Nigeria but the difference shrunk in the study period, suggesting RevEmp is growing faster in Nigeria than in Canada and that the industry in Nigeria is improving its utilization of labor in generating revenue. However, unlike Nigeria, RevEmp in the industry in Canada increased steadily except in 2012 and 2013 when it declined but was still comparable to previous years. This observation is unique to Canada: no other country in the study displayed this level of stability. Its peers in HICs and OECD showed erratic RevEmp (Figure 6.2D). This irregular pattern creates difficulty in predicting labour effectiveness and signifies any increase or decrease may be attributed to variability in revenue rather than to labour effectiveness. Nonetheless, the findings of growth in RevEmp for the panel dataset and for Canada and Nigeria points to increased revenue per labour employed in the deregulated environment. This finding harmonizes with Megginson et al., (1994) who reported increased sales per employee in an empirical analysis of the financial and operating performances of newly privatized firms.



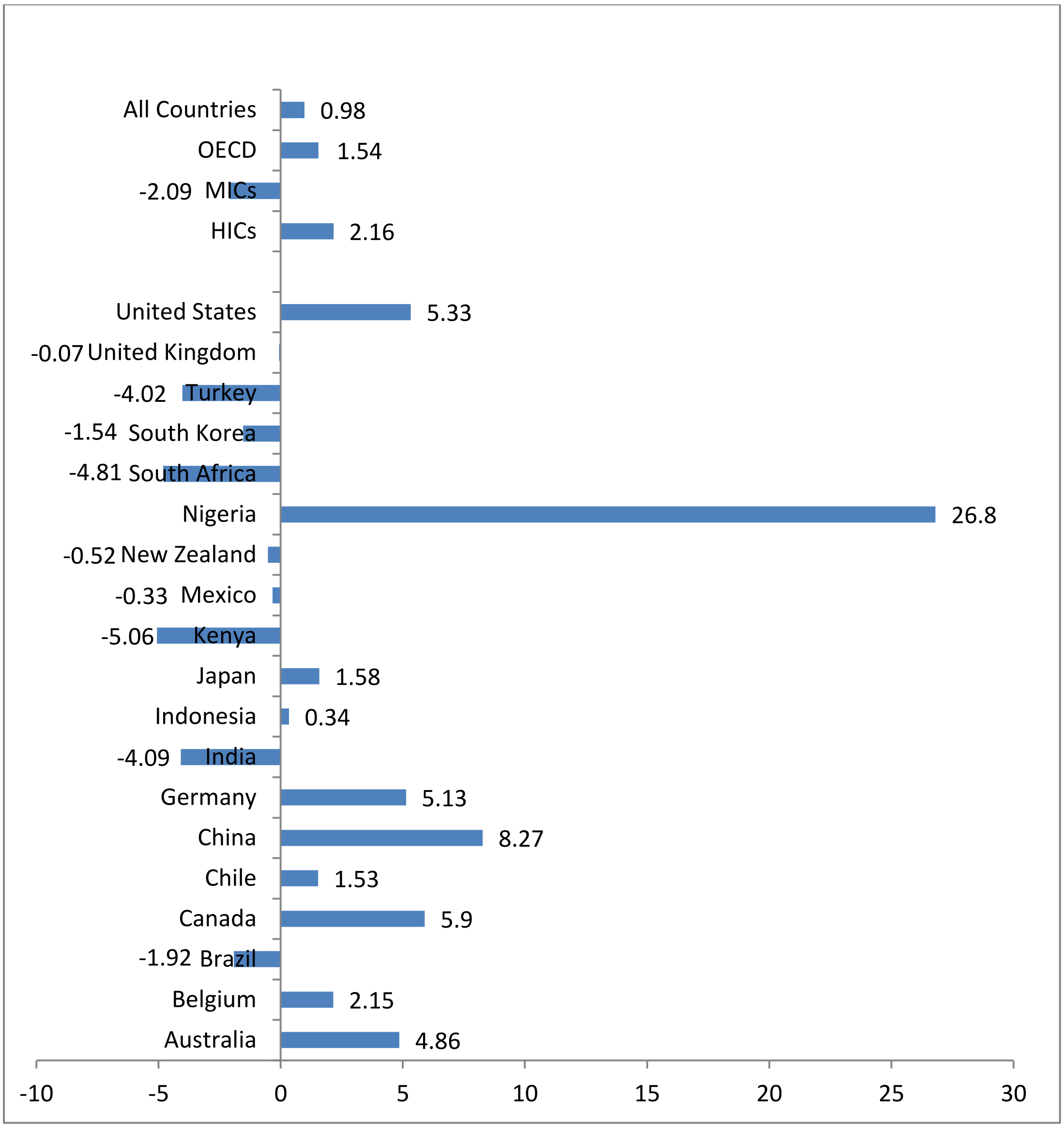
Source(s): Developed by the author for this research

Figure 6.2D: Revenues to Employment trends.



Source(s): Author's calculations

Figure 6.2E: Revenue to employment by country and category (USD).



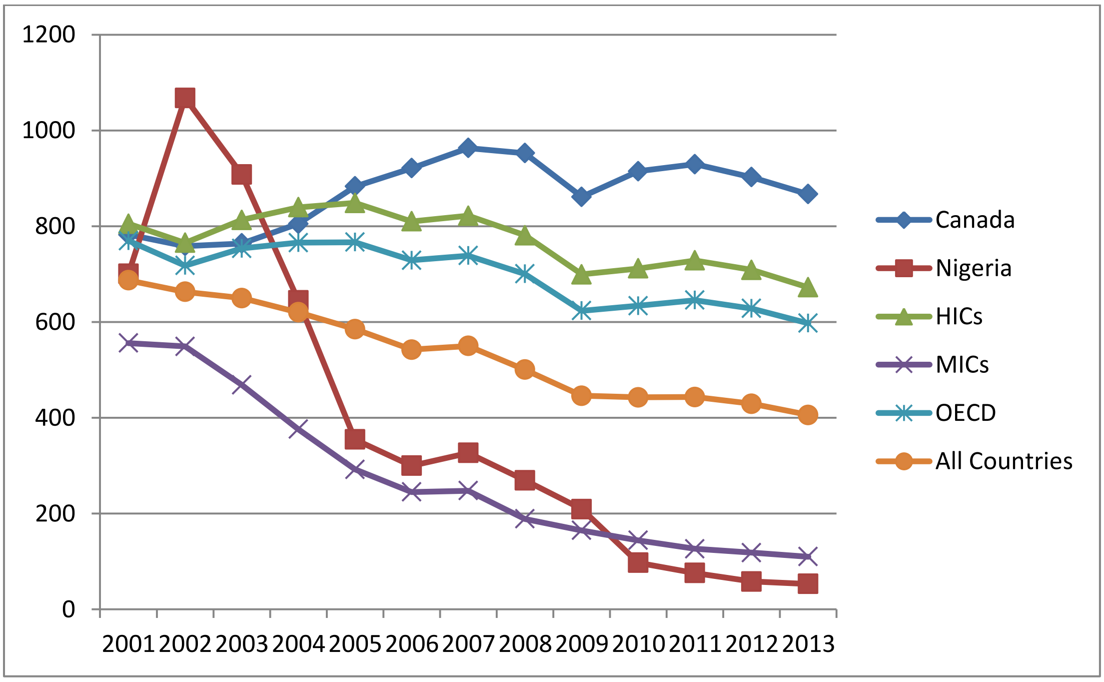
Source(s): Author's calculations

Figure 6.2F: Annual revenue to employment growth by country and category.

6.4.4 Revenue to subscriptions ratio

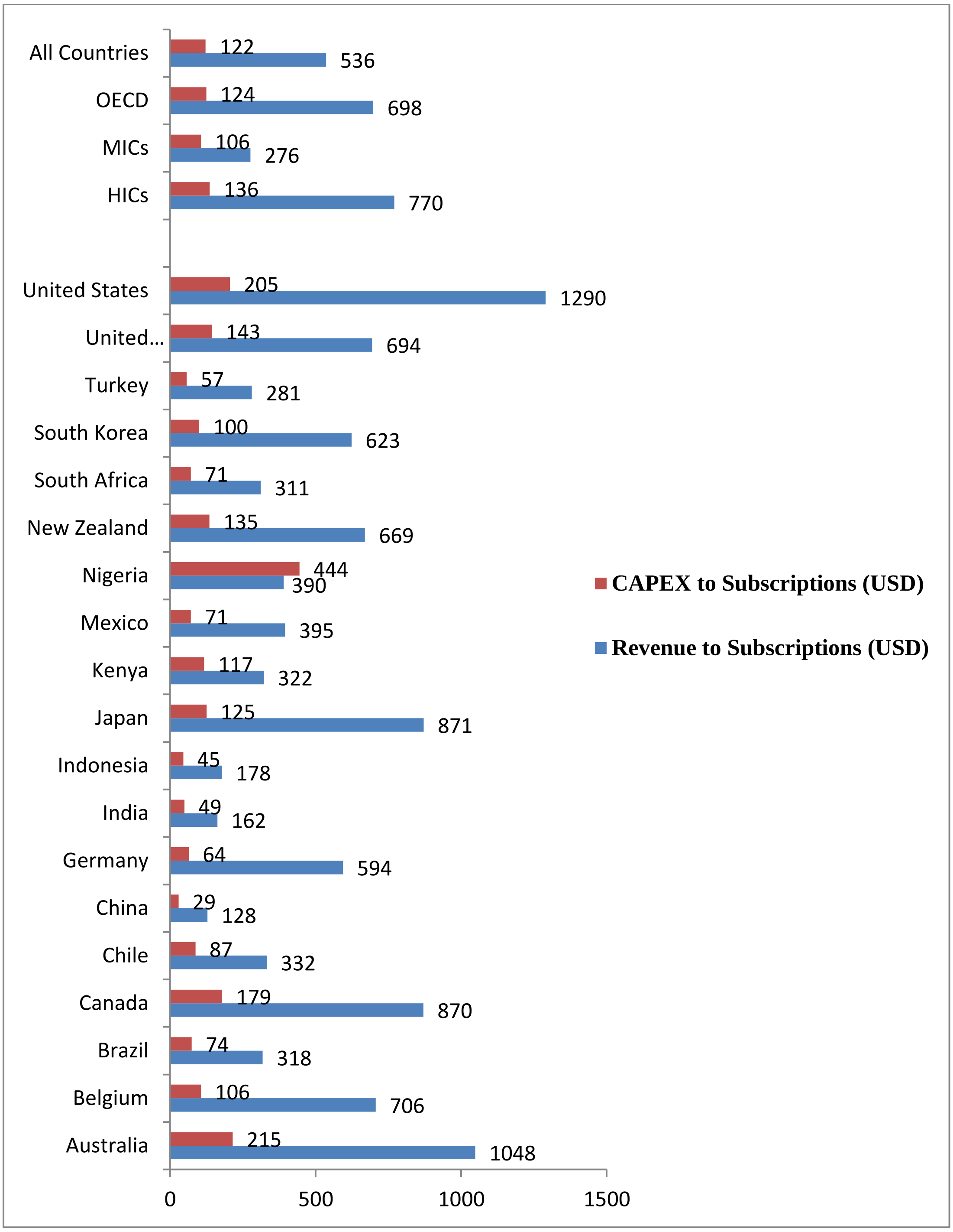
The average yearly revenue to subscriptions (RPS) in the sample countries is $536, and Canada's average ($870) is higher than Nigeria's ($390) (Figure 6.2H). Only two countries (Australia: $1,048; US: $1,290) have higher average RPS, and Japan's is somewhat comparable to Canada. Nigeria's average yearly RPS is 45% of Canada's and is less than all countries in HICs except Chile. Furthermore, the average yearly RPS for Nigeria is 23% more than Brazil ($318), but the average for Brazil which is comparable to South Africa ($311) is almost twice that of India ($162) and 2.5 times the average for China ($128) (Figure 6.2H). The revenue to subscriptions trends in Figure 6.2G shows relatively stable pattern in Canada and a decline in Nigeria. On monthly basis, the the average revenue per subscriber (ARPS) in Nigeria which was $58 in 2001 declined significantly to $4.4 in 2013, indicating an average annual decline of 7.11% (Figure 6.2I). The Canadian telecommunications industry recorded ARPS increase from $65.25 in 2001 to $80.25 in 2007, but experienced a decline in the following two years to $71.75. However, it has remained relatively stable and was $72.35 in 2013, which represents 0.84% average annual increase. ARPS, which is rendered average revenue per user in Deshpande & Narahari (2014, p. 557), is a yardstick used in the telecommunications industry: it is obtained by dividing the yearly revenue per subscriber (RPS) by 12. Figure 6.2I reveals that all countries experienced negative growth in average revenue per subscriber (ARPS) except Australia and Canada.

Average revenue per subscriber, which is considered a reliable proxy and an indicator of price, is used widely in empirical research (e.g., Deshpande & Narahari, 2014). The finding of decline in average revenue per subscriber in all countries in the sample except Australia and Canada may be due to a combination of the need to increase telecommunications services affordability and high competitive intensity in the industry (GSMA, 2014). Average revenue per subscriber continues to decline as firms compete fiercely for market share. However, the decline has generated an increase in subscriber base as revealed by subscriptions increases in all countries. Furthermore, regulators often review the revenues and fees that firms charge each other for network access and in a number of cases have encouraged downward reviews of fees which erode revenues (Gruber, 2005). The result also reveals that in 2001 subscribers in Nigeria paid 89% of what Canadian subscribers paid to access telecommunications services but by 2013 it had declined to 6%. The average revenue per subscriber trends support the finding in Li & Xu (2004) that deregulated telecommunications industries in industrialized countries (e.g., Canada) tend to have higher average revenue per subscriber than less industrialized countries (e.g., Nigeria). However, while Li & Xu (2004) associated the price differential to high inflation and price control that artificially depressed price in less industrialized countries. The observed difference in average revenue per subscriber between Canada and Nigeria in this research may be related to intensified competition among service providers in Nigeria (Hassan, 2011) and the difference in the choice of service demand by customers in the two countries. Furthermore, the average revenue per subscriber trend shows it is higher and relatively stable in Canada but lower and in decline in Nigeria, an observation that corroborates ITU (2007) that reported low average revenue per subscriber in telecommunications markets in Africa but attributed it to limited economic resources and the prudence of customers.



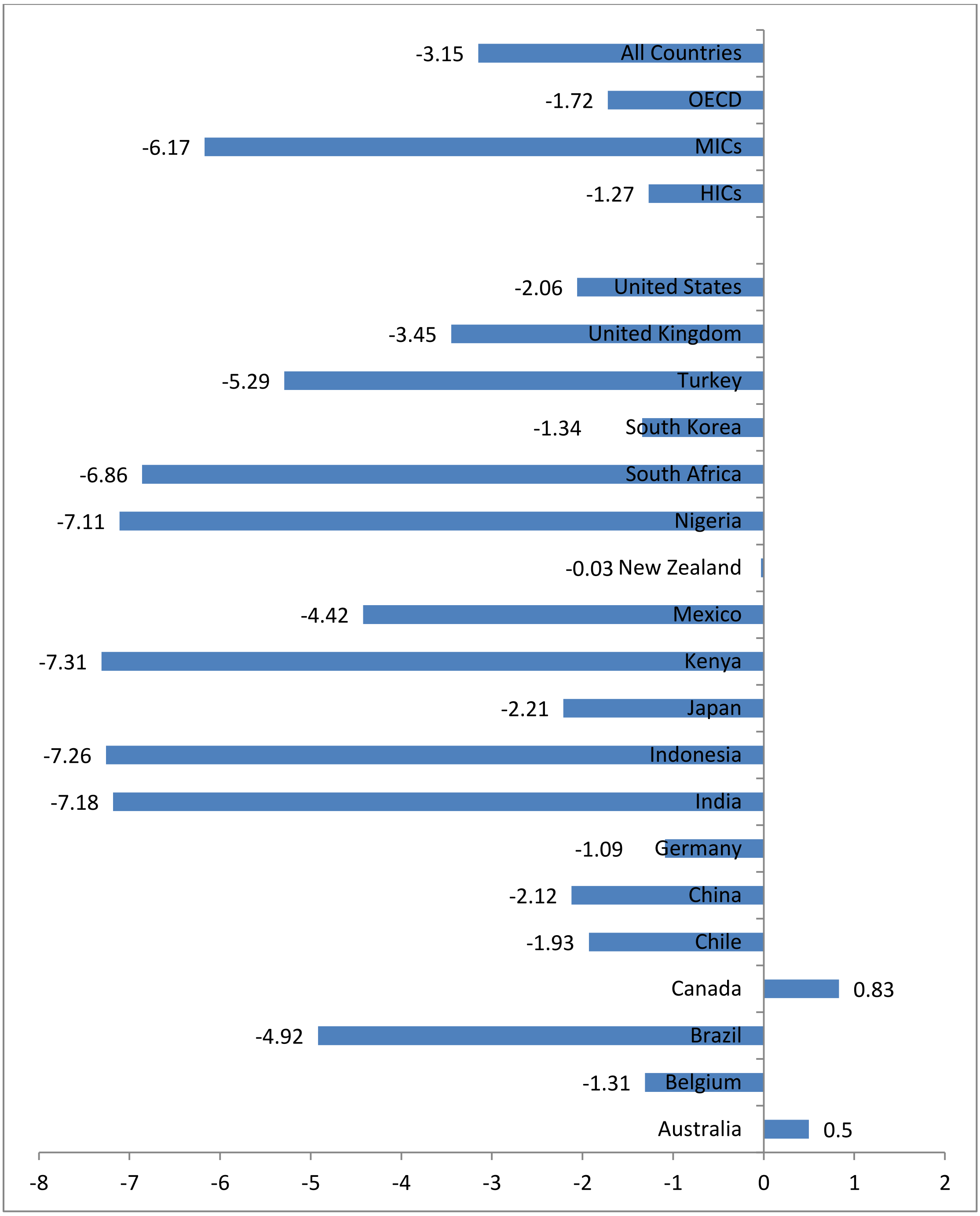
Source(s): Developed by the author for this research

Figure 6.2G: Revenues to Subscriptions trends.



Source(s): Author's calculations

Figure 6.2H: Revenue to subscriptions and Capex to subscriptions.



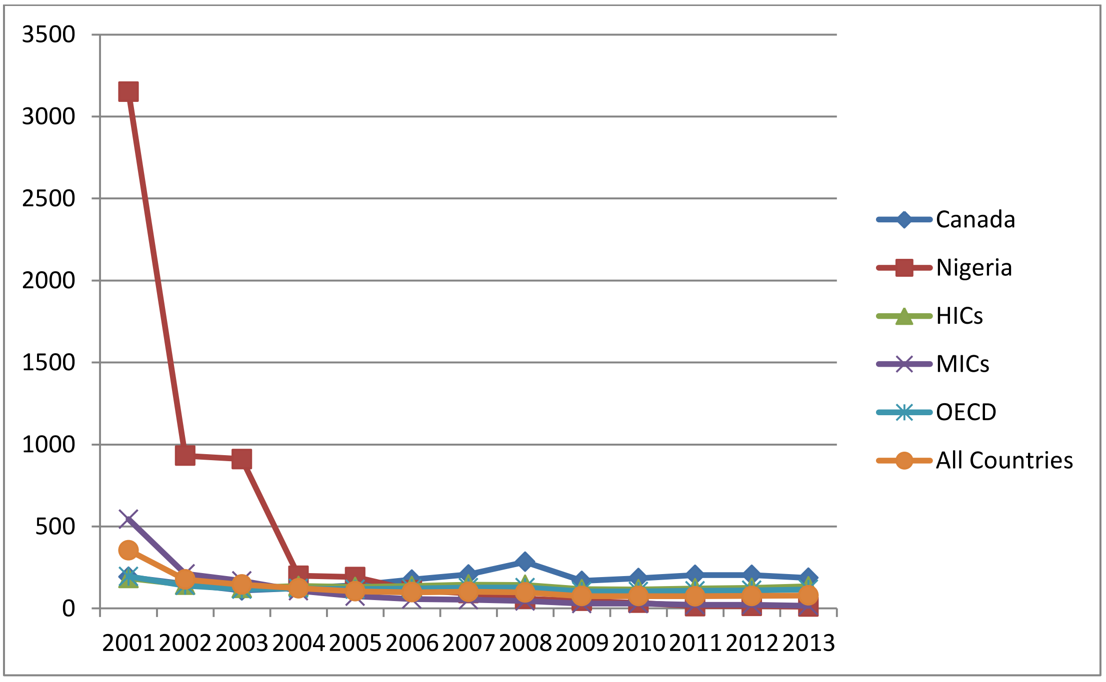
Source(s): Author's calculations

Figure 6.2I: Annual growth in revenue to subscriptions by country and category (%).

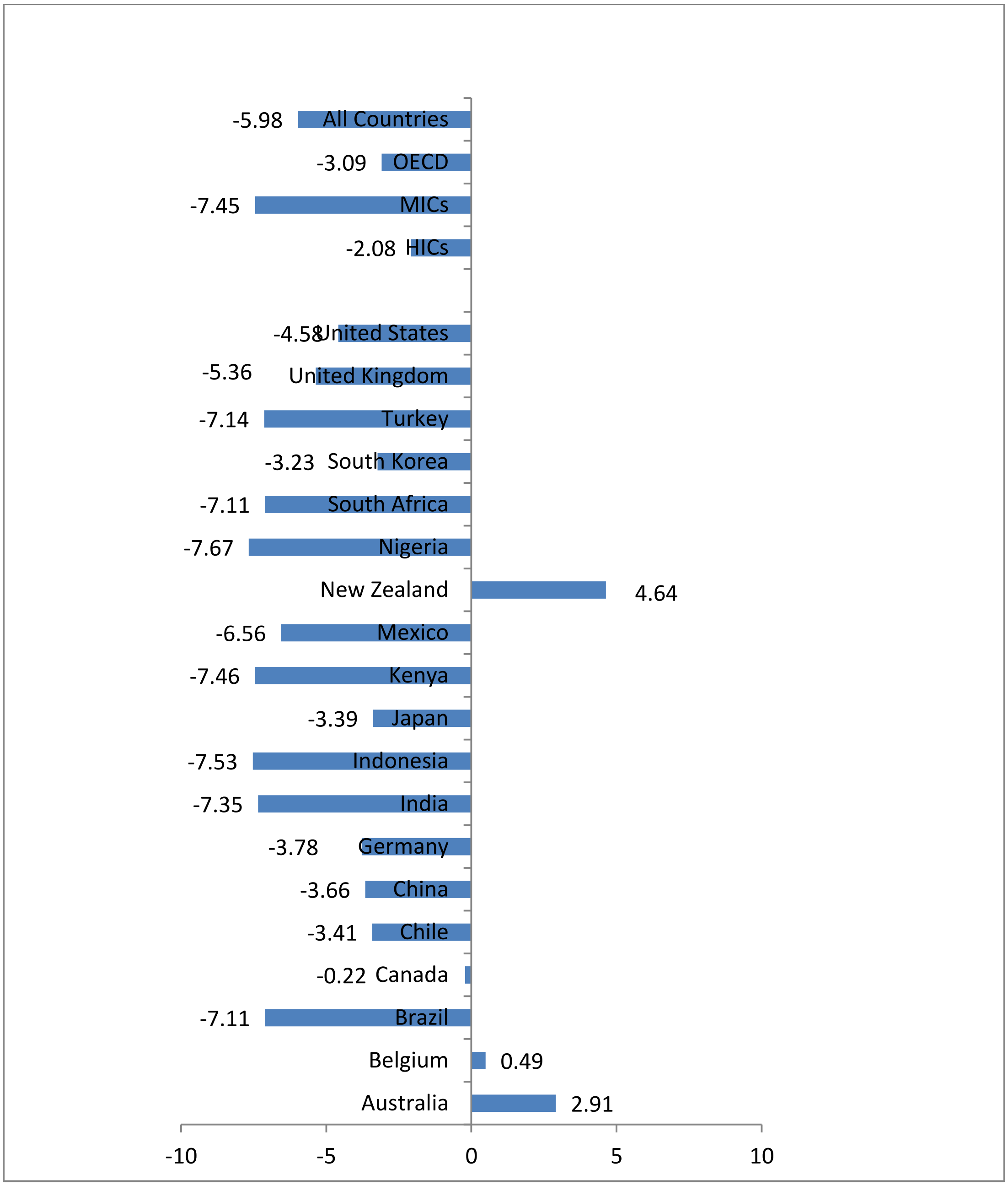
6.4.5 Capex to subscription ratio

Table 6.1A displays Capex by category and shows that HICs and OECD countries have higher Capex than MICs. In addition, Table 6.1A reveals that MICs' share of total Capex rose from 27% in 2001 to 33% in 2013. Capex increase in MICs could be rational. Compared to HICs, MICs have less developed infrastructure and require investment commitment to accommodate subscriptions growth in the deregulated environment. The data lends support to this notion because MICs are increasingly accounting for a greater percentage of Capex to accommodate subscriptions growth (42.3%) (Figure 6.1B). For country-specific Capex, Nigeria's average Capex of $2,825 million pales in comparison to the $7,099 million for Canada. Capex trends in the last five years of the study (2009–13) shows that 10 (53%) of the countries in the sample increased Capex (Appendices 1A–1S): the 10 countries are Australia, Belgium, Brazil, Canada, Chile, China, Mexico, New Zealand, South Korea and the US. Surprisingly, only three of the 10 are MICs: Brazil, China and Mexico. This is contrary to the initial expectation that most countries with Capex increase would be from MICs. Figure 6.2H reveals the average CapexSub by country and by categories. The Figure shows that the average CapexSub in Nigeria ($444) is the highest in the sample and is 2.5 times the average in Canada, suggesting increased investment per subscription in the industry in Nigeria than in Canada. However, it suffices to say that since 2006, Canada has continued to surpass Nigeria on this measure (Appendices 1D and 1N). Australia ($215) has the second highest CapexSub and is followed by the US ($205) while India ($49), Indonesia ($45) and China ($29) have low CapexSub. Nigeria's CapexSub could be associated with the newness of the industry to deregulation and the accompanying higher spending on network deployment in the industry; a finding in consonance with Bollou & Ngwenyama (2008) who stated that increased network deployment usually accompanies deregulation.

CapexSub declined in the period of study (Figure 6.2J). However, the country by country CapexSub growth presented in Figure 6.2K indicates negative growth in all but Australia, Belgium and New Zealand. Additionally, the decline in Nigeria (-7.67%) is larger than the decline in Canada (-0.22%) and the sample of countries (-5.98%) (Figure 6.2K). The decline in Nigeria is about 35 times that of Canada and may be associated with declining average revenue per subscriber which does not encourage firms to invest in network infrastructure (GSMA, 2013). Furthermore, the decline noted in both countries may signal that subscriptions are increasing faster than Capex, signifying underinvestment to bolster profitability given the declining average revenue per subscriber and the margin squeeze caused by increased competition. However, as noted in Masse & Baundry (2014), to enhance coverage and agility in responding to customers' needs, firms need to continually invest in network infrastructure. While Capex spending in a current period may result in inferior performance, it would benefit the industry in future periods by keeping pace with technological innovation and in offering products of value to customers. Care should be exercised when CapexSub is used as a performance measure. Asserting a condition of underinvestment based on reduced Capex and/or CapexSub may be inappropriate if firms in the industry engage in cost reduction joint ventures and cooperate in the area of infrastructure and network development (GSMA, 2014).



Source(s): Developed by the author for this research
Figure 6.2J: Capex to Subscriptions trends.



Source(s): Author's calculations

Figure 6.2K: Capex to subscriptions growth by country and category (%).

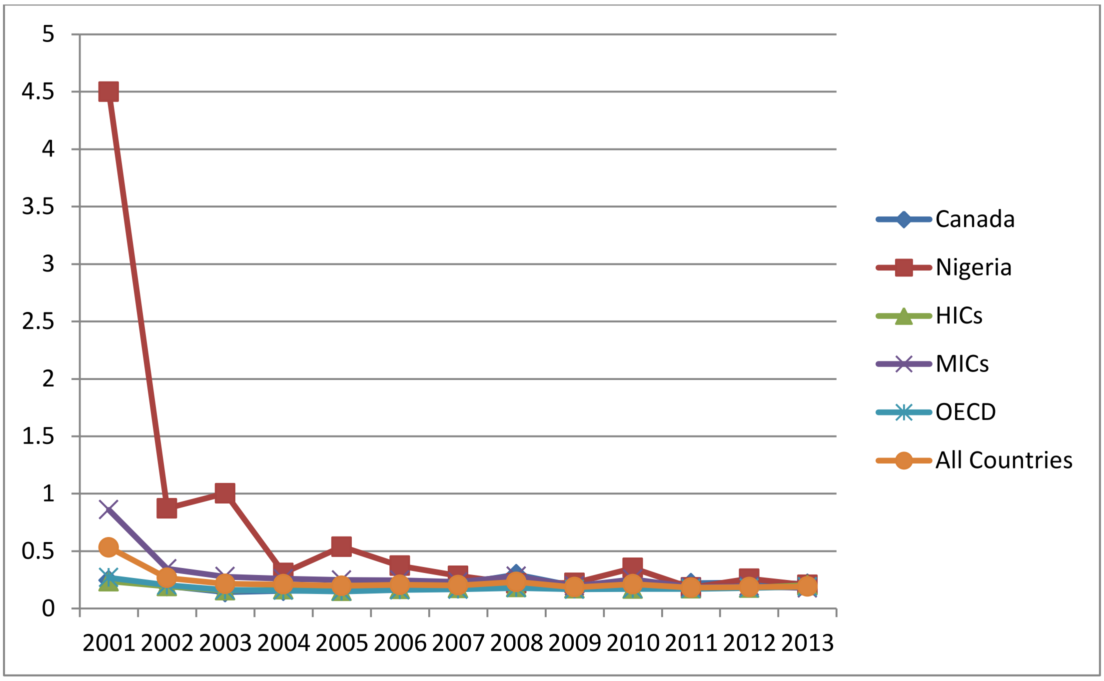
6.4.6 Capex to Revenue Ratio

Figure 6.2L presents the Capex to revenue (CapexRev) trends. Used in Gupta (2005) and Majumdar (2014), this measure evaluates investments in assets essential to enhancing future operations. From 2001-02, the decline in CapexRev was steep. Thereafter, the decline has been relatively steady in Canada and the categories of countries. (Figure 6.2L). Interestingly, in the last three years of the study, CapexRev in Canada, Nigeria, HICs, and MICs seemed to have gravitated towards the average for all of the countries in the study (Figure 6.2L). Figure 6.2M depicts the Capex to revenue (CapexRev) ratio by country and categories. The average for Canada (0.20) is similar to the average for the sample of countries in HICs and OECD but is less than the sample average of 0.23 for all of the countries in the study and MICs (0.29) and is only 28% of the average for Nigeria (0.72). Table 6.3 displays the CapexRev ratio bands. Three countries (i.e., Belgium, Germany and Japan) have CapexRev ratios that are in line with the 0.10 and 0.15 for most telecommunications firms in the research conducted by PWC (2014) which examined factors that drive EBITDA multiples and the valuation of telecommunications firms. While the objective in PWC (2014) is not the focus of this research, its use of CapexRev indicates the measure is appropriate in the assessment of performance. Six countries (i.e., Canada, Mexico, South Korea, Turkey, the UK and the US) have ratios between 0.16 and 0.20; six countries (i.e., Australia, Brazil, China, Indonesia, New Zealand and South Africa) have ratios between 0.20 and 0.25; and four countries (i.e., Chile, India, Kenya and Nigeria) have ratios above 0.25 (Table 6.3).

Table 6.3: Capex to revenue ratio bands.

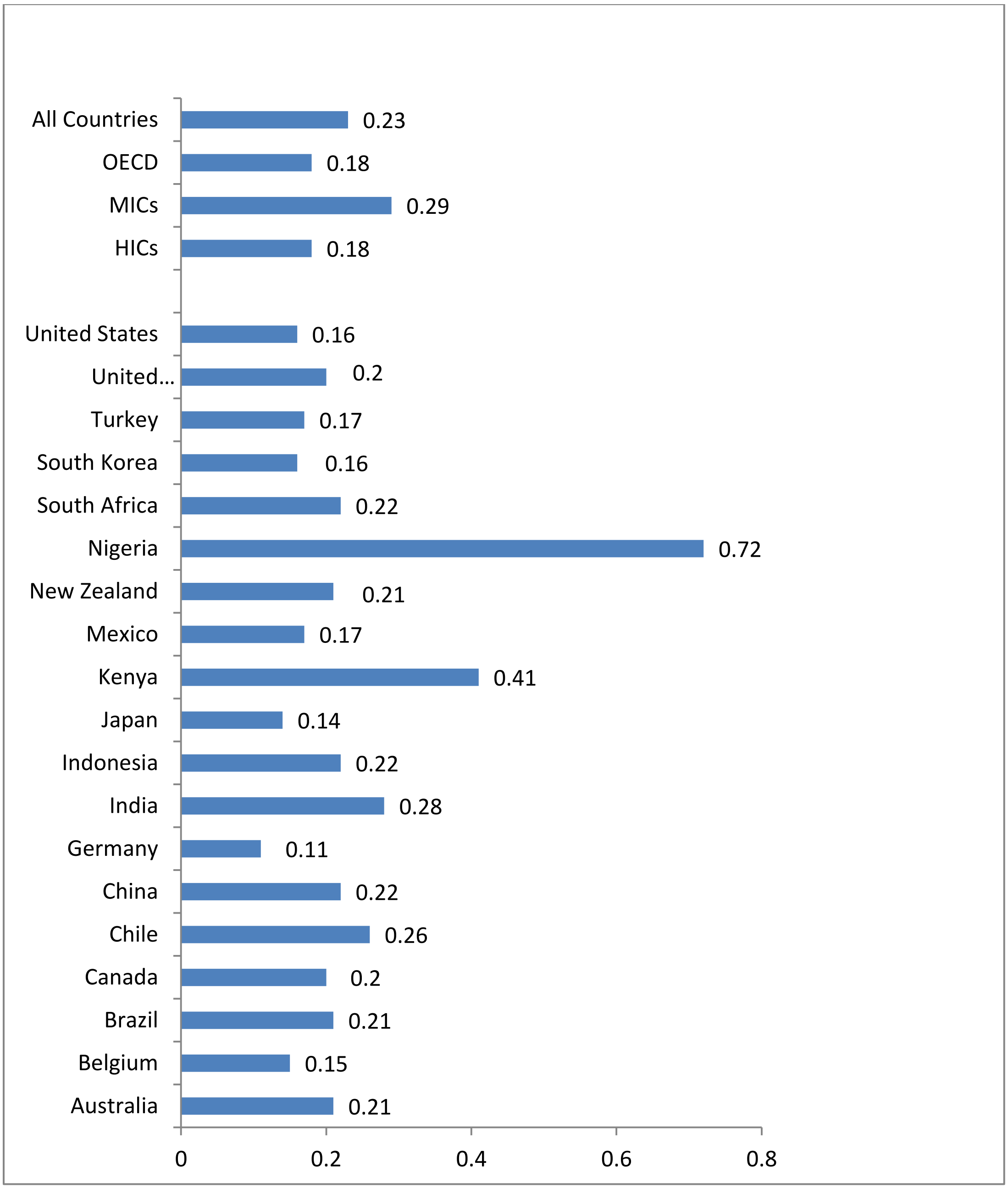
Capex to Revenue Ratio Range	Number of Countries
0.1–0.15	3 (15.8%)
0.16–0.20	6 (31.6%)
0.21–0.25	6 (31.6%)
Above 0.25	4 (21%)
Total	**19**

Source(s): Author’s calculations



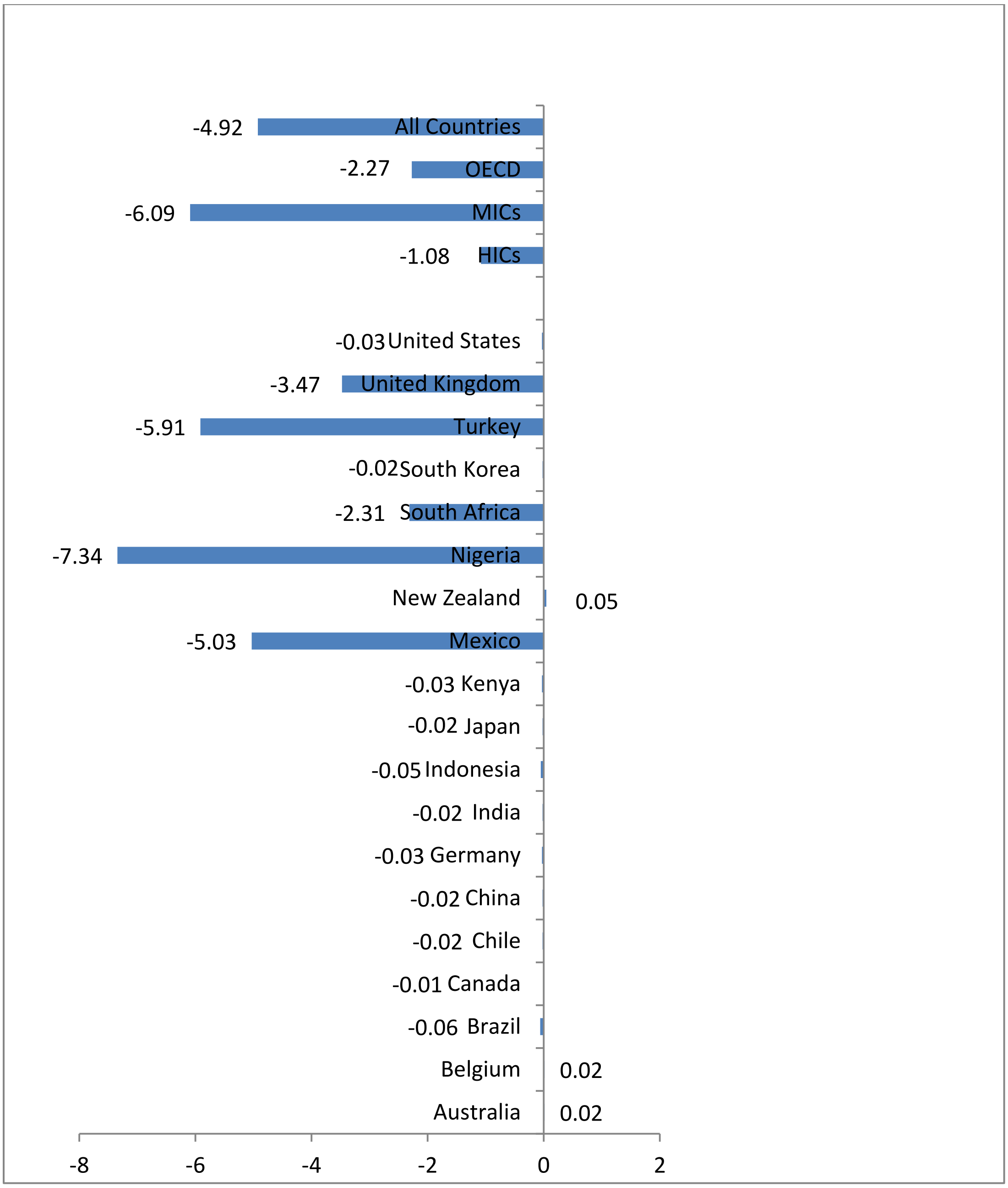
Source(s): Developed by the author for this research

Figure 6.2L: Capex to Revenue trends.



Source(s): Author's calculations

Figure 6.2M: Average Capex to revenue ratio.



Source(s): Author's calculations

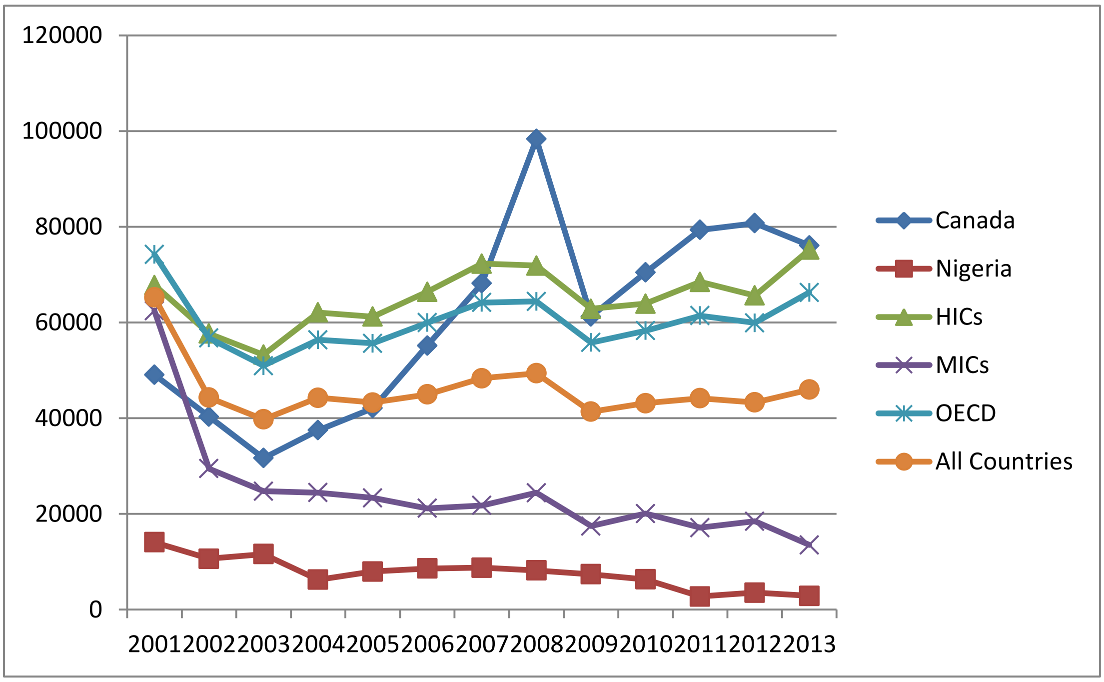
Figure 6.2N: Annual growth in Capex to revenue ratio (%).

Similar to other partial measures of performance, CapexRev ratio should be interpreted with caution. A low ratio in a current period implies low capital expenditures per dollar of revenue and may enhance short-term performance to the detriment of long-term performance. Several reasons may be adduced for the low CapexRev ratio in Canada. First, it may reflect limited growth opportunities as the industry approaches saturation with a teledensity of 128.8 in 2013. Second, it may be due to increased partnership among firms in the industry on project financing and infrastructure development. Third, it may signify flattened capital expenditure amidst rising revenues. However, this may not indicate efficiency improvements because the industry is capital intensive and requires firms to commit cash outlays in current periods to enhance profitability in the future. Flattened or declining CapexRev ratios may signal underinvestment and jeopardize service quality and the ability to introduce new products and/or respond to customers' needs. This may increase churning risk and cause customers to switch service providers (Ahn, Han, & Lee, 2006). In addition, it may increase the motivation for customers to explore alternative communications platforms, resulting in revenue loss and diminished performance for the industry. The finding of high CapexRev ratio in Nigeria complements ITU (2007) which examined ICT and market trends in Africa and found African countries displayed a higher ratio than other regions but noted that this may be due to increased confidence regarding industry profitability. However, it is possible that the high CapexRev rati in Nigeria reflects the shortage of infrastructure and/or the deplorable state of essential infrastructure (e.g., an unstable power supply) that has been neglected by various levels of government. The infrastructure gaps necessitate building and maintaining basic infrastructure prior to developing platforms and network infrastructure for telecommunications product and service delivery. Furthermore, the high CapexRev may suggest increased spending on network expansion as firms in the industry deploy new network infrastructure and/or upgrade existing ones to accommodate subscription growth and to enhance services with a view to retaining/attracting new customers (Esselaar, Gillwald, & Stork, 2007). Also, as shown in Figure 6.2N, the negative CapexRev growth in MICs (-6.09%) and the sample of countries (-4.92%) combined with the decline in HICs (-1.08) and OECD countries (-2.27) reveals a general decline in CapexRev but the decline is more pronounced in MICs. Additionally, the decline in Canada is 0.14% of that in Nigeria. Surprisingly, among the four countries with a substantial percentage decline (i.e., Nigeria, Turkey, Mexico and the UK), Nigeria is the only country with CapexRev in the band above 0.25 (Figure 6.2M; Table 6.3). The other three have ratios between 0.16 and 0.20 (Figure 6.2M; Table 6.3).

6.4.7 Capex to employment ratio

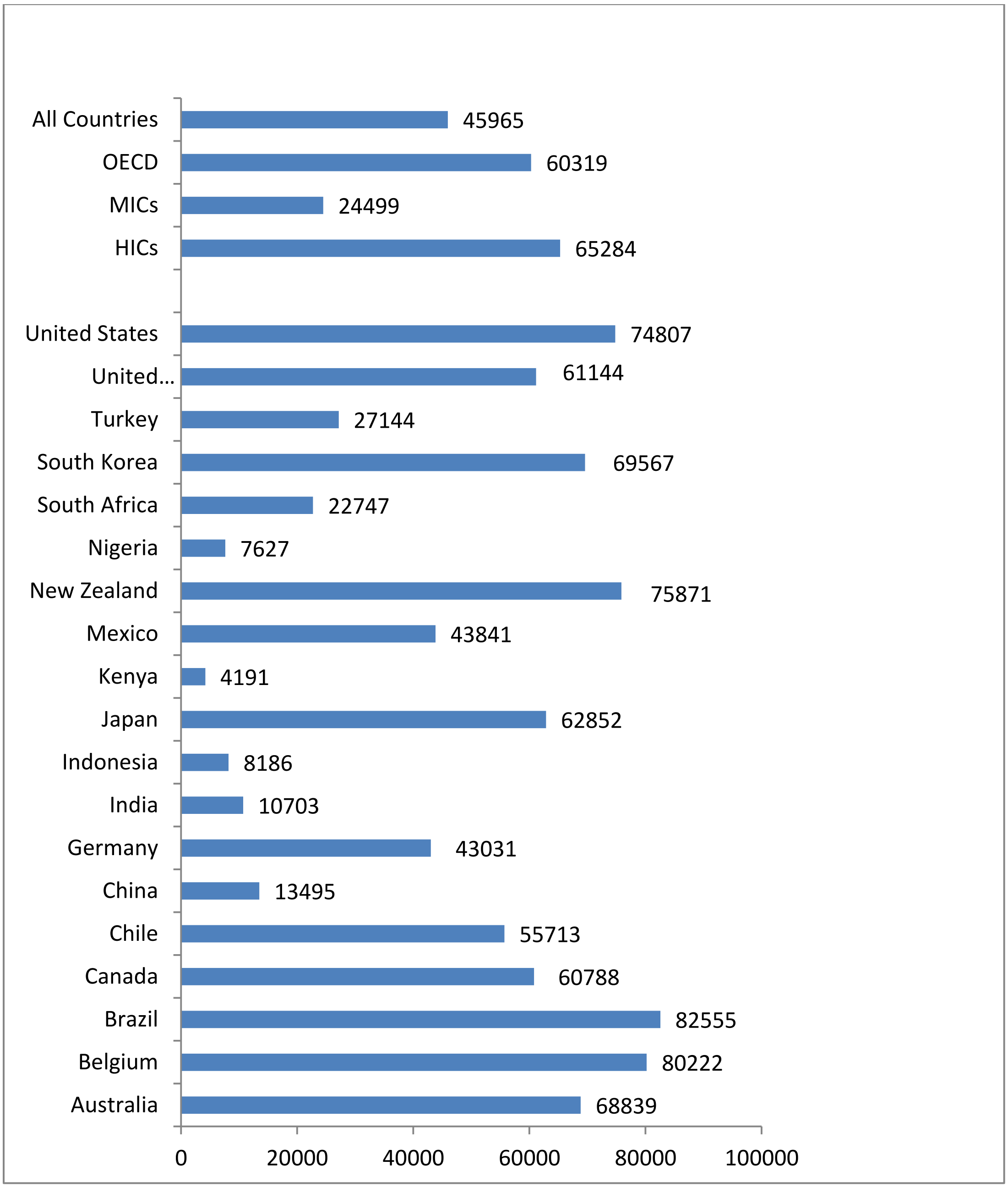
The Capex to employment (CapexEmp) trend is presented in Figure 6.2O. The trend shows that the pattern of the decline in Nigeria is similar to MICs. On the other hand, the pattern in Canda deviated from HICs and OECD countries (Figure 6.2O). Figure 6.2P displays the average CapexEmp and shows that Brazil has the highest Capex to employment (CapexEmp) ratio. The CapexEmp for the sample of countries is $45,965. However, it is $65,284, $60,319, and $24,499 for HICs, OECD countries and MICs respectively. In HICs category, Germany and Chile spent less than $60,000 per employment in the industry. With the exception of Brazil, all countries in MICs appeared to have low CapexEmp ratios. Three MICs (i.e., Indonesia, Kenya and Nigeria) have a CapexEmp ratio of less than $10,000. Furthermore, Figure 6.2P shows that the $60,788 average for Canada is 74% of Brazil's $82,555 and 88% of Australia's $68,839 but is eight times the average in Nigeria and 4.5 and 5.7 times the average in China and India. Deductively, for every dollar in CapexEmp spending in the industry in Nigeria, Canada spent $8 whereas it spent up to $4.50 and $4.70 for each CapexEmp dollar in the industry in China and India respectively. Similar to other partial measures of performance, caution is needed when using Capex to employment ratio to gauge plausible labour productivity improvement. High CapexEmp may be due to outsourcing and decline in employment that result. In addition, high CapexEmp may be the result of increased Capex only and may not confer any labour productivity improvement.

The average yearly growth in CapexEmp is presented in Figure 6.2Q. Australia has the highest with an annual growth rate of 8.55%. It is followed by Belgium (4.92%), Canada (4.23%), China (3.86%) and New Zealand (3.84%). The remaining countries have negative growth, including Brazil which was identified earlier as spending the most on CapexEmp ($82,555) (Figure 6.2P). The panel dataset negative growth of 2.27% suggests a general decline. Unlike Canada with positive growth of 4.23%, Nigeria exhibited a decline of 6.21%. A combination of factors may be responsible for this. In Canada, employment in the industry was relatively stable but Capex spending of $8,471 million in 2013 was 39% above what it was in 2001. On the other hand, in Nigeria, the Capex of $1,398 million in 2013 was a 49% decline from the Capex spending in 2001 but employment in the industry increased by 150% in the same period. The finding of low CapexEmp and declining growth in Nigeria is somewhat surprising given that the country's infrastructure is inadequate and requires firms in the industry to build their own infrastructure to support product and service delivery to customers. Also, given that Canada's teledensity suggests that the industry in Canada is saturated, the expectation was that CapexEmp in Canada would decline. However, the high CapexEmp and positive growth in Canada may suggest investment in new technologies and network expansion that would facilitate the delivery of services (Ovum Consulting, 2010).



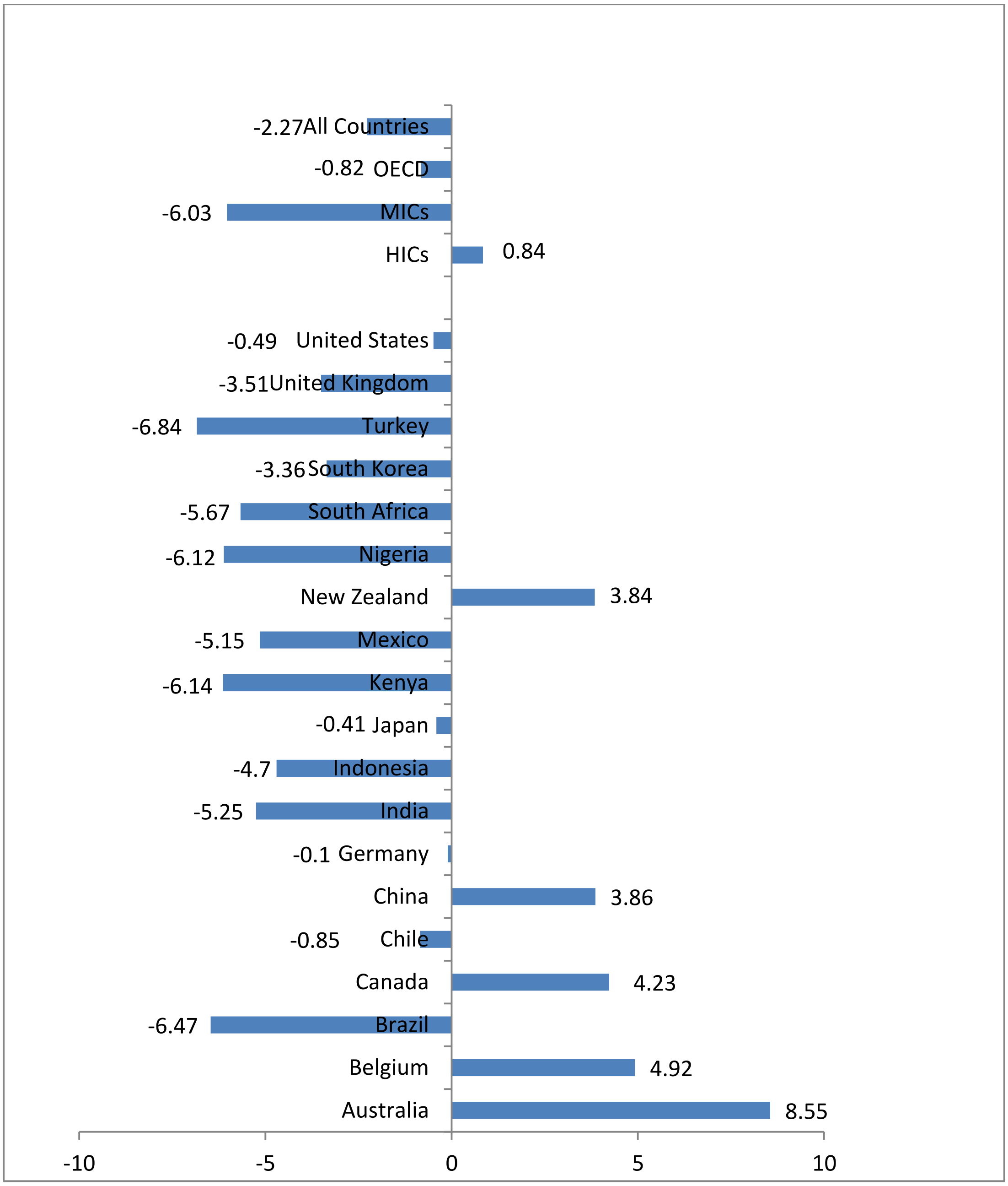
Source(s): Developed by the author for this research

Figure 6.2O: Capex to Employment trends.



Source(s): Author's calculations

Figure 6.2P: Average Capex to employment ratio (USD).

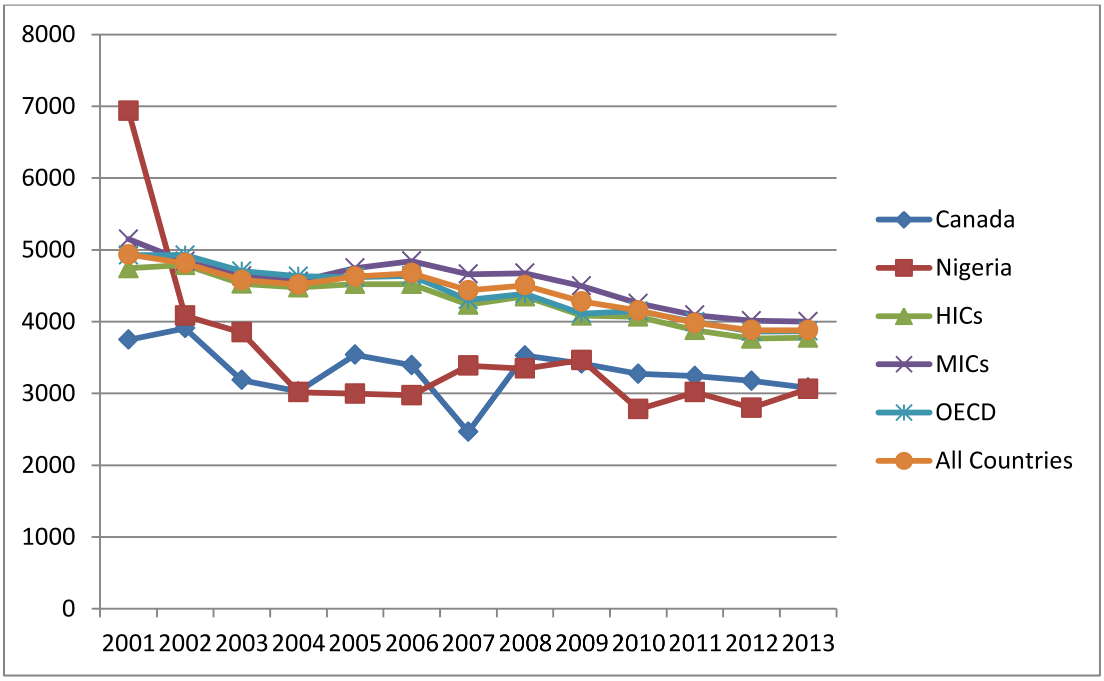


Source(s): Author's calculations

Figure 6.2Q: Annual growth in Capex to employment ratio (%).

6.4.8 Level of industry concentration

The Herfindahl–Hirschman Index (HHI), which is the sum of the square of the market share of each firm in an industry (Noam, 2005), is an acceptable indicator of industry concentration that regulators and firms use to access industry competitiveness and market power. The HHI scale ranges from 0 to 10,000; the closer the HHI is to 0, the greater the number of firms and level of industry competition (Ertl & McCarrell, 2002). Figure 6.2R shows the HHI trend. Compared to Canada, Nigeria attained significant reduction in HHI during the study period. HHI for each of the 19 countries is shown in Appendices 1A to 1S. The appendices show that HHI declined in the study period in all countries in the sample panel dataset. The decline in HHI is consistent with the findings in Noam (2005) that show unregulated industries are less concentrated than those regulated. Also, it supports Ertl & McCarrell (2002) revelation that deregulation diminishes HHI and creates competition. However, the HHI findings indicate deregulation has a greater impact in HICs than in MICs as more countries in MICs exhibited high HHI.



Source(s): Developed by the author for this research

Figure 6.2R: Industry Concentration (HHI) trends.

Although HHI for all countries declined in the period of study, the findings indicate that the industry is concentrated as each country displayed HHI above 1,500 (US Department of Justice and Federal Trade Commission, 2010). In 2013 Turkey (2,146) and Brazil (2,405) with HHI in the range of 1,500 to 2,500 met the guideline for a moderately concentrated industry. All other countries have concentration level above 2,500, signifying a concentrated industry. However, if the more liberal classification in Ertl & McCarrell (2002) is used, none would be considered as having a perfectly competitive industry. However, the industry in ten countries would have HHI ranging between 2,000 and 4,000 and would be considered as monopolistic competition. The industry in the remaining nine countris would have HHI ranging between 4,000 and 7,000 and would be considered as oligopolies. None of the countries fit monopoly classification as all had HHI below 7,000 in 2013. Although the US Department of Justice and Federal Trade Commission (2010) is credible and is a widely used regulatory guideline, the classification in Ertl & McCarrell (2002) is ideal for using the conventional market structure classifications (i.e., perfect competition, monopolistic competition, oligopoly and monopoly) that makes it possible to describe the structure of the market in each country.

Adopting the classifications in Ertl & McCarrell (2002), the industry in China, Germany, Indonesia, Japan, Kenya, Mexico, New Zealand, South Africa and South Korea fits oligopoly description. The industry in the remaining countries would be considered monopolistic competition. In view of this, the HHI for Canada (3,078) and Nigeria (3,062) suggests monopolistic competition. However, in the context of this research, the notation in Djolov (2013) and Ferreira (2013) describing an industry lying between 1,800 and 10,000 on the HHI as a concentrated oligopoly is considered more appropriate. This is because an oligopoly describes a market structure where a few firms control and dominate the market (Ciobanu, 2011; Fuentelsaz & Gomez, 2006). A significant portion of the Canadian and Nigerian telecommunications industry is controlled by a few firms, thus making the assertion of an oligopoly plausible. In addition, some studies (e.g., Byambaakuu, Kwon, & Rho, 2014; Herath, 2012; Karamti & Kammoun, 2011) have linked evidence of price decline in a deregulated industry to an increase in competition. Therefore, the rationale given for the average revenue per subscriber decline in Nigeria in Section 6.4.4 is tenable with HHI declining from 6,934 in 2001 to 3,062 in 2013 (Appendix 1N). HHI in Canada has been relatively stable (3,078 in 2013), although the rise experienced between 2004–05 and 2007–08 creates the impression of increased concentration and market power that typically results in higher prices (Masse & Beaudry, 2014). Nonetheless, like Nigeria, it could be described as an oligopoly. HHI decline may signal lower concentration and increased competition, caution should be exercised because it is possible for HHI to decline a minimum of 2,500 without changes in the number of firms in the industry provided the market share among the firms in the industry trends towards equality.

One-sample t test was conducted to determine if the mean HHI is significantly different from the theorectical HHI of 2,500 for moderate level of concentration (US Department of Justice and Federal Trade Commission, 2010). Given the null hypothesis (H_0) that the sample mean is equal to the hypothesized mean, the result in Table 6.4A shows that the null could not be accepted (p-value = 0.000; < 0.05). This indicates that the mean HHI for the sample of countries in the period of study is above the theoretical level of moderate concentration, indicating that the decline in HHI has not been significant in the deregulated environment. Research (e.g., Blackman & Srivastava, 2011; Noam, 2005; Usero, Grigorios, & Asimakopoulos, 2013; Fink, Mattoo, & Rathindran, 2003) that have exmined telecommunications industry deregulation present that deregulation leads to an increase in competition in the industry. The finding in this research confirms this assertion but also shows that the decline in HHI is not substantial to declare that the industry is highly competitive. In addition, the concentration of the industry in the two countries of interest (i.e. Canada and Nigeria) was examined to determine if the mean level of concentration differs. The null hypothesis (H_0) is that mean value of HHI in the two countries are equal. The result presented in Tble 6.4B indicates that the null could not be rejected (p-value = 0.4266; > 0.05), implying that there is no statistically significant difference between the mean HHI in the two countries.

Table 6.4A: One-sample t test

One-sample t test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
HHI	247	4404.567	81.98295	1288.463	4243.089	4566.045

mean = mean(HHI)   t = 23.2313

Ho: mean = 2500   degrees of freedom = 246

Ha: mean < 2500	Ha: mean != 2500	Ha: mean > 2500
Pr(T < t) = 1.0000	Pr(|T| > |t|) = 0.0000	Pr(T > t) = 0.0000

Source(s): Author's calculation

Table 6.4B: HHI comparison test between Canada and Nigeria using Mann-Whitney (Wilcoxon Rank-Sum) test

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

Countries	obs	rank sum	expected
Canada	13	191	175.5
Nigeria	13	160	175.5
combined	26	351	351

unadjusted variance	380.25
adjustment for ties	-0.13
adjusted variance	380.12

Ho: HHI(Countr~s==Canada) = HHI(Countr~s==Nigeria)

z = 0.795

Prob > |z| = 0.4266

Source(s): Author's calculation

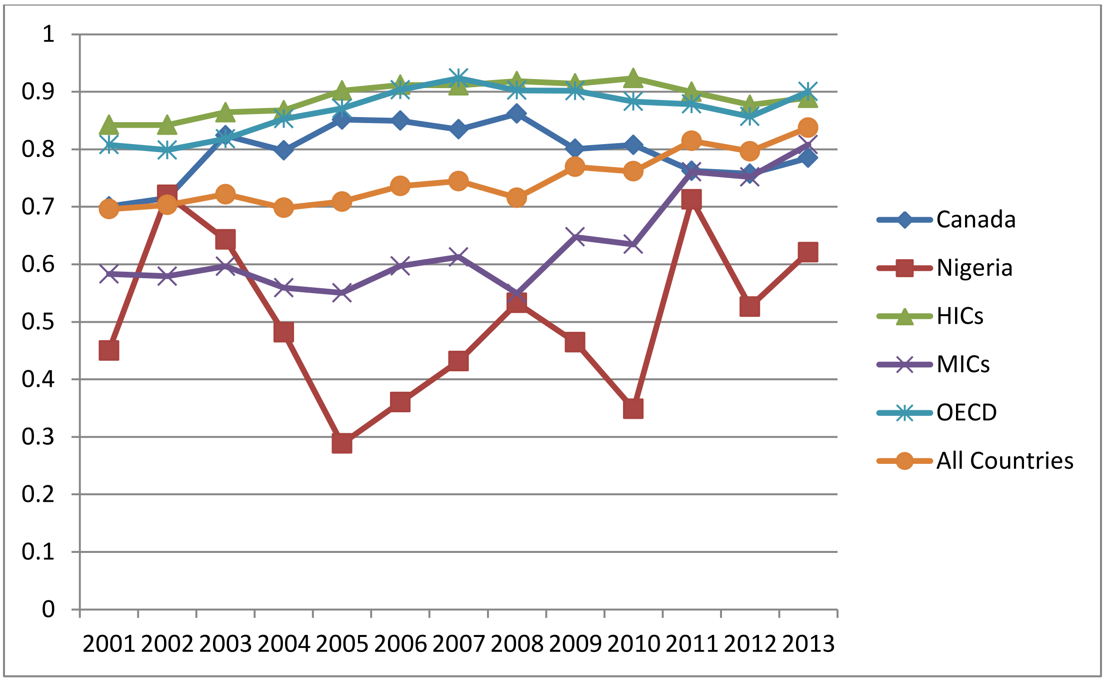
6.5 Efficiency and productivity performance in deregulated environment

The partial measures of performance results in Section 6.4 show the two countries under study elicited different levels of performance on each measure, a finding consistent with Naimy & Merheb (2014) that DMUs tend to show different levels of performance depending on what is being measured. The results showed that Canada displayed better performance on teledensity, SubEmp, RevEmp, CapexSub and CapexRev. Although Canada exhibited higher RevSub, Nigeria attained better price decline in the deregulated environment. Also, Nigeria showed better performance on subscriptions growth and RevEmp growth albeit Canada had a superior average RevEmp. Furthermore, the two countries displayed comparable industry concentration and are oligopolies.

The partial measures of performance provide information on the performance (i.e., operational efficiency and productivity) of the industry but the results in Section 6.4 failed to show that a single country consistently performed better on each measure. Rather, each country displayed better performance than the other depending on what is measured, making it difficult to identify the country with superior performance without a normative statement. Even though the partial measures of performance are considered insufficient because they fail to capture the series of inputs used simultaneously to generate outputs, nonetheless their use provided insightful information on the performance of the industry in the two countries. For a complete picture of the performance of the industry, the partial measures of performance are complemented with total factor analysis (ToFA) of the efficiency and productivity of the industry. The results are presented below.

6.5.1 Efficiency analysis

The approach discussed in Estache, Rossi, & Ruzzier (2004) was used to evaluate the efficiency scores under constant returns to scale and variable returns to scale. It involves establishing a frontier for each of the 13 years with the efficiency of each country relative to the frontier determined for each year. DEA efficiency frontiers were constructed in reference to a benchmark which is the best performer in the group and not the 'theoretical maximum' that could be attained (Petrović et al., 2011, p. 731). Thus the efficiency scores for each country in this research are relative in comparison to the best frontier that represents the best performer in the group of countries being studied. Furthermore, it is possible that differences in regulatory and economic order in the countries under study may have accounted for some of the variations in efficiencies. This will be investigated in the second stage analysis. Trends in mean CRS technical efficiency scores for all countries, categories of countries, and Canada and Nigeria are shown in Figure 6.3 and Appendix 2A which provides the CRS technical efficiency pattern from 2001 to 2013. Figure 6.3 reveals an upward trend in CRS technical efficiency scores. However, while the pattern in Canada is upward and relatively stable, Nigeria displayed a haphazard pattern with wide variations. Nonetheless, it increased from 0.45 in 2001 to 0.6206 in 2013 (Appendix 2A). Given that an objective of deregulation is to improve efficiency, the outcomes in Canada and Nigeria are insightful. Eliminating cross-subsidization in Canada compelled the industry to effectively allocate resources. This may have resulted in the upward and relatively stable CRS technical efficiency. The CRS technical efficiency pattern in Nigeria rose in 2001-02. This may have been due to the issuance of licenses that allowed new entrants into the industry. While the increase in competition stimulated infrastructure investment and enhanced network coverage, the introduction of unified licensing code and number portability heightened price competition, slowed revenue growth, and inhibited CRS technical efficiency performance in the remaining periods of the study. Additionally, on a yearly basis, the long-term trend indicates that the percentage of countries that displayed efficiency (i.e., a CRS TE score of 1) increased from five (26%) in 2001 to eight (42%) in 2013 (Appendix 2A), suggesting that the industry in more countries became technically efficient in the deregulated environment with the passage of time.



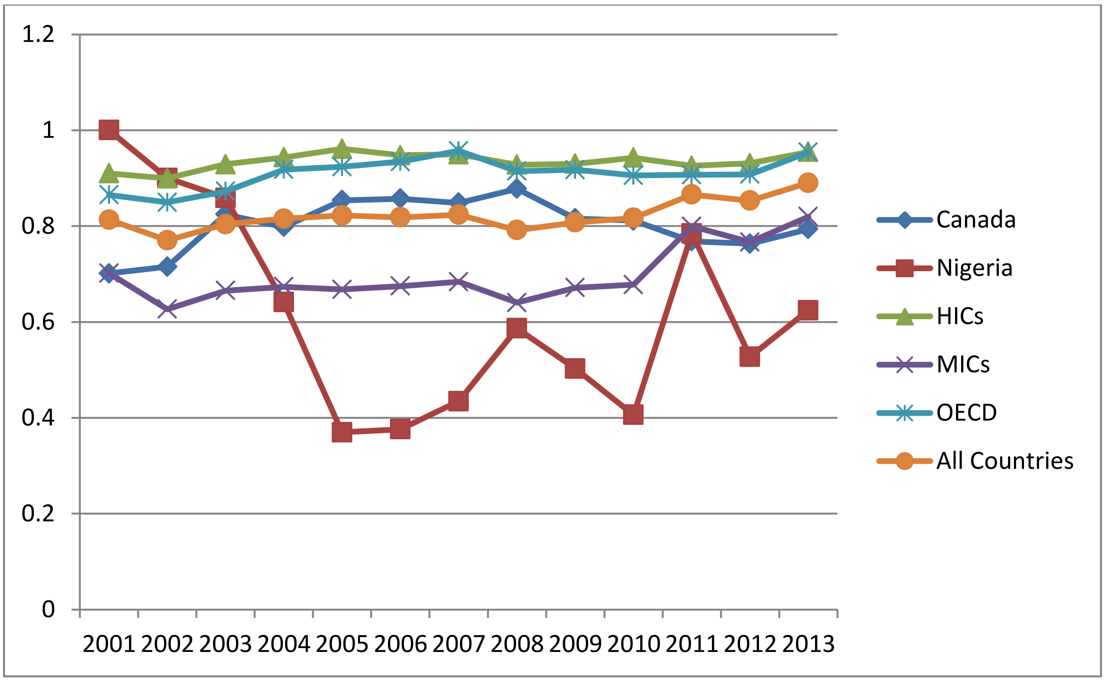
Source(s): Developed by the author for this research

Figure 6.3: CRS technical efficiency trends.

Table 6.5 shows the mean CRS technical efficiency, VRS technical efficiency and scale efficiency scores for all countries. The CRS technical efficiency provides information on efficiency levels and assumes that firms in the industry have flexibility and could adjust their size to that similar to the best performer (Kritikos, Markellos, & Prastacos, 2010). Under CRS technical efficiency, Table 6.5 reveals three countries (i.e., Belgium, New Zealand and the US) are efficient with each having a mean efficiency score of 1. All other countries have mean CRS technical efficiency scores of less than 1 and are considered inefficient (Table 6.5; Appendix 2A). In addition, the mean CRS technical efficiency score for the sample of countries in the panel dataset is 0.7464, suggesting that on average the industry in each country would have reduced inputs by 25.4%. This signifies that only 74.64% of current inputs is needed to produce the same level of output or that the current level of inputs could have been used to produce an output 1.34 times (i.e., 1/0.7464) the current output level; implying overall technical inefficiency of 34% (i.e., 1.34 less 1).

The mean CRS technical efficiency for the HICs (0.8895) and OECD countries (0.8691) are higher than the overall average, indicating that countries in these two categories have better efficiency performance than the average firm in the panel dataset. The mean CRS technical efficiency score for the sample of countries in MICs (0.6331) is lower and highlights technical inefficiency in MICs. While these findings confirm inefficiencies in all categories of countries, HICs are 1.4 times more efficient than MICs in that they would require 88.95% of current inputs to produce the same level of output whereas MICs would require 63.31%. The mean CRS technical efficiency score for Canada is 0.7960 and for Nigeria is 0.5062. This suggests that both countries were inefficient in the period of study, but Canada is closer to the best performing frontier than Nigeria. For Canada, the score reveals that the industry could utilize 79.6% of current input to produce the same amount of output (i.e., reduce inputs by 20.4%) or utilize the current level of inputs to produce an output that is 1.26 times (i.e., 1/0.7960) the current output level. This is tantamount to a CRS technical inefficiency of 26% (i.e., 1.26 less 1). The mean CRS technical efficiency score of 0.5062 in Nigeria indicates that it could double its output level using the current level of inputs, signifying a CRS technical inefficiency of 98%. A remarkable feature of DEA is that it allows for peer comparison and identifies role models for inefficient DMUs. Under CRS technical efficiency the five countries that serve as peers for others are HICs: South Korea (for Brazil, Mexico and Turkey), Belgium (for Chile, Mexico and Turkey), New Zealand (for Australia, Canada, Chile, Germany, Indonesia, Kenya, Nigeria, South Africa and the UK), Japan (for Australia, Brazil, Canada, Chile, China, Germany, India, Indonesia, Kenya, Mexico, South Africa and the UK), the US (for Australia, Canada, Indonesia, Kenya, Nigeria, South Africa and the UK). Interestingly, Australia which is marginally inefficient could become efficient with a slight reduction in inputs or an increase in outputs and learn from New Zealand, Japan and the US. These three countries also serve as role models for Canada which is distinctively inefficient; but only New Zealand and the US) are role models for Nigeria.

Constant returns to scale allows comparability of telecommunications industries in different countries irrespective of the size. However, the assumption of scale flexibility and adjustment typical under constant returns to scale may not hold if firms operate at suboptimal scales due to organizational (e.g., financial constraints) and non-organizational (e.g., imperfect competition) factors (Hung & Lu, 2007). To remove the impact of scale, the DEA efficiency was determined under variable returns to scale imposition to generate the VRS technical efficiency scores. The VRS technical efficiency scores reflect pure technical efficiency and reveals any inefficiencies relating to underperformance of management in allocating productive inputs (Kumar & Gulati, 2008). Exploring the VRS technical efficiency scores allow the industry in each country to be compared to those similar in size but it increases the potential for a handful that are large to display efficiency due to lack of peers (Kumar, 2013). Figure 6.4 shows the VRS technical efficiency trends. Additionally, consistent with Sharma et al. (2010) and Gokgoz & Demir (2014) who examined performance under constant returns to scale and variable returns to scale, the observations in Table 6.5 reveal that the variable returns to scale generated efficiency scores that are greater than or equal to the constant returns to scale efficiency scores.



Source(s): Developed by the author for this research

Figure 6.4: VRS technical efficiency trends.

The VRS technical efficiency trend in Canada increased from 0.701 in 2001 to 0.7938 in 2013, although there was a decline in trend in 2008 (Figure 6.4; Appendix 2B). The VRS technical efficiency trend in Nigeria varied widely with an indication of a decline from 1 in 2001 to 0.6164 in 2013 (Appendix 2B). Furthermore, Table 6.5 reveals four countries are efficient under VRS technical efficiency with each displaying a score of 1. It consists of the three countries that were efficient under constant returns to scale and Germany. Furthermore, five countries (i.e., Australia, Japan, Kenya, South Korea and the UK) though not efficient exhibited an average VRS technical efficiency score greater than 0.9 (Appendix 2B). The marginal inefficiency in these countries suggests each may have attained efficiency status by making slight adjustments to how productive inputs are used. The overall mean VRS technical efficiency score for the panel dataset is 0.8223 and is 110% of the average CRS technical efficiency score. This indicates 22% inefficiency in that current inputs could have been used to produce outputs that are 1.22 times (i.e., 1/0.8223) the current output level. HICs and OECD countries showed average VRS technical efficiency scores higher than 0.9. Nonetheless, both categories displayed inefficiency of 7% and 9.9%, respectively, and could have generated more outputs from current level of inputs. The mean VRS technical efficiency score in MICs (0.6967) is lower in comparison to HICs (0.9346), OECD countries (0.9097) and the overall average (0.8223) (Table 6.5). The average MICs could have produced the current output with only 69.7% of current inputs, suggesting 44% inefficiency as it could have produced outputs that are 1.44 times the current levels without having to increase inputs. The telecommunications industry in Kenya exhibited mean VRS technical efficiency score of 0.9290 and is the highest among MICs while India (0.4761) is the lowest. Nigeria (0.6164) is near the middle, implying an inefficiency of 62% (i.e., 1.62 less 1). The industry in Nigeria could have produced current outputs with only 61.64% of inputs or output should have been 1.62 times (i.e., 1/0.6164) what it produced given the current level of inputs. During the study period, a second national carrier entered the industry in Nigeria and interconnection rules in favour of new entrants were implemented. However, the uncertainties created may have caused managers of firms in the industry to make suboptimal decisions that resulted in the exhibited inefficiencies. Additionally, Appendix 2B shows the VRS technical efficiency score of 0.8022 in the Canadian telecommunications industry is below the average displayed by each country in HICs except Chile, suggesting it could have reduced inputs by 19.8% or it could have produced an output that is 1.25 times (i.e., 1/0.8022) the current output levels, indicating an inefficiency of 25% (i.e., 1.25 less 1). Delineating the nature of inefficiency in the Canadian telecommunications industry, the CRS and VRS technical efficiency scores show that within the period of this study the Canadian telecommunications industry is distinctly inefficient (CRS TE < 1; VRS TE < 0.9), signifying it could not have attained efficiency in the short term with slight modifications of productive inputs (Demirag et al., 2010). Like Canada, Chile consistently displayed a distinctly inefficient status. But Germany is unique in that it was marginally efficient (CRS TE < 1; VRS TE = 1) in 2001 and ran the risk of becoming inefficient if there was a slight increase in input or a slight change in output. However, since 2002 it has been robustly efficient (CRS TE = 1; VRS TE = 1). Unlike Germany, South Korea was robustly efficient in 2001 (CRS = 1; VRS = 1) but relapsed to marginally efficient status (CRS TE < 1; VRS TE = 1) in 2002 and 2003, declined further to marginally inefficient status (CRS TE < 1; 0.9 < VRS TE < 1) in 2004, regained marginally efficient status between 2005 and 2007 but has continued to display a marginally inefficient status since 2008 (Appendices 2A and 2B). South Korea's marginally inefficient status signals it could attain efficiency status by slightly reducing inputs or by slightly increasing outputs. The experience of Japan is similar to that of South Korea. However, the difference is that Japan has been able to attain and maintain robustly efficient status (CRS TE = 1; VRS TE = 1) since 2010. Other countries in the HICs that were marginally inefficient but became robustly efficient include the UK in 2013 and Australia. But Australia has not been consistent in that it was robustly efficient from 2010 to 2012 but regressed to marginally efficient status in 2013 (Appendices 2A and 2B).

Nigeria reveals marginally efficient status in 2001 (CRS TE < 1; VRS TE = 1), indicating it could have become inefficient with a slight increase in inputs or a slight decline in output. Nonetheless, deterioration in efficiency after 2001 shows the industry in a marginally inefficient status in 2002 (CRS TE < 1; 0.9 < VRS TE < 1) and it has remained distinctly inefficient since 2003 (CRS TE < 1; VRS TE < 0.9) (Appendices 2A and 2B). Like Canada, the distinctly inefficient status implies that the industry would have difficulty in becoming efficient in the short term through slight modifications in inputs. Aside from Kenya, all other MICs are distinctly inefficient. Surprisingly, Mexico is an OECD country but it is categorized in MICs and its efficiency performance in 2013 is superior to Canada's. Both are North American countries, but Canada's performance in 2013 lags behind Mexico and the US (Appendices 2A and 2B). Among MICs, Brazil is the best performer under CRS technical efficiency while Kenya is the best performer under VRS technical efficiency. However, unlike Brazil, Kenya attained distinctively efficient status in 2012.

Although the telecommunications industries in Canada and Nigeria are distinctly inefficient, it is important to note that the Canadian telecommunications industry experienced growth in CRS and VRS technical efficiency scores whereas the Nigerian telecommunications industry experienced growth in CRS technical efficiency but a decline in VRS technical efficiency (Figure 6.4; Appendices 2A and

2B). This observation may be because VRS technical efficiency ignores scale impact and compares the telecommunications industries in the two countries (i.e. Canada and Nigeria) to those of comparable sizes in the panel dataset rather than to all countres in the sample. VRS technical efficiency provides information on the effectiveness of management. Thus, its decline in Nigeria signifies deteriorating managerial effectiveness. Another finding is that the mean CRS and VRS technical efficiency in Canada is higher than in Nigeria; an observation attributable to using less inputs and better managerial acumen.

The mean efficiency scores in this research show HICs possess better efficiency performance than MICs. This finding is consistent with Gokgoz & Demir (2014) analysis of the efficiency of European telecommunications sector in 32 countries that indicated that telecommunications industries in high income countries in Europe displayed efficiency scores superior to those in low and middle income countries. Nonetheless, while Gokgoz & Demir (2014) data reveals decline in mean efficiency over the two years of study focus, this research finds an increase in the overall mean efficiency of the 19 countries. The difference in findings could be because Demir & Gokgoz (2014) examined the industry over a shorter period (i.e., two years) while this research examined the industry over a longer period (i.e., 13 years) which is appropriate in DEA studies (Li, 2009). Additionally, peer comparisons under VRS technical efficiency were examined. The result shows six countries as peers to others and one of them is MICs. Belgium (for Australia), Japan (for Australia, Brazil, Canada, China, India, Indonesia, Mexico, South Africa and Turkey), Kenya (for Canada, Chile, Indonesia and South Africa), New Zealand (for Australia, Canada, Chile, China, India, Indonesia, Mexico, South Africa and Turkey), South Korea (for Brazil, Mexico and Turkey) and the US (for Australia, Canada, Chile, Indonesia and South Africa). While Canada has four countries as peers it could learn from to address any inefficiency caused by pure technical efficiency, Nigeria has no peers, signifying it would have difficulty finding a role model it could learn from to eliminate pure technical inefficiency.

Table 6.5: Mean estimate of CRS TE, VRS TE and SE.

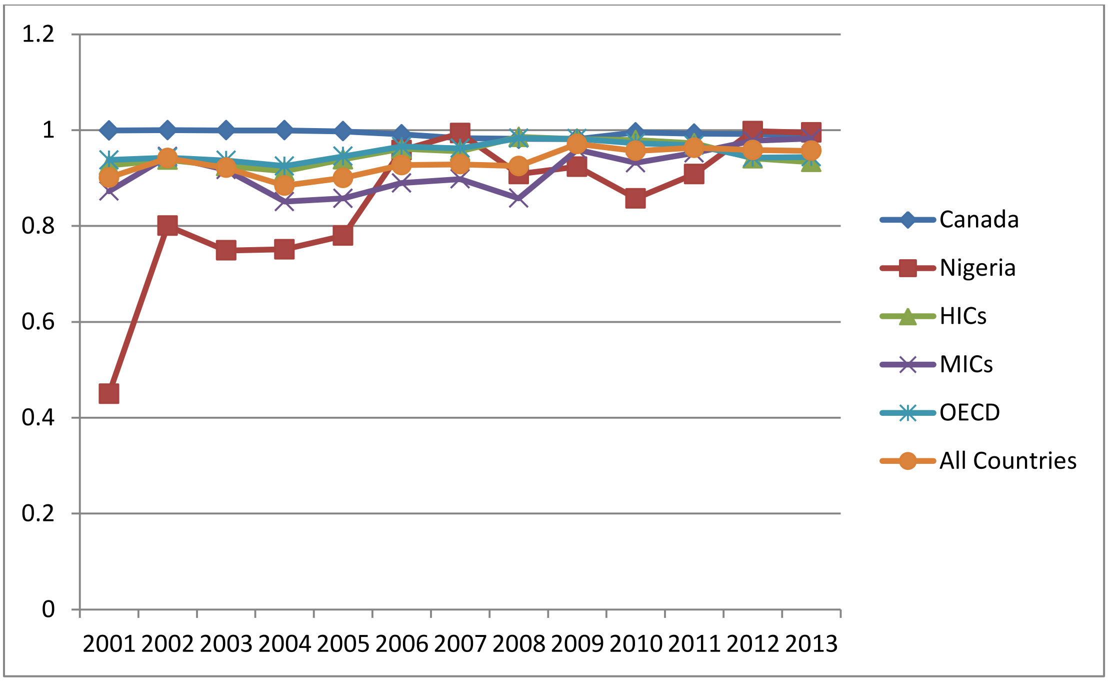
	CRS TE	VRS TE	SE
Australia	0.9038	0.9462	0.9532
Belgium	1	1	1
Brazil	0.8159	0.8630	0.9472
Canada	0.7960	0.8022	0.9924
Chile	0.5860	0.6654	0.8830
China	0.4785	0.5208	0.9202
Germany	0.9852	1	0.9852
India	0.4650	0.4761	0.9755
Indonesia	0.5785	0.6103	0.9475
Japan	0.9450	0.9732	0.9712
Kenya	0.6544	0.9290	0.6800
Mexico	0.7370	0.7594	0.9690
New Zealand	1	1	1
Nigeria	0.5062	0.6164	0.8516
South Africa	0.6653	0.6922	0.9591
South Korea	0.8945	0.9640	0.9278
Turkey	0.7972	0.8111	0.9826
United Kingdom	0.7844	0.9955	0.7888
United States	1	1	1
HICs	0.8895	0.9346	0.9502
MICs	0.6331	0.6976	0.9147
OECD	0.8691	0.9097	0.9544
All Countries	0.7464	0.8223	0.9334

Source(s): Author's calculations

Scale efficiency is used to determine whether efficiency is affected by scale size, indicating an efficiency increase could be attained by moving to a technically optimal productive scale (i.e., the most productive scale size, MPSS) (Coelli et al., 2005, p. 59). A DMU is scale efficient if CRS technical efficiency equals VRS technical efficiency but scale inefficient if CRS technical efficiency is less than VRS technical efficiency. Scale inefficiency may mean a DMU's size is too large and has difficulty allocating inputs effectively. This situation requires decreasing returns to scale in which case the firm will benefit from operational scale size reductions because increasing inputs will result in a less than proportionate increase in the output level. Scale inefficiency could also occur if a DMU is too small an operation than its productive size indicates. This situation requires increasing returns to scale in that it would benefit from size increase because an increased inputs will result in a higher than proportionate increase in outputs. To determine the returns to scale status, the non-increasing returns to scale (NIRS) is generally imposed to yield the returns to scale status for the DMU which could fall under categories that include

CRS, IRS or DRS (Coelli et al., 2005). While a scale efficiency value of 1 is categorized as CRS (i.e., MPSS), the scale efficiency yields decreasing returns to scale (DRS) if the NIRS technical efficiency is equal to VRS technical efficiency and increasing returns to scale (IRS) otherwise (Hung & Lu, 2007).

Figure 6.5 shows that the trend in mean scale efficiency scores for all countries increased in the study period. Appendix 2C shows the mean scores for each year for the categories of countries and scale efficiency scores for each country. Three countries (i.e., Belgium, New Zealand and the US) are scale efficient as each displayed mean scale efficiency score of 1, the remaining countries are scale inefficient, indicating they operated at an inappropriate scale and would benefit from scale adjustment (Appendix 2C). Of the remaining 16 scale inefficient countries, Australia, Canada, China and South Korea experienced a decline in scale efficiency as their scale efficiency in 2013 was less than what it was in 2001, providing a hint that scale inefficiency is increasingly contributing to the technical inefficiencies in these countries and that the industry in the four countries is moving farther away from MPSS. Surprisingly, three of the four countries with deteriorating scale efficiency are HICs. The remaining 12 scale inefficient countries experienced scale improvement in the study period. This creates the impression that the contribution of scale inefficiency to technical inefficiency in these countries is declining and that the industry in these countries gravitated towards MPSS during the study period; signifying improved efficiency attainment in the 12 countries as the scale impact diminished.



Source(s): Developed by the author for this research

Figure 6.5: Scale efficiency trends.

To decipher the nature of scale inefficiency, the non-increasing returns to scale was imposed to yield the true nature of the returns to scale. However, it is worth mentioning that a DMU's returns to scale is dependent on the position of efficient DMU and that changes in an efficient DMU's position may change the returns to scale (Seiford & Zhu, 1999). Appendix 2D shows that in 2001 the telecommunications industry in most countries experienced diseconomies of scale as 10 of the 19 countries (52.6%) were under increasing returns to scale which indicates that increasing input would result in a more than proportionate increase in output and that size increase would benefit the industry. This suggests that firms in the industry could liaise with others and engage in mergers and acquisitions or patronize other forms of collaboration on projects and network infrastructure sharing that would result in expanded operational scale and improved efficiency performance (Glynn & Tymburski, 2010). Nonetheless, this research does not promote this strategy because the number of countries exhibiting increasing returns to scale diminished to four (21%) in 2013 and slightly more than half (52.6%) of the countries displayed MPSS in 2013. Three countries displayed decreasing returns to scale in 2001, by 2013 the number increased to five; two (i.e., Australia and UK) of the three (i.e., Australia, Germany and UK) that exhibited decreasing returns to scale in 2001 were among the five that showed decreasing returns to scale in 2013. The findings that countries under decreasing returns to scale increased from three in 2001 to five in 2013 indicates that more firms are becoming scale inefficient due to being too large. This suggests that increasing inputs results in a less than proportionate increase in outputs for these countries and that they would benefit from operational size decrease. As size decrease and downsizing is expected through a reduction of offices/service centres and rationalization of human resources, any consolidation that would result in size increase of existing large telecommunications firms in the industry could be subjected to rigorous review by the regulatory agencies.

Furthermore, while Canada's scale efficiency diminished slightly, it increased in Nigeria from 45% in 2001 to 99.5% in 2013 (Appendix 2C), showing that the Nigerian telecommunications industry benefitted scale-wise from operating in the deregulated environment more than the Canadian telecommunications industry, although its mean scale efficiency of 0.8516 is less than Canada's average of 0.9924 (Table 6.5). Both countries have similar returns to scale and exhibited increasing returns to scale in most of the years. Nigeria reached MPSS in 2013, providing a hint at the difficulty attaining MPSS through operational size increase. It suffices to say that the motivation for size increase may be dampened by regulatory authority that may be unwilling to issue new spectrum licenses or to allow mergers and acquisitions if it is perceived that doing so would limit competition. Also, the level of existing competition, declining average revenue per subscriber and unfavourable macroeconomic conditions may impact on operational scale decisions.

In addition to the display of increasing returns to scale, the scale inefficiency in both countries seemed to occur in years when the industry was technically inefficient. This finding contradicts Moreno, Lozano, & Gutierrez (2013) who claimed that no relationship exists between scale and efficiency. However it is consistent with Sung (2012) and Naimy & Merheb (2014) who affirm the relationship between scale and efficiency and reported inefficient operators operate below MPSS. Furthermore, the mean scale efficiency score of 0.9924 in Canada is closer to 1 but reflects scale inefficiency of 0.77% (1/0.9924 less 1), indicating that technical inefficiency in Canada is caused mostly by pure technical inefficiency with a minute contribution from scale inefficiency. This finding implies that technical inefficiency in Canada is mostly the result of managerial inefficiency. Hence, improved efforts concentrating on enhancing management capacity would steer the industry towards better efficiency in the short term. The mean scale efficiency score of 0.8516 in Nigeria indicates that it could increase efficiency by 14.8% if it were to increase its scale of operation to MPSS. Also, it is an indication of scale inefficiency of 17.4% (1/0.8516 less 1) which is 23 times the scale inefficiency in Canada. This finding suggests that the technical inefficiency in the Nigerian telecommunications industry is jointly caused by scale inefficiency and pure technical inefficiency and that addressing the technical inefficiency will necessitate a long-term focus as the industry would require a combination of scale increase and enhanced managerial capabilities. However, while it could learn from New Zealand and the US to improve technical efficiency, it would have difficulty identifying an appropriate role model to learn from in order to eliminate the pure technical inefficiency in the telecommunications industry.

Following the observation of increasing returns to scale in most years for Canada and Nigeria (Appendix 2D), their returns to scale peers were examined. The result shows that the countries that serve as peers are from HICs: Belgium (for Australia, Chile, Mexico and Turkey), Japan (for Australia, Brazil, Canada, Chile, China, India, Indonesia, Kenya, Mexico, South Africa and Turkey), New Zealand (for Australia, Canada, Chile, Indonesia, Kenya, Nigeria and South Africa), South Korea (for Brazil, Mexico and Turkey) and the US (for Australia, Canada, Indonesia, Kenya, Nigeria and South Africa). While Canada has three countries (Japan, New Zealand and the US) as peers, these countries were earlier identified as its role models for correcting the technical inefficiency. Two countries (New Zealand and the US) that serve as peers for Nigeria in rectifying the technical inefficiency are also its returns to scale peers. This result suggests that if Canada and Nigeria were to work together to explore opportunities for improving their telecommunications industries, it would be appropriate for them to involve either New Zealand or US or both.

6.5.2 DEA sensitivity analysis

To evaluate if a change in input and/or output will greatly influence the efficiency scores, two sensitivity analyses were performed on the DEA model. The first (Model 1) assessed the sensitivity of the original DEA model to input reduction involving the removal of employment as an input variable. The second evaluated the sensitivity of the original DEA model to output change and entailed deleting teledensity as an output variable (Model 2). The results in Appendix 2F show efficiency estimates that are comparable to the original DEA results (Table 6.5). The overall average efficiency scores did not change by much. Also, the efficiency scores for the two countries of focus (i.e., Canada and Nigeria), HICs, MICs and OECD member countries are comparable to the original DEA model. The relative stability of the CRS technical efficiency, VRS technical efficiency, and scale efficiency suggests that the original DEA model produced consistent estimate of the efficiency scores.

6.5.3 Productivity analysis

The productivity analysis carried out in this research provides information on changes in productivity and identifies which of the two countries (i.e., Canada and Nigeria) is making progress. Using productivity change is appropriate and has been applied in studies involving comparative analyses across two or more countries (e.g., Cabanda, Ariff, & Viverita, 2004; Petrović et al., 2012). To determine productivity change for each country in the panel dataset, DEA-based MPI was used with variable returns to scale imposed. Unlike the constant returns to scale assumption that yields information on technical change and efficiency change but no details about the sources of the efficiency change, imposing variable returns to scale decomposes efficiency change into pure technical efficiency change (PTEC) and scale efficiency change (SEC). The MPI is greater than 1 if productivity increases, less than 1 if it declines, and equal to 1 if no productivity change occurs (Margaritis, Fare & Grosskpf, 2007).

Table 6.6 reveals the mean technical change (TC), efficiency change (EC) and total factor productivity change (TFPC) and the decomposition of efficiency change into pure technical efficiency change (PTEC) and scale efficiency change (SEC). The table shows that TFPC is 1.0569 for the sample of countries in the study period. While total factor productivity declined in four of the periods, it increased overall (Figure 6.6). The total factor productivity change of 1.0569 signifies 5.7% (1.0569 less 1 times 100) per year growth in total factor productivity. In addition, the table indicates mean efficiency change of 1.0572 (5.7% increase per year) and mean technical change of 1.0009 (0.09% increase per year), signifying that technical change stagnated and that the major source of productivity growth was efficiency improvements or that there was ‘catching up’ (i.e., convergence towards efficiency)

(Hu & Chu, 2008, p. 230). This finding also suggests that for the sample of countries in the study, it is easier to leverage efficiency improvement measures than it is to engage in innovation to attain improved productivity. In decomposing the sources of the efficiency change for the sample, Table 6.6 shows the mean pure technical efficiency change and scale efficiency change are 1.0357 and 1.0208 respectively, showing that pure technical efficiency change contributed more to the efficiency improvements than scale efficiency change. This implies that efficiency improvement was attained through managerial effectiveness. Similar observations were noted in all of the categories of countries.

Table 6.6: Mean estimate of TC, SEC, PTEC and TFPG.

	TC	**EC**	**SEC**	**PTEC**	**TFPG**
Australia	1.0132	0.9837	0.9698	1.0144	0.9963
Belgium	1.0000	1.0049	1.0049	1.0000	1.0049
Brazil	1.0099	1.0163	1.0144	1.0018	1.0331
Canada	1.0047	1.0129	1.0010	1.0120	1.0181
Chile	0.9471	1.1157	1.0684	1.0442	1.0398
China	1.0524	0.9933	0.9756	1.0181	1.0362
Germany	1.0045	1.0217	1.0217	1.0000	1.0273
India	1.0108	1.2522	1.0036	1.2478	1.2543
Indonesia	1.0089	1.1244	1.0063	1.1174	1.1273
Japan	1.0199	1.0016	1.0003	1.0013	1.0220
Kenya	0.9697	1.1960	1.1810	1.0127	1.2104
Mexico	1.0133	1.0552	0.9996	1.0556	1.0667
New Zealand	1.0000	1.0000	1.0000	1.0000	1.0000
Nigeria	0.9689	1.1228	1.1087	1.0127	1.0809
South Africa	0.9768	1.0743	1.0087	1.0650	1.0389
South Korea	1.0086	0.9851	0.9862	0.9989	0.9935
Turkey	1.0086	1.0773	1.0008	1.0765	1.0879
United Kingdom	0.9997	1.0442	1.0439	1.0003	1.0433
United States	1.0000	1.0000	1.0000	1.0000	1.0000
HICs	**0.9998**	**1.0168**	**1.0096**	**1.0071**	**1.0145**
MICs	**1.0022**	**1.1029**	**1.0332**	**1.0675**	**1.1040**
OECD	**1.0016**	**1.0251**	**1.0080**	**1.0169**	**1.0250**
All Countries	**1.0009**	**1.0572**	**1.0208**	**1.0357**	**1.0569**

Source(s): Author's calculations

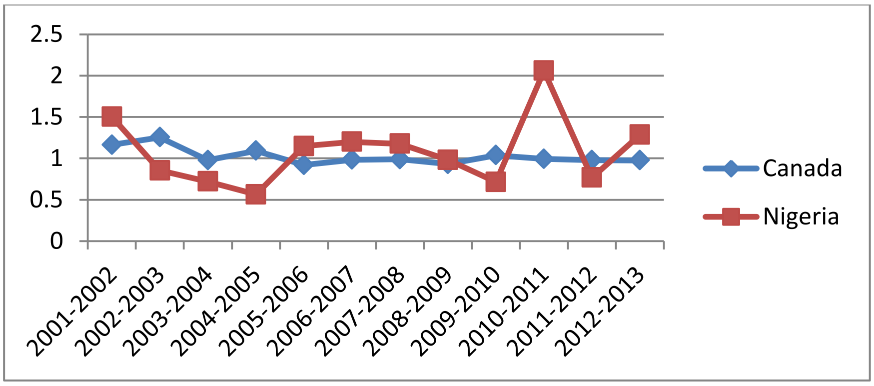
India displayed the highest total factor productivity growth (25.4% per year) which was attained through 25.2% per year efficiency improvement (EC: 1.2522) and 1.1% per year technological progress (TC: 1.0108). The source of the two digits growth in efficiency change was pure technical efficiency change (1.2478) and scale efficiency change (1.0036), but the contributions from pure technical efficiency change (PTEC: 24.8% per year) surpassed operational scale improvement (SEC: 0.04% per year). Hence, the efficiency improvement was mostly due to improved managerial capabilities and effectiveness in making rational decisions. Indonesia (1.1273) and Kenya (1.2104) are two other countries with double digits total factor productivity growth. However, while Indonesia displayed characteristics similar to India, Kenya attained total factor productivity growth through efficiency improvements in spite of a 3% per year retardation in technical change, suggesting inadequate Capex on technological innovations with potential impact on future productivity of labour and capital. Unlike India and Indonesia, the source of efficiency change in Kenya was mostly operational scale improvement. Two countries (i.e., Australia and South Korea) experienced total factor productivity regress due to efficiency deteorioration. Inefficient scale caused efficiency deterioration in Australia but managerial ineffectiveness and inefficient scale were responsible for the efficiency decline in South Korea (Table 6.6).

Four countries (Chile: 0.9471, Kenya: 0.9697, Nigeria: 0.9689 and South Africa: 0.9768) experienced technological regression, while two countries (Belgium: 1; the US: 1) had no technological change. Together, these six countries represent 32% of the countries in the sample. The remaining 13 countries experienced technical change progression. However, some (Canada: 1.0047, Germany, 1.0045, Indonesia: 1.0089 and South Korea: 1.0086) had marginal improvements. The occurrence of technical change decline, no growth and/or marginal increase suggests difficulty in achieving total factor productivity growth through technology in most of the countries in the study period and may have been spurred by the increase in competition in the industry (GSMA, 2013). Also, the high costs associated with innovation through research and development or Capex relating to adopting new technologies and the impact on financial results may have played a role. However, as noted in GSMA (2013), an industry that invests in innovative technologies may broaden its customer base by delivering existing products and services to more customers cheaper and/or delivering new products to customers. The mean efficiency change for each country reveals three countries (i.e., Australia, China and South Korea) experienced efficiency change decline and the remaining 16 countries experienced efficiency change of at least 1. The deterioration in efficiency change in Australia and China were the result of inappropriate scale while for South Korea it was due to managerial ineffectiveness and inappropriate scale.

Appendix 2E shows that four countries (i.e., Belgium, Germany, New Zealand and the US) displayed no decline in mean technical change, efficiency change and total factor productivity growth in each of the period of study. Countries that experienced regression in technical change but were able to augment total factor productivity growth through efficiency enhancement are Chile, Kenya, South Africa and UK. However, the caveat is that for total factor productivity growth to accrue, efficiency improvement should be large enough to absorb retardation in technical change. Without this, total factor productivity will decline. Australia, China and South Korea are interesting in that they experienced efficiency change deterioration. However, China attained total factor productivity growth through technological progress and the cases of Australia (TC: 1.0132; EC: 0.9837) and South Korea (TC: 1.0086; EC: 0.9850) show it is possible for total factor productivity to decline if growth from technical change does not sufficiently accommodate deterioration in efficiency (Cabanda, Ariff, & Viverita, 2004). The total factor productivity decline in Australia and South Korea may suggest diminishing labour productivity and capital productivity relative to other countries in the panel dataset. The major revelations are that while it is desirable to pursue productivity increases through a combination of efficiency improvements and technological innovation, it is not impossible to attain productivity growth by focusing only on efficiency improvement measures or on innovation. This finding is consistent with Cabanda, Ariff, & Viverita (2004) who presented evidence of either efficiency change or technical change or both having an impact on total factor productivity growth in a study of telecommunications industry productivity in 39 countries in Africa, Asia–Pacific, Europe and the Americas.

Canada’s total factor productivity growth of 1.0181 is greater than the mean for HICs (1.0145) but less than the overall mean of 1.0569 (5.7% per year). Conversely, Nigeria’s mean of 1.0809 is less than the average for MICs (1.1040) but greater than the 1.0569 overall mean for all countries in the study. This observation suggests that Canada’s total factor productivity growth performance is better than the average country in HICs and that while Nigeria’s total factor productivity growth lags behind the average country in MICs, it seemed to have outperformed Canada. Furthermore, Table 6.6 shows Canada’s mean technical change (TC: 1.0047) and efficiency change (EC: 1.0129) and signals that total factor productivity growth occurred due to improvements in technical and efficiency change but that the contribution from efficiency change is greater. However, the technical change trend shown in Figure 6.6 reveals technological regression in 8 of the 12 periods while efficiency change deteriorated in 6 of the 12 periods. The decomposition of the sources of 1.29% (1.0129 less 1 times 100) per year efficiency improvements, indicates scale improvement (SEC: 1.0010) and managerial effectiveness (PTEC: 1.0120) played a role, but the the efficiency growth was mainly due to enhanced managerial capability (Table 6.6). The result of productivity growth in Canada indicates efficiency improvement as the main source of productivity growth. This observation mirrors the overall source of productivity for the panel dataset and harmonizes with Li (2009) who applied stochastic frontier analysis and data envelopment analysis in the study of efficiency and the total factor productivity of 22 mobile telecommunications firms in seven countries from 1995 to 2007. Similar to this research, the results in Li's study show efficiency change and technical change contributed to total factor productivity growth but the contribution from efficiency change is greater. However, it is inconsistent with Calabrese, Campsi, & Mancuso (2002) who investigated telecommunicatons industry productivity change in 13 OECD countries and found that efficiency change and technical change contributed to total factor productivity growth but identified technical change as the main source of the growth. The difference in outcome may be related to the proxy for capital inputs. Calabese, Campsi, & Mancuso (2002) used number of lines to proxy capital input while this research applied Capex. However, Coelli et al. (2005) relate that investment which Capex reflects is more appropriate proxy for capital inputs if the focus of the study is to measure productivity growth.

In the case of Nigeria, Table 6.6 reveals technological retardation of 3.1% per year (TC: 0.9689) but 12.3% per year improvement in efficiency (EC: 1.1228), suggesting that the total factor productivity growth of 8.1% per year (TFPG: 1.0809) was mainly due to efficiency improvement. The decline in technical change signals technological retardation is an issue in the industry and may indicate underinvestment or that the industry is yet to realize gains from existing investment. Furthermore, the trends in scale efficiency change and pure technical efficiency change shown in Figures 6.9 and 6.10 reveal more varied scale efficiency change and pure technical efficiency change in Nigeria than in Canada. However, the mean scale efficiency change of 1.1087 and pure technical efficiency change of 1.0127 are higher than that of Canada (Table 6.6). The decomposition of efficiency change indicates 10.87% per year scale improvement and 1.27% per year improvement in managerial effectiveness, implying that efficiency improvement was due to an enhanced operational scale with little contribution from better managerial acumen. The finding for Nigeria is similar to Li (2009) and Moshi, Mwakatumbula & Mitomo (2013). However, while similar to Li (2009) in identifying efficiency change as the source of total factor productivity growth, it differs from Moshi, Mwakatumbula & Mitomo (2013) who studied productivity growth of telecommunications firms in Africa and noted technical change as the main source of total factor productivity growth. The variation between Moshi, Mwakatumbula & Mitomo (2013) and this research may be related to differences in focus. It may also highlight the observation in a comparative study of European telecommunications by Dabler, Parker, & Saal (2002) that presented mixed evidence of sources of productivity. Nonetheless, the result in this research is congruent with Cabanda, Ariff, & Viverita (2004) who investigated telecommunications industry productivity growth in Africa, Asia–Pacific, the Americas and Europe. While the study acknowledges differences in productivity pattern in the countries studied, it concludes that technical change was the main cause of the overall decline in total factor productivity, suggesting that efficiency change rather than technical change was the driver of total factor productivity growth.



Source(s): Developed by the author for this research

Figure 6.6: Canadian and Nigerian telecommunications TFPG.

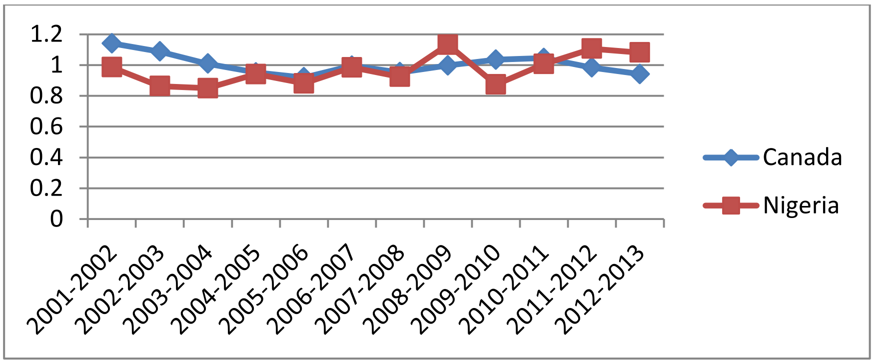


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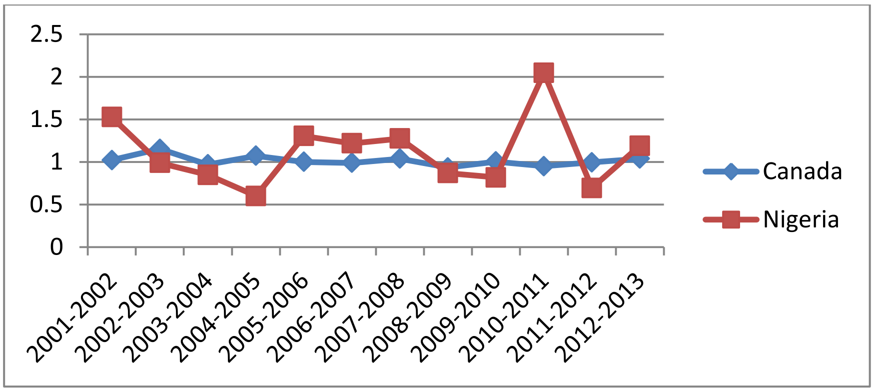
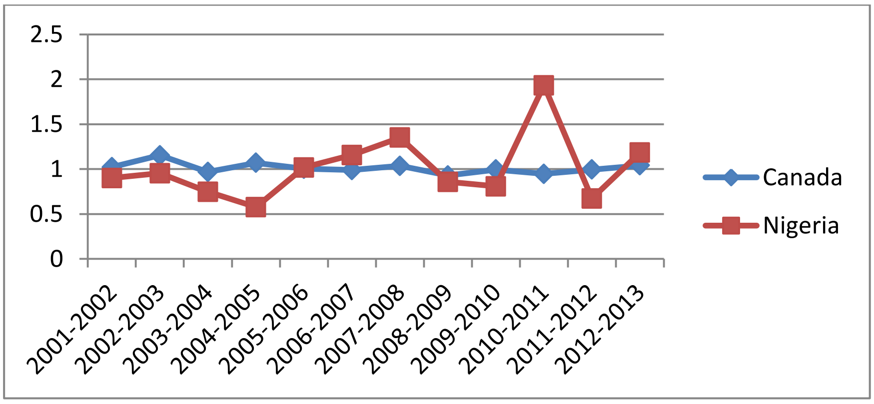
Figure 6.7: Canadian and Nigerian telecommunications industry technical change.



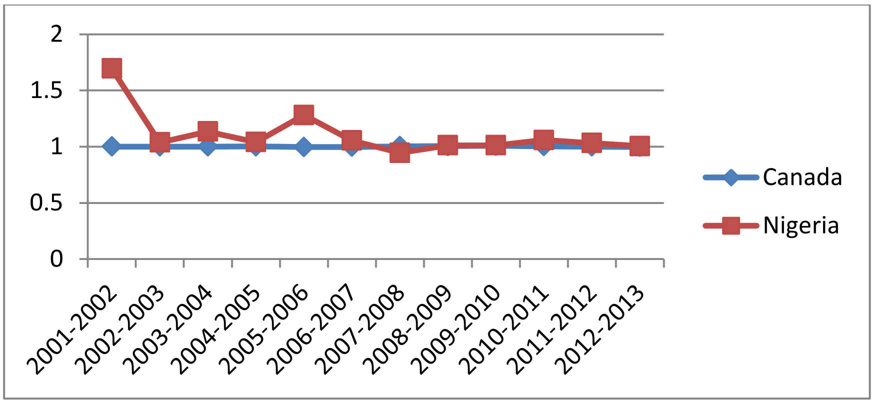
Source(s): Developed by the author for this research

Figure 6.8: Canadian and Nigerian telecommunications industry efficiency change.



Source(s): Developed by the author for this research

Figure 6.9: Canadian and Nigerian telecommunications industry pure technical efficiency change.



Source(s): Developed by the author for this research

Figure 6.10: Canadian and Nigerian telecommunications industry scale efficiency change.

6.6 Mann-Whitney test of efficiency and productivity scores

Mann-Whitney test, also considered Wilcoxon Rank-sum test (Fan & Datta, 2013), was conducted to test the null hypothesis that no statistical difference exists in the performances of the industry in the two countries with Canada as country 1 and Nigeria as country 2 at 95% confidence interval (i.e., 5% significance level). The results of the comparison of the CRS technical efficiency shows a higher mean rank for Canada (19.77 *vs.* 7.23) and it is statistically significant (p value < 0.05) which indicates that the Canadian telecommunications industry attained better CRS technical efficiency scores. Also, the test was ran for the VRS technical efficiency and indicates a higher mean rank for Canada (16.77 *vs.* 10.23) and the p value of 0.029 (p value < 0.05) implies the VRS technical efficiency score of the industry in Canada is higher than in Nigeria. In addition, Mann-Whitney test was conducted on the scale efficiency and the tests produced a higher mean value for Canada (18.23 *vs.* 8.77) and an exact p value of 0.01 which is less than 0.05 indicates that the industry's operational scale differs and that Canada displayed better operational scale. Furthermore, the test was performed on the total factor productivity growth results. The mean rank for Canada (12.42) is less than Nigeria (12.58) but the the p value of 0.977 in two-tail (p value > 0.05) implies that the null hypothesis that there is no statistical difference between the total factor productivity growth results could not be rejected. The conclusion is that Nigeria seem to display slightly higher average total factor productivity growth than Canada, there is no statistically significant difference in the total factor productivity growth performance of the two countries.

6.7 Second stage Tobit regression results

Random effect (RE) panel Tobit model was applied to avoid incorrect estimate of the influence of environmental factors. According to Ramalho, Ramalho, & Henriques (2010) and Karagiannis (2015), the use of Tobit model was first introduced in Ray (1991) and has become the standard approach used to generate a model that corrects efficiency scores for environmental factors (Coelli et al., 2005). The DEA efficiency analysis was presented in Section 6.5.1. However, it is possible that firms strove to enhance performances but were constrained by environmental factors. Evaluating the effect of environmental factors on technical and scale efficiency performance provides better insight on efficiency drivers. The correlation of dependent variables (i.e., CRS TE, VRS TE and SE) and explanatory variables are presented in Appendices 3A–3C. Each appendix indicates that all of the explanatory variables have a low correlation between of +0.7 and -0.7 and is consistent with the recommendation in Anderson et al. (2014, p. 703) and the suggestion in Choi & Zhang (2011). The results of Tobit regression analysis with specified left censoring limit of 0, right censoring limit of 1 and 95% confidence level are presented in Tables 6.7A-6.7C. Parameters with positive signs improve efficiency performance while those with negative signs detract efficiency. The regression parameters for the CRS technical efficiency scores are presented Table 6.7A, and the regression parameters for VRS technical efficiency and scale efficiency scores are presented in Table 6.7B and Table 6.7C.

The proxy for the number of yeard in deregulation is NYRS. This measure has a negative and statistically insignificant influence on CRS technical efficiency (*p*-value = 0.165; > 0.05) (Table 6.7A), VRS technical efficiency (*p* value = 0.182; > 0.05) (Table 6.7B) and scale efficiency (*p* value = 0.373; > 0.05) (Table 6.7C). The observation that NYRS has negative and insignificant influence on technical and scale efficiencies is contrary to the notion of efficiency improvement over time reported in Li and Xu (2004) and Karamti & Kammoun (2011). The finding indicates that the number of years in deregulation has little to do with efficiency performance and that over time the efficiency of the industry will fluctuate irrespective of the number of years it has been deregulated. The fluctuation in efficiency is the outcome of the industry’s response to regulatory policies and changes in operating environment. As the operating environment changes, the industry will require time to adjust its operational size and reorganize productive inputs, causing fluctuations in technical and scale efficiencies over time. RevSub, which reflects financial viability positively influence CRS technical efficiency (*p*-value = 0.000; < 0.05) (Table 6.7A) and VRS technical efficiency (*p*-value = 0.000; < 0.05) (Table 6.7B) and the coefficient is statistically significant. Also, its effect on scale efficiency is positive and significant (*p*-value = 0.000; < 0.05) (Table 6.7C) This finding indicates that higher RevSub enhances technical and scale efficiency performance and substantiates Li & Xu (2004) who noted that lower prices are disincentives for firms in the industry to invest in infrastructure which in turn diminishes efficiency. Furthermore, the findings imply that the telecommunications industry with rising RevSub would exhibit better technical efficiency and enhanced Scale.

HHI, which is indicative of the structure of the industry, has a positive but not statistically significant effect on CRS technical efficiency (*p*-value = 0.781; > 0.05) (Table 6.7A) but negative and insignificant relationship with VRS technical efficiency (*p* value = 0.520; > 0.05) (Table 6.7B). Its impact on scale efficiency is positive and not statistically significant (*p*-value = 0.686; > 0.05) (Table 6.7C). The statistically insignificant relationship between HHI and efficiency performance seems to suggest that the level of concentration in the telecommunications industries does not influence technical efficiency and scale performance. The positive but not significant relationship between HHI and efficiency performance in this research contradicts Li & Price (2011) who indicated a significant and positive relationship between efficiency and level of competition. The difference in findings could be related to the narrow focus (i.e., the mobile sector) in Li & Price (2011) while this research has a broader focus. It also departs from Gutierrez (2003) who uses a partial measure of performance (i.e., subscriptions to employment) as efficiency instead of the aggregate measure applied in this research. Also, the finding is inconsistent with Moreno, Lozano, & Gutierrez (2013) who noted that competition detracts from efficiency, but their study use single input and single output in the DEA analysis and the Durbin Watson score of 2.083 in the multiple regression in the second stage is indicative of higher risk of autocorrelation although it is within the recommended range of 1.5 to 2.5. Nevertheless, the finding in this research harmonizes with Hu & Chu (2008) which shows that HHI has no significant effect on technical efficiency. It is plausible that HHI is not an important consideration for technical and scale efficiency due to regulatory barriers (e.g., licensing requirements) and firm imposed barriers (e.g., economies of scale, network effect, access to infrastructure etc.). In spite of the increase in competition, the barriers insulate existing firms and make HHI less of a consideration for technical and scale efficiencies. In addition, HHI decreased in some years in the study period and yet the industry displayed poor technical and scale efficiency levels. Also, the industry exhibited increased concentration in other years but showed poor efficiency performances. These observations signify that post deregulation increase in competition and resultant price decline may have deterred network augmentation essential to enhancing efficiency performance. Nonetheless, the finding in this research does not seem to indicate that HHI is important to technical and scale efficiency performance. CapexRev ratio, which reflects the intensity of capital expenditures to revenues generated (Elmasr, 2007), has no significant negative influence on CRS technical efficiency (*p*-value = 0.077; > 0.05) (Table 6.7A), and a positive but not statistically significant effect on VRS technical efficiency (*p*-value = 0.069; > 0.05). While Torres & Bachiller (2013) indicated that investment in infrastructure positively influence efficiency, the finding that capital intensity has no significant influence on technical efficiency aligns with Torres & Bachiller (2013). The insignificance of capital intensity to technical efficiency enhancement may be due to the reduction in capital expenditures in the industry when the return from investment is lower than the cost of capital. Furthermore, the Tobit model shows capital intensity has a statistically significant negative influence on scale efficiency (*p* value = 0.000; < 0.05) (Table 6.7C). The negative sign indicates that increasing capital intensity decreases scale efficiency, suggesting that the industry could attain scale efficiency improvement by optimising Capex. This does not imply underinvestment in infrastructure but full capacity utilization and/or avoiding infrastructure duplication by collaborating and engaging in infrastructure sharing and construction to reduce costs (GSMA, 2015).

The proxy for labour productivity used in the Tobit model is SubEmp. This measure has a positive and significant relationship with CRS technical efficiency (*p*-value = 0.0024; < 0.05) (Table 6.7A), VRS technical efficiency (*p*-value = 0.000; < 0.05) (Table 6.7B). On the other hand, its influence on scale efficiency is negative and insignificant (*p*-value = 0.652; > 0.05) (Table 6.7C). This implies that increased labour productivity drives technical efficiency performance but it is not consequential to operational scale enhancement. The increase in labour productivity in the deregulated environment is the outcome of effective use of labour. While the effect of labour productivity is insignificant to scale efficiency, the finding that it has negative influence on it is puzzling. It may be that with increased labour productivity, firms in the industry do not see the need to make scale adjustments that may be required to move the industry closer to the most productive scale size. Change in real GDP per capita (CRGDPPC) proxy economic growth. It was found to have a negative and insignificant effect on CRS technical efficiency (*p* value = 0.257; > 0.05) (Table 6.7A), VRS technical efficiency (*p* value = 0.870; > 0.05) (Table 6.7B) and scale efficiency (*p* value = 0.0928; > 0.05) (Table 6.7C). The discovery implies that a change in real GDP per capita is irrelevant to technical and scale efficiency. Also, the finding indicate that telecommunications industries in countries with lower economic growth may display technical and scale efficiency levels that are similar to telecommunications industries in countries with higher economic growth and wealth. However, the finding differs from Akhtar (2009) that suggests a negative relationship between real GDP per capital and efficiency performance. The difference in findings may be due to Akhtar's focus on allocative efficiency. Also, it contradicts Lemstra et al. (2014) and Li (2009) who suggest growth in GDP enhances technical efficiency. Nonetheless, it complements Bortolotti, D'Souza, Fantini, & Megginson (2002) observation that GDP has no significant relationship with efficiency. The finding also aligns with Petrović et al. (2011) that noted uncertainty in the link between economic development and telecommunications industry performance and concludes that telecommunications industries in developing countries could perform as successful as those in economically developed countries. The probable explanation for CRGDPPC appearing to have no important effect on technical and scale efficiency is that it signifies a country's wealth (Moshi, Mwakatumba, & Mitomo, 2013; Koski & Kretschmer, 2007) and does not reflect income distribution and/or disposable income which have effects on the propensity of individuals to purchase telecommunications products and services (Jappelli & Pistaferri, 2014).

The influence of CPI which is a measure of inflationary trend in an economy (Csipak & Zuccaro, 2014) is found to have positive and significant effect on CRS technical efficiency (*p*-value = 0.000; < 0.05) (Table 6.7A), VRS technical efficiency (*p*-value = 0.000; < 0.05) (Table 6.7B) and scale efficiency (*p*-value = 0.000; < 0.05) (Table 6.7C). This result shows that CPI is important to technical and scale efficiency but deviates from Li & Xu (2004) finding that higher CPI results in lower telecommunications outputs. It is possible that the higher inflation in the economy, the more likely it is for prices and output to rise in the industry. Also, it may indicate that the industry is able to increase/decrease price at a rate higher/lower than inflation/deflation in the economy. The level of development (LDev) variable is positively associated with CRS technical efficiency but its effect is not significant (*p* value = 0.416; > 0.05). Also, it has positive but insignificant impact on VRS technical efficiency (*p*-value = 0.267; > 0.05) (Table 6.7B). On the other hand, its relationship with scale efficiency is negative but also statistically insignificant (*p*-value = 0.739; > 0.05) (Tale 6.7C). This implies that the level of development in a country has unimportant influence on technical and scale efficiency of the industry. This outlook is inconsistent with Cabanda, Ariff, & Viverita (2004) that show telecommunications industries in developed countries exhibited better performance than those from developing countries. Nonetheless, the finding that the level of development does not seem to have important influence on technical efficiency and scale of operations suggests that telecommunications industry in developed and developing countries may exhibit similar levels of managerial effectiveness and operational scale. In some years during the study period, telecommunications industries in some developing countries achieved better technical and scale efficiency performances than their counterparts from developed countries (Appendices 2A, 2B, & 2C).

Table 6.7A: CRS technical efficiency regressed with explanatory variables

Random-effects tobit regression	Number of obs	=	246
Group variable: CountryID	Number of groups	=	19
Random effects u_i ~ Gaussian	Obs per group:		
	min	=	12
	avg	=	12.9
	max	=	13
Integration method: mvaghermite	Integration pts.	=	12
	Wald chi2(8)	=	120.56
Log likelihood = 54.224432	Prob > chi2	=	0.0000

CRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0071464	.0051523	-1.39	0.165	-.0172448	.002952
SubEmp	.0002076	.0000668	3.11	0.002	.0000767	.0003385
RevSub	.0005627	.000085	6.62	0.000	.0003961	.0007292
CapexRev	-.0636291	.0359756	-1.77	0.077	-.1341399	.0068818
CRGDPPC	-5.55e-06	4.90e-06	-1.13	0.257	-.0000152	4.05e-06
HHI	4.73e-06	.000017	0.28	0.781	-.0000287	.0000381
CP1	.0071352	.0012188	5.85	0.000	.0047463	.0095241
LDev	.0731775	.0898803	0.81	0.416	-.1029846	.2493396
_cons	-.1494133	.136059	-1.10	0.272	-.416084	.1172573
/sigma_u	.1491648	.0311907	4.78	0.000	.0880322	.2102974
/sigma_e	.1356535	.0074967	18.09	0.000	.1209602	.1503469
rho	.5473316	.1050245			.3443153	.7384451

0 left-censored observations
177 uncensored observations
69 right-censored observations

Source(s): Author's calculations

Table 6.7B: VRS technical efficiency regressed with explanatory variables

```
Random-effects tobit regression             Number of obs      =       246
Group variable: CountryID                   Number of groups   =        19

Random effects u_i ~ Gaussian               Obs per group:
                                                          min =        12
                                                          avg =      12.9
                                                          max =        13

Integration method: mvaghermite             Integration pts.   =        12

                                            Wald chi2(8)       =     70.28
Log likelihood  =  15.924201                Prob > chi2        =    0.0000
```

VRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.008101	.0060738	-1.33	0.182	-.0200054	.0038033
SubEmp	.0002912	.0000776	3.75	0.000	.0001391	.0004433
RevSub	.0006007	.0001111	5.41	0.000	.000383	.0008183
CapexRev	.0767571	.0422777	1.82	0.069	-.0061057	.1596198
CRGDPPC	-1.04e-06	6.36e-06	-0.16	0.870	-.0000135	.0000114
HHI	-.0000131	.0000204	-0.64	0.520	-.0000532	.0000269
CP1	.0054022	.0014237	3.79	0.000	.0026117	.0081926
LDev	.132396	.1193362	1.11	0.267	-.1014986	.3662906
_cons	.0726513	.1638663	0.44	0.658	-.2485208	.3938234
/sigma_u	.2029684	.0422014	4.81	0.000	.1202553	.2856816
/sigma_e	.1437862	.0089903	15.99	0.000	.1261655	.1614069
rho	.6658437	.0940838			.4688361	.8251383

```
  0  left-censored observations
143     uncensored observations
103 right-censored observations
```

Source(s): Author's calculations

Table 6.7C: Scale efficiency regressed with explanatory variables

```
Random-effects tobit regression             Number of obs     =       246
Group variable: CountryID                   Number of groups  =        19

Random effects u_i ~ Gaussian               Obs per group:
                                                          min =        12
                                                          avg =      12.9
                                                          max =        13

Integration method: mvaghermite             Integration pts.  =        12

                                            Wald chi2(8)      =     88.72
Log likelihood  =  124.93661                Prob > chi2       =    0.0000
```

SE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0031043	.0034846	-0.89	0.373	-.009934	.0037254
SubEmp	-.0000209	.0000464	-0.45	0.652	-.0001118	.0000699
RevSub	.0002287	.0000568	4.02	0.000	.0001173	.0003401
CapexRev	-.1295805	.0239753	-5.40	0.000	-.1765713	-.0825897
CRGDPPC	-5.43e-06	3.23e-06	-1.68	0.092	-.0000118	8.93e-07
HHI	4.72e-06	.0000117	0.40	0.686	-.0000182	.0000276
CP1	.0037414	.0008193	4.57	0.000	.0021355	.0053472
LDev	-.0209656	.0628105	-0.33	0.739	-.1440719	.1021407
_cons	.6026006	.0933819	6.45	0.000	.4195754	.7856258
/sigma_u	.1068584	.0222761	4.80	0.000	.063198	.1505187
/sigma_e	.0897652	.0050177	17.89	0.000	.0799307	.0995998
rho	.5862811	.1035936			.3808713	.7700984

```
  0  left-censored observations
175     uncensored observations
 71 right-censored observations
```

Source(s): Author's calculations

6.8 Robustness check

Robustness checks involving specifications and estimation method change were carried out on the baseline regression models (Table 6.7A, Table 6.7B & Table 6.7C). The varied specification test has three parts. The first part was the introduction of efficiency lag in the mix of explanatory variables to ascertain if prior period's efficiency influences future efficiency performance. The second part was the inclusion of an interaction term (i.e., SubEmp*CapexRev) as an explanatory variable to provide insight on the joint impact of labour productivity (SubEmp) and capital intensity (CapexRev) on efficiency performance. The third part was the introduction of quadratic terms. NYRS was introduced as quadratic term and its influence on efficiency examine. This was followed by the inclusion of CRGDPPC as a quadratic term. Appendices 4A, 4B, & 4C are the results of the model with the lag of the dependent variable (i.e., CRS TE, VRS TE, and SE). The efficiency lag was found to have positive and significant influence on CRS technical efficiency (p-value = 0.000; < 0.05) (Appendix 4A), VRS technical efficiency (p-value = 0.000; < 0.05) (Appendix 4B) and scale efficiency (p-value = 0.000; < 0.05) (Appendix 4C). The coefficient of the lag in each Appendix indicates that prior periods' efficiency substantially influence future efficiency performance. Compared to the baseline regression model (Table 6.7A, Table 6.7B, & Table 6.7C), introducing the efficiency lag in the model caused reduction in the magnitude of the coefficients of the other explanatory variables. In addition, modest differences were noted on how lags influence future efficiency scores. With the CRS technical efficiency lag, CapexRev became significant. In the case of VRS technical efficiency lag, CapexRev became significant and CPI turned insignificant. The scale efficiency lag did not change the significance of the other explanatory variables. Overall, these findings imply that past periods' technical and scale efficiencies have substantial influence on future periods' technical and scale efficiency scores.

Appendices 5A, 5B, & 5C are the results of introducing the interaction term (i.e. SubEmp*CapexRev) in the model. The interaction term has a negative and significant influence on CRS technical efficiency (p-value = 0.000; < 0.05) (Appenix 5A) and VRS technical efficiency (p-value = 0.000; < 0.05) (Appendix 5B). However, its influence on scale efficiency is positive but not significant (p-value = 0.508; > 0.05) (Appendix 5C). These findings imply that the complementary relationship between labour productivity and capital intensity impairs technical efficiency but not scale efficiency. Technical efficiency impairment by the interaction of labour productivity and capital intensity may be due to increased hiring and/or training of employees when new infratructures and technologies are acquired. However, it is less of a concern when seeking scale efficiency. NYRSSquare as a quadratic term has positive but insignificant association with CRS technical efficiency (*p*-value = 0.233; > 0.05) (Appendix 6A), VRS technical efficiency (*p*-value = 0.129; > 0.05) (Appendix 6B), and scale efficiency (*p*-value = 0.527; > 0.05) (Appendix 6C). Surprisingly, all of the variables displayed the same statistical significance they had prior to including NYRSSquare. The positive influence of NYRSSquare signifies that it could have irrelevant improvement on the technical and scale efficiencies due to the industry gaining more experience in the deregulatory environment, better adaptability and stability in the regulatory and policy frameworks governing the industry (Banker et. al., 2010; Li, 2009). Also, the influence of change in real GDP per capita (CRGDPPC) as a quadratic term was investigated. It has a positive but insignificant influence on CRS technical efficiency (*p*-value = 0.127; > 0.05) (Appendix 7A), negative and insignificant effect on VRS technical efficiency (*p*-value = 0.534; > 0.05) (Appendix 7B). Its influence on scale efficiency is positive and significant (*p*-value = 0.020; < 0.05) (Appendix 7C). Also, all of the variables maintained the statistical significance they had before the introduction of CRGDPPCSquare. Furthermore, the effect of both quadratic terms (i.e., NRRSSquare & CRGDPPDSquare) in the model was investigated. The presence of both revealed a positive and insignificant relationship with CRS technical efficiency (Appendix 8A). On the other hand, NYRSSquare has a positive influence on VRS technical efficiency (*p*-value = 0.141; > 0.05) while the effect of CRGDPPCSquare on VRS technical efficiency is negative but both are insignificant (*p*-value = 0.635; > 0.05) (Appendix 8B). Their effect on scale efficiency is positive but while the NYRSSquare is insignificant (*p*-value = 0.268; > 0.05), CRGDPPCSquare is significant (*p*-value = 0.015; < 0.05) (Appendix 8C).

Using Tobit model with continuous endogenous covariates, a change in estimation methods was effected to check for possible endogeneity among some of the independednt variables. The results are presented in Appendices 9A, 9B, & 9C. Compared to the baseline model for VRS technical efficiency (Table 6.7B), significance of the coefficients in Appendix 9B are remarkably consistent with the VRS technical efficiency baseline model. Also, the result in Appendix 9A is comparable to the baseline CRS technical efficiency in Table 6.7A except that the NYRS (*p*-value = 0.002; < 0.05) and CapexRev (*p*-value = 0.024; < 0.05) turned significant. Results for scale efficiency (Appendix 9C) is also similar to the baseline scale efficiency results in Table 6.7C but the variables NYRS (*p*-value = 0.038; < 0.05) and SubEmp (*p*-value = 0.007; < 0.05) are significant. Another estimation method involving instrumental variable regression was carried out but with Hausman test conducted to determine if fixed effect (FE) model or the random effect (RE) model would be appropriate for the estimation of the influence of environmental variables on efficiency. The null hypothesis (H_0) was that the random effect model would be appropriate. The Hausman test results with CRS technical efficiency, VRS technical efficiency, and scale efficiency as dependent variables are shown in Table 6.8A, Table 6.8B, & Table 6.8C. The *p*-value in each Table is greater than 0.05, indicating that the random effect model is appropriate. If the *p*-values were less than 0.05, H_0 would have been rejected and the fixed effect model would be deemed suitable.

The results of the random effect instrumental variables are shown in Appendices 10A, 10B, & 10C. The significance of the coefficients of the variables in the model with CRS technical efficiency in Appendix 10A is similar to the baseline random effect (RE) Tobit (Table 6.7A) except that the NYRS turned significant (*p*-value = 0.014; < 0.05). Similarly, most of the coefficients in the model with VRS technical efficiency as dependent variable in Appendix 10B are similar to the VRS technical efficiency baseline results in Table 6.7B but RevSub (*p*-value = 0.069; > 0.05) turned insignificant while CapexRev (*p*-value = 0.019; < 0.05) became significant. On the other hand, the result with scale efficiency as dependent variable in Appendix 10C displays coefficients with the same level of significance as the baseline model in Table 6.7C. Similar to Gutierrez (2003) and Ros (1999) that indicated models that assumed exogeneity and those that mitigated endogeneity yielded comparable results, the results in this research show that endogeneity had minimum effect on the baseline regression estimates. Overall, the robustness checks suggest that the baseline model is seemingly insensitive to change in specification and estimation methods. Also, it indicates that the baseline model is relatively effective in estimating the impact of environmental variables on technical and scale efficiency performance.

Table 6.8A: Result of Hausman Test with CRS technical efficiency as dependent variable

	(b) CRSTEFixed~t	(B) CRSTERando~t	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
RevSub	.00117	.0005361	.0006338	.0004521
CapexRev	-.0962201	-.0336274	-.0625928	.0703346
CRGDPPC	-.000062	-.000017	-.000045	.000026
NYRS	-.0063118	-.0086165	.0023047	.0055415
SubEmp	.0002157	.0002044	.0000113	.0000937
HHI	.0000291	8.87e-06	.0000202	.0000294
CP1	.0109915	.0070717	.0039198	.0029138

Coefficients

b = consistent under Ho and Ha; obtained from xtivreg
B = inconsistent under Ha, efficient under Ho; obtained from xtivreg

Test: Ho: difference in coefficients not systematic

chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 2.41
Prob>chi2 = 0.8779

Source(s): Author's calculations

Table 6.8B: Result of Hausmant test with VRS technical efficiency as dependent variable

	(b) VRSTEFixed~t	(B) VRSTERando~t	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
RevSub	.0004739	.0004548	.0000191	.000185
CapexRev	.1098266	.1057722	.0040544	.0263583
CRGDPPC	-.0000226	-.0000209	-1.69e-06	.
NYRS	-.0068641	-.0063821	-.0004819	.0020226
SubEmp	.0002498	.0002295	.0000203	.0000349
HHI	-6.84e-06	-1.75e-06	-5.09e-06	.0000135
CP1	.0049956	.0049143	.0000813	.0010665

Coefficients

b = consistent under Ho and Ha; obtained from xtivreg
B = inconsistent under Ha, efficient under Ho; obtained from xtivreg

Test: Ho: difference in coefficients not systematic

chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 1.45
Prob>chi2 = 0.9841
(V_b-V_B is not positive definite)

Source(s): Author's calculations

Table 6.8C: Result of Hausman test with scale efficiency as dependent variable

	(b) SEFixedEff~t	(B) SERandomEf~t	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
RevSub	.0008118	.0003252	.0004866	.0003151
CapexRev	-.1997038	-.141621	-.0580828	.0491157
CRGDPPC	-.0000447	-.0000225	-.0000221	.0000178
NYRS	-.0008242	-.0043409	.0035167	.0038512
SubEmp	-.0000272	.0000224	-.0000495	.0000648
HHI	.0000334	5.33e-06	.000028	.0000206
CP1	.0071319	.0040815	.0030504	.0020234

b = consistent under Ho and Ha; obtained from xtivreg
B = inconsistent under Ha, efficient under Ho; obtained from xtivreg

Test: Ho: difference in coefficients not systematic

chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 3.93
Prob>chi2 = 0.6862

Source(s): Author's calculations

Summary

This chapter analyzes and discusses the partial measures of performance and total factor analysis of the efficiency and productivity performance. The partial measures of performance show that Canada performed better than Nigeria in the period of study on measures such as labour productivity (i.e., SubEmp and RevEmp) while Nigeria attained better results on CapexSub through reduced capital expenditures but this proved to be detrimental to its efficiency performance. The assessment of the efficiency analysis indicates the two countries are distinctly inefficient and need to supplement the required decrease in input–output mix with increased operational scale to attain efficiency. Nonetheless, improvements in mean efficiency scores in both countries and for the sample of countries in the study indicate that operating in deregulated environment enhances efficiency and confirms prior empirical studies (e.g., Ros, 1999; Lee, Park, & Oh, 2000; Gutierrez, 2003) but contradicts Torres & Bachiller (2013).

While the total factor productivity growth (TFPG) in the two countries varied, both achieved productivity growth. The decomposition of total factor productivity growth showed both chose different paths. Technical and efficiency change were responsible in Canada, but the contribution from technical change was marginal. Efficiency change was the main contributor in Nigeria as the country's technical change regressed. Further analysis of efficiency change showed that pure technical efficiency change was mostly responsible for the efficiency improvement in Canada, whereas scale efficiency enhancement was the main contributor in Nigeria. The finding of improved efficiency is not entirely suprising given the level of competition in the industry and the constant threats from non-traditional low cost service providers such as Skype, Watzapp etc. that compel firms in the industry to engage in efficiency and productivity improvements. However, the finding that both countries attained total factor productivity growth through efficiency chnage suggests it is easier to augment productivity through efficiency improvement measures (e.g., employee training and development, proper management, enhanced managerial acumen, input reduction, output increase, scale adjustment etc.) that contribute to effective allocation of organizational resources rather than technical change which typically requires capital expenditure and could take longer to implement. The Mann-Whitney tests indicate that Canada has higher mean efficiencies than Nigeria but their total factor productivity growth is comparable.

Environmental factors that influence efficiency performance were investigated using a random effect (RE) panel Tobit model. The model showed that the number of years in deregulation has a negative but insignificant influence on technical and scale efficiencies, indicating it may detract efficiency performance. However, when included as a quadratic term, the coefficient is positive albeit insignificant statistically. This finding suggests that as the number of years in deregulation increases, its effect on technical and scale efficiency is strengthened and the industry may start to experience efficiency gains but the gains could be less of a consideration for technical and scale efficiency improvements. It would not be unsual to expect newly deregulated telecommunications industry to display lower technical and scale efficiency scores. This is because after deregulation, the industry would require time to adjust its operational size and reorganize productive inputs. However, as time progresses, efficiency would improve due to increased experience in the deregulatory environment, better adaptability and stability in the regulatory and policy frameworks governing the industry (Banker et. al., 2010; Li, 2009). Revenue to subscriptions was found to drive technical and scale efficiency performances. This signals that countries with rising revenue per subscriptions will display better technical and scale efficiency scores. Also, high economic growth has a negative and statistically insignificant relationship with efficiency, implying that it has irrelevant negative influence on efficiencies. This suggests that the industry in a country with low economic growth may display technical and scale efficiencies that are comparable to countries experiencing high economic growth. However, when added as a quadratic term, its effect on scale efficiency is positive and significant (Appendices 7C & 8C), signifying that economic growth may have unimportant influence on technical efficiencies, the marginal influence on scale should not be ignored. Although infinitesimally small, the value of the coefficient signals that countries with high economic growth may express better scale efficiencies but it would be marginal.

Labour productivity is important in determining technical but not scale efficiency, suggesting that countries with high labour productivity tend to display better technical efficiency performance. Capex to revenue ratio does not appear to have an influence on technical efficiency, but it does have a negative and statistically significant influence on scale efficiency. This implies that the higher the capital expenditure per dollar of revenue in the industry, the lower the scale efficiency. This is an interesting finding and should not be interpreted to imply cutting capital expenditures as doing so would imperil innovation and responsiveness of firms in the industry to customers' needs (GSMA, 2013). Rather, it should be construed to indicate maximizing capacity usage and/or avoiding infrastructure duplication by sharing and collaborating on infrastructure spending. Nonetheless, the foregoing shows that a higher CapexRev ratio in Nigeria (0.72) compared to Canada (0.2) contributed to the inefficiency noted in Nigeria. Furthermore, the partial measure of performance in Section 6.4.8 showed HHI declined in all of the countries in the sample over the study period, thus indicating the occurrence of increased competition. However, its influence on technical and scale efficiencies are not statistically significant, meaning that it has no relevant influence on efficiency performance. Prior studies present mix evidence. Some (e.g., Gutierrez, 2003; Li & Price, 2011) found it influences performance while others (e.g., Hu & Chu, 2008) established it does not. This research confirms the findings in the latter.

Inflation was found to have significantly positive influence on technical and scale efficiency levels, suggesting improvements in performance in an inflationary economy. The level of development positively drives technical efficiency but negatively impacts scale efficiency. Because these impacts are statistically insignificant, a country's development level is not essential to technical and scale efficiency of the industry, suggesting that irrespective of the level of development, the industry in different countries may display similar technical and scale efficiency levels. The evaluation of the effect of lags of technical and scale efficiency performance revealed a significantly positive relationship and the magnitude of the coefficient is also large, suggesting that past periods' efficiency score has the greatest influence on future technical and scale efficiency performance. The interaction term (i.e., SubEmp*CapexRev) provided insight on how the complementary relationship between labour productivity and capital intensity influence technical and scale efficiency. It has a statistically significant negative influence on technical efficiency scores but a statistically insignificant positive link with scale efficiency. The undermining of technical efficiency by the interaction term may be due to labour productivity not sufficiently compensating for the higher capital intensity.

Chapter 7

Results and Discussion of the Survey of Industry Participants

7.1 Introduction

Chapter 6 presents the results of the efficiency and productivity analysis of the telecommunications industry and showed that the industry improved in the period of study. Also, the chapter discusses the influence of environmental factors and higlights variables that influence technical and scale efficiency levels. Chapter 7 presents the analysis of the survey questionnaire completed by industry participants and provides more insights on the deregulated environment and events in the industry in the two countries (i.e. Canada and Nigeria) of focus. The chapter concludes with a narrative that summarizes the findings.

7.2 Results of the survey questionnaire

The industry's performance evaluated in Chapter 6 was further examined by asking individuals knowledgeable about the industry to complete a survey questionnaire consisting of 20 questions (Appendix 11). In completing the questionnaire, participants were allowed to describe and interpret events in the industry from their own perspective. Involving individuals with knowledge of the industry enriches the research process, provides in-depth understanding of the problems and complements the partial measures of performance and total factor analysis findings. Participants' responses were analyzed with the outcomes presented descriptively and inferences drawn. The descriptive statistics provides useful understanding and interpretation of responses from participants. To allow inferences to be made about the two countries, econometric analysis was considered. Given that the sample size that yielded the primary data is not large enough, alternative inferenctial statistics (i.e. t-test and nonparametric test) which have been used in studies (e.g. Demirbag, Tatoglu, Glaister, & Zaim, 2009) with similar approach to this research were considered. Unlike the t-test, the nonparametric test accommodates categorical and quantitative data and does not require the assumption that the population has a normal probability distribution (Egboro, 2015). In view of this, Mann-Whitney (Wicoxon rank-sum) test which is a nonparametric test was applied and the level of significance was set at alpha of 0.05. The analysis provided insightful information and allowed inferences to be made on the differences between the two countries of focus in this reseracrch.

7.2.1 Background and profile of participants

7.2.1.1 Number of years at current employment

Participants' background and profile provide the basis for understanding participants' views and placing their responses in the context of the research. Table 7.1 shows how long participants have worked at their current place of employment. Three of the five participants from Canada have spent over 20 years at their place of employment. Of the remaning two, one indicated less than five years and the other stated 6-10 years. Responses from participants form Nigeria clustered around less than five years (22 participants). The remaining 10 participants identified 6-10 years as the number of years they have spent at their current employment. Most participants, 23 (62%), have been at their current employment for less than five years, 10 (27%) for 6–10 years, 1 for 11–15 years and 3 (8%) for more than 20 years.

Table 7.1: Participant's response on duration at current place of employment.

Duration	Canada n = 5	Nigeria n = 32	Total n = 37
Less than 5 years	1	22	23
6–10 years	-	10	10
11–15 years	1	-	1
16–20 years	-	-	–
Over 20 years	3	-	3
Total	**5**	**32**	**37**

Source: Survey data analysis

7.2.1.2 Occupational title of participants

Table 7.2 presents the job titles of participants. Of the five participants from Canada, three were directors, one was a manager, and the remaining participant indicated other as job title but did not specify. Most (19) participants from Nigeria were managers, six were supervisors, three were coordinators, two were directors. The remaning two particpants indentified other as their job titles but did not specify. Overall, 20 (54%) of pariticipants in the study were managers, 6 (16%) were supervisors, 3 (8%) were coordinators, 5 (14%) were directors and 3 (8%) indicated other but did not specify their exact titles.

Table 7.2: Participants' job title.

Job Title	Canada n = 5	Nigeria n = 32	Total n = 37
Manager	1	19	20
Supervisor	-	6	6
Coordinator	-	3	3
Director	3	2	5
Executives	-	-	–
Other (Please Specify)	1	2	3
Total	**5**	**32**	**37**

Source: Survey data analysis

7.2.1.3 Educational attainment of participants

Participants were asked to indicate their educational attainment. All have at least a college level education (Table 7.3): 13 (35%) possess a postgraduate degree (Masters/PhD), 21 (57%) have a university education and 3 (8%) indicated college education.

Table 7.3: Participants' educational attainment.

Educational Attainment	Canada n = 5	Nigeria n = 32	Total n = 37
Less than high school	-	-	–
High school	-	-	–
College (e.g., certificate/diploma)	1	2	3
University	1	20	21
Postgraduate (e.g., Masters/PhD)	3	10	13
Other (Please Specify)	-	-	–
Total	**5**	**32**	**37**

Source: Survey data analysis.

7.2.1.4 Types of services provided

To gain knowledge of the services provided in the industry, participants were asked to indicate the services their firms offer. Because participants were allowed select all that applied to them, a total of 51 responses were obtained (Table 7.4). 29 (56.8%) responses identified Wireless/mobile phones (GSM) services, 6 (11.8%) responses indicated CDMA, 9 (17.7%) specified fixed/wireless services and 7 (13.7%) stated other services (Table 7.4). In the category of 'other services', Canadian participants specified Internet/data, TV, satellite TV and video content while Nigerian participants specified Internet, data and customer care services. The response pattern shows firms offer multiple services to customers. Also, Table 7.4 reveals wireless/mobile phone as the service most mentioned by participants from both countries. In addition, the analysis of other services shows multiple product/service offerings which suggest diversification in the industry. The benefit of diversification is that it reduces revenue risks (Ernst & Young Global Ltd, 2015). Due to a greater scope for diversification (i.e., TV, satelite TV and video content), the Canadian telecommunications industry may withstand competitive pressures better than the Nigerian telecommunications industry in a period of declining telecommunications revenue. However, it may reduce the flexibility of management in using inputs and also expose the industry to new sets of risks (Noam, 2006).

Table 7.4: Types of services provided.

Services	Canada	Nigeria	Frequency
Wireless/mobile phone services	3	26	29
CDMA	1	5	6
Fixed/wireless services	1	8	9
Others (Please specify)	5	2	7
Total	**10**	**41**	**51**

Note: Participants were allowed to select all that apply
Source: Survey Data Analysis

7.2.2 Deregulation

7.2.2.1 Telecommunications industry stage

To assess performance from participants' perspectives, it was important to get a sense of their views of the industry. When asked to indicate the nature of the industry, all of the five participants from Canada indicated it was maturing, a finding that is consistent with the partial measures of performance in Section 6.4.1 that showed limited opportunity for growth in the Canadian telecommunications industry. On the other hand, most participants from Nigeria, 21 (66%) described the industry as emerging, a finding that harmonizes with the teledensity trend in Section 6.4.1 that showed potential for growth in the industry in Nigeria. Unexpectedly, a sizeable number of participants from Nigeria, 10 (31%) viewed the industry as maturing which is contrary to the majority opinion. This observation may be due to the negative impact of slowed growth and increased competition on profitability (Enders, König, Hungenberg, & Engelbertz, 2009). Furthermore, the results demonstrate perception differs among participants from the two countries. This is not entirely surprising given that the telecommunications industry in Canada was deregulated earlier than the telecommunications industry in Nigeria. In addition, the finding that the Canadian telecommunications industry is mature is consistent with Simon (2013) who noted that the mature state of the industry in Canada compels firms to be customer-centric while the observation that the Nigerian telecommunications industry is emerging align with Omowunmi, Niran, & Oluseyi (2009) who evaluated Nigeria's telecommunications policy and suggested the industry fits the description of an emerging industry.

7.2.2.2 Pattern of change in the industry

When asked to classify change in the industry, all of the 8 (22%) participants who indicated it was very rapid were from Nigeria (Table 7.5). Of the 18 (49%) that said it was rapid, 5 were from Canada and 13 from Nigeria. 10 (27%) stated it was moderate and one identified it as slow (Table 7.5). The responses cluster around very rapid and rapid, suggesting that most participants viewed the change in the industry as rapid or very rapid. Nonparametric Mann-Whitney (Wilcoxon Rank-Sum) test was conducted to determine if the views expressed by Canadian participants differ from that expressed by Nigerian participants. With the null hypothesis that participants from the two countries have similar views of the pattern of change in the industry, the result in Table 7.5 singifies the null hypothesis could not be rejected (p-value = 0.7187; > 0.05). This finding highlights that participants from both countries have similar views of the pattern of change in the industry which they noted as at least rapid. This harmonizes with Massey & Beaudry (2015, p. 6) who reported that the Canadian telecommunications industry has undergone 'substantial and rapid change'. It is also consistent with the view in Obayemi (2014) that competition in the Nigerian telecommunications industry has led to remarkable growth.

Table 7.5: Pattern of change in the industry.

Change Pattern	**Canada n = 5**	**Nigeria n = 32**	**Total n = 37**
Very rapid	-	8	8
Rapid	5	13	18
Moderate	-	10	10
Slow	-	1	1
Very slow	-	-	–
Rank sum Expected z = 0.360 p-value = 0.7187	102.5 95	600.5 608	703 703

Source: Survey data analysis

7.2.2.3 The role of the industry regulator

For insights on the perception of the regulatory agency's role, participants were asked to describe the role of industry regulator. The responses formed seven categories (Table 7.6). While all five participants from Canada answered this question, 12 (38%) participants from Nigeria did not. However, the result shows that participants identified a variety of roles performed by the regulatory agency. Most see the regulator as promoting competition (8) and protecting customers (8). Other roles are policy maker and enforcer (6), supervision (6), regulator (4), resolving disputes (1) and support (1). This result indicates respondents view the main role of the regulator as promoting competition and protecting customers.

The answer from one participant was:

> *'Regulate broadcast and Telecom industry to promote competition and better options for customers'.*

This response cuts across multiple categories and provides a comprehensive view of the role of the regulatory agency. The finding that the regulator promotes competition and protects customers is consistent with the goals of regulation noted in Blackman & Srivastava (2011). In addition, the perception that the regulaor performs many functions aligns with (OECD, 2002b) which identifies telecommunications industry regulators as performing several functions.

Table 7.6: Describing the role of the industry regulator.

Category	Reasons
Regulator	• 'Regulation' • 'Regulator' • 'Regulation' • 'Regulate broadcast and telecom industry'
Sub total	**4**
Promote competition	• 'Maintain competition' • 'Promote competition' • 'To promote healthy competition in the industry' • 'Promoting competition' • 'Maintain competitiveness of the industry' • 'Controls vertical integration' • 'Allocates wireless spectrum' • 'Promote competition'
Subtotal	**8**
Policy maker and enforcer	• 'Policy maker' • 'To maintain stability' • 'Policy maker' • 'Policy enforcement' • 'Setting guidelines' • 'Mandate minimum levels of content'
Subtotal	**6**
Consumer protection	• 'Protecting consumer interest' • 'Protecting customers' • 'The do protect customers interest' • 'Customer right protector' • 'Consumer protection' • 'Customer transaction policy' • 'Maintain consumer fairness' • 'Better options for customers'
Subtotal	**8**
Supervision	• 'To supervise industry activities' • 'Supervisory' • 'Watchdog' • 'They ensure that telecom firms operate by the rule' • 'Market monitoring' • 'Minimum product performance'
Subtotal	**6**
Resolving disputes	• 'Dispute Settlers'
Subtotal	**1**
Support	• 'Provide any necessary support to telecom firms'
Subtotal	**1**
Grand total	**34**

Source: Survey data analysis

7.2.2.4 Support received from the regulatory agency

Participants were asked to indicate the type of support received from the regulatory agency. Because participants were allowed to select all that apply, 75 responses were obtained, resulting in an average of two responses per participant (Table 7.7). Of the 75 responses, 5 (7%) identified financial support, 11 (15%) related to industry and market analysis, 6 (8%) indicated infrastructure development and 13 (17%) referred to training and development. Furthermore, 24 (32%) responses leaned toward the provision and availability of information, and 15 (20%) responses identified contract/dispute resolution. The remaining response (1%) indicated 'other', but did not specify the support. The provision/availability of information, industry/market analysis and contract/dispute resolution were the top three areas identified by Canadiaan participants. Interestingly, the provision/availability of information and contract/dispute resolution were also identified by Nigerian participants, thus indicating that regulators perform the role of disseminating information and resolving disputes which typically arise from network access, fees and tariffs (Bruce et al., 2004). Nonetheless, a difference is noted. Canadian participants indicated industry/market analysis as one of the top three areas of support but Nigerian participants identified training and development as one of the top three areas of support, suggesting the need for capacity building and competency acquisition in the industry in Nigeria. The DEA technical efficiency scores in Section 6.5.1 showed a lower average technical efficiency performance for Nigeria, hence, the findings relating to training and development provide insights that buttress the DEA findings. In addition, the total factor productivity change analysis in Section 6.5.3 reflects the beneficial effect of training and development as the pure technical efficiency change of the industry in Nigeria which was 0.9002 between 2001 and 2002 (i.e., a decline of 10% per year) was reversed to a progress of 18.3% between 2012 and 2013. The training may have contributed to the industry's 1.27% per year pure technical efficiency change improvement. Without it, the total factor productivity growth would have been lower than the 8.1% per year (Table 6.6).

Table 7.7: Support received from the regulatory agency.

Type of Support	Canada	Nigeria	Frequency
Financial	1	4	5
Industry/market analysis	3	8	11
Infrastructure development	2	4	6
Training and development	-	13	13
Provision/availability of information	3	21	24
Contract/dispute resolution	3	12	15
Other(s) please specify	-	1	1
Total	**12**	**63**	**75**

Note: Participants were allowed to select all that apply
Source: Survey data analysis

7.2.2.5 Motivation for deregulating the telecommunications industry

To guage participants' views on the reasons for deregulating the industry, participants were asked to identify motivations for deregulating the industry. Participants were asked to select all reasons that apply from the list provided in the questionnaire. The list is comprehensive and was the outcome of the review of literature (see Section 3.3.1). A total of 214 responses (Canada: 28; Nigeria: 186) were obtained (Table 7.8). The 28 responses obtained from Canadian participants respresent approximately 6 responses per participant. Also, the 186 responses obtained from participants from Nigeria indicate approximately 6 repsonses per participant. The ranking of the responses shown in Table 7.8 reveals that participants perceive the top six reasons for deregulating the industry as: universal service/wider access to telephone services (30), service quality improvement (26), promote competition (23), economic development (22), promote investment (20), maintain reasonable rates (20) and technological trend (18). Surprisingly, government deficit was the least identified while political and legal trends had 11 and 12 responses, respectively. Some studies (e.g., Akhtar, 2009; Torres & Bachiller, 2013) suggest increased competition is the primary reason for deregulating the industry, but the results in this research proved otherwise. However, it identified increased competition as one of the reasons for deregulating the industry which is consistent with OECD (2003b) and Latipulhayat (2014). Also, the finding aligns with Wallsten (2004, p. 306) who identified the main objectives of deregulation as to 'get consumers more, better, new, and less costly services'.

In addition, the finding buttresses a similar observation in Ikpe & Idiong (2011) who stated that the objective of deregulation is to extract the maximum public benefit from the free market and competition, indicating that competition is not the goal of deregulation but the vehicle through which deregulatory objectives are achieved. Furthermore, the identification of investment as one of the top six reasons corroborates Awoleye et al., (2012) who identified increased investment in telecommunications infrastructure as stemming from deregulation. Interestingly, technological trend was also identified among the top reasons for deregulating the industry. This is fitting as the industry has been shaped by technological innovations (Gruber, 2005). Also, Table 7.8 shows socio-cultural trends as an additional motivation for deregulating the industry. Awoleye et al. (2012) recognize the social and economic significance of the telecommunications industry and note that deregulation generates economic growth and social development.

Table 7.8: Motivation for deregulating the telecommunications industry.

Change Pattern	Canada	Nigeria	Total response	Ranking
Promote investment	2	18	20	5th
Universal/wider access	3	27	30	1st
Increase teledensity	2	11	13	8th
Promote competition	3	20	23	3rd
Maintain reasonable rates	2	18	20	5th
Service quality improvement	3	23	26	2nd
Address government deficit	-	4	4	11th
Technological trend	4	14	18	6th
Economic development	3	19	22	4th
Socio-cultural trend	3	13	16	7th
Political trend	2	8	10	10th
Legal& and regulatory trend	1	11	12	9th
Other (Please Specify)	-		-	
Total	**28**	**186**	**214**	

Note: Participants were allowed to select all that apply
Source: Survey data analysis

7.2.2.6 Level of the impact of government policies

On a scale of 1 to 5, with 5 being the highest, participants were asked to rank the impact of government policies on the industry. The result presented in Table 7.9 shows that deregulation, licensing, competition and tax policies have mean ranking of least three each in Canada, suggesting each has an above moderate impact on the industry. Wage, trade and macroeconomic policies ranked less than three, indicating below moderate impact. In Nigeria, all but wage and trade policies have mean rank above three and are considered to have above moderate impact. Furthermore, Mann-

Whitney (Wilcoxon rank-sum) test was performed on each to reveal if there were dfferences in participant's responses from the two countries. The result in Table 7.9 indicates that the null hypothesis that no difference exist could not be rejected, suggesting similarities in the perception of the impact of each policy in both countries. Competition, deregulation and tax are the top three policies that impact the industry in Canada. The top three policies in Nigeria are competition, licensing and deregulation. In addition, Table 7.9 reveals interesting commonalities between the two counties. Competition ranks above three in both countries and two of the top three policies with an above moderate impact in Canada (i.e., competition and deregulation) were also in the top three in Nigeria. The recognition of deregulatory policy as having an above average impact on the industry has the support of Petrović et al. (2011) who infer good regulatory reform positively influences performance.

Table 7.9: Level of the impact of government policies.

Government Policies	Level of Impact in Canada	Level of Impact in Nigeria	Z score	p-value
Deregulatory policy			0.311	0.7559
Mean	3.4	3.3		
S.D	0.9	1.1		
Rank sum	99	567		
Expected	92.5	573.5		
Licensing policy			-0.644	0.5197
Mean	3.0	3.4		
S.D	0.7	1.2		
Rank sum	81.5	621.5		
Expected	95	608		
Wage policy			0.381	0.7028
Mean	2.6	2.6		
S.D	0.5	1.1		
Rank sum	103	600		
Expected	95	608		
Trade policy			-0.962	0.3362
Mean	2.4	2.8		
S.D	0.5	1.0		
Rank sum	74.5	628.5		
Expected	95	608		
Competition policy			0.715	0.4744
Mean	3.8	3.5		
S.D	1.1	1.1		
Rank sum	110.5	592.5		
Expected	95	608		
Macroeconomic policy			-1.425	0.1542
Mean	2.6	3.2		
S.D	0.9	0.8		
Rank sum	65.5	637.5		
Expected	95	608		
Taxes policy			-0.190	0.8491
Mean	3.2	3.2		
S.D	1.3	1.2		
Rank sum	91	612		
Expected	95	608		
Other(s) (Please specify)	–	–	-	-

Note: Participants were allowed to rate more than one area
Source: Survey data analysis

7.2.2.7 Influence of government policies on the industry

On a scale of 1 to 5, with 5 being the highest, participants were asked to identify the influence of government policies on the industry. The Mann-Whitney (Wilcoxon rank-sum) test result in Table 7.10 shows that the similarities between the two countries. The mean responses from participants from both countries indicate that participants viewed increased competition as the area where government policies had the most influence (Canada: 3.8; Nigeria: 3.7). Network access, increased subscriptions, innovation, and product pricing and delivery each have a score of at least 3. In addition, participants from both countries saw partnership among operators as a low impact area. However, there exist some subtle and insignificant differences between the two countries. Canadian participants viewed government policy impact on reduced cost and investment in infrastructure as low and high respectively, signifying that government policies have minimum effect on operators' costs but higher effect on investment in infrastructure. The opposite is the case in Nigeria.

Table 7.10: Influence of government policies on the industry.

Areas of Impact	Level of Policy Impact in Canada	Level of Policy Impact in Nigeria	z score	p-value
Innovation Mean S.D Rank sum Expected	 3.0 0.7 73 87.5	 3.4 1.3 522 507.5	-0.725	0.4682
Product pricing and delivery Mean S.D Rank sum Expected	 3 0.7 89.5 90	 3.0 1.1 540.5 540	-0.025	0.9802
Increased partnership among operators Mean S.D Rank sum Expected	 2.4 0.9 68 85	 2.9 1.3 493 476	-0.883	0.3370
Network access Mean S.D Rank sum Expected	 3.4 0.5 83.5 87.5	 3.5 1.0 511.5 507.5	-0.207	0.8362
Increased competition Mean S.D Rank sum Expected	 3.8 0.4 72 85	 4.0 1.0 489 476	-0.693	0.4883
Reduced costs Mean S.D Rank sum Expected	 2.8 0.8 77.5 87.5	 3.1 1.2 517.5 507.5	-0.504	0.6146
Increased subscriptions Mean S.D Rank sum Expected	 3.2 1.3 62 82.5	 3.8 1.1 466 445.5	-1.125	0.2605
Increased investment in infrastructure Mean S.D Rank sum Expected	 3.0 0.7 91.5 80	 2.7 1.3 404.5 416	0.636	0.5248
Other(s) (Please specify)	–			

Source: Survey data analysis

7.2.2.8 Perception of operating in a deregulated environment

Participants were asked to describe their perception of the deregulated environment. As shown in Table 7.11, 5 (14%) participants said it was very successful, 23 (62%) indicated it was successful, six (16%) were neutral and 3 (8%) said it was unsuccessful. The Mann-Whitney (Wilcoxon rank-sum) test indicated that percepton in both countries are statistically similar. Overall, the findings reveal that majority of participants perceived that operating in the deregulated environment has been a success, suggesting the industry benefitted from deregulation. This finding harmonizes with the result of the DEA (Sections 6.5.1 and 6.5.3) that showed efficiency improvement and total factor productivity growth in the two countries in the period of study.

Table 7.11: Perception of operating in a deregulated environment.

Perception	Canada n = 5	Nigeria n = 32	Total n = 37
Very successful	1	4	5
Successful	3	20	23
Neutral	1	5	6
Unsuccessful	-	3	3
Very unsuccessful	-	-	–
Total	**5**	**32**	**37**
Mean S.D Rank sum Expected z = 0.486 p-value = 0.6267	4 0.7 104.5 95	3.78 0.8 598.5 608	3.8 0.1

Source: Survey data analysis

7.2.2.9 Difficulty experienced in the deregulated environment

To identify challenges affecting performance, participants were asked to list difficulties experienced in the industry. Overall, finance (8), infrastructure (7), policy (5) and compliance (3) issues are the dominant difficulties in the industry (Table 7.12). Other issues identified were technology (2), disputes (2) and scale economies (2). Difficulties specific to each country were examined. The difficulties most cited by the Canadian participants were changing technology, infrastructure funding and scale economies. One of the participants from Canada invoked competition as an issue expecially for small players in the industry and stated:

‘It is hard for small companies to compete against the well established giants’.

The issues most mentioned by Nigerian participants were financial, policy, infrastructure and compliance. The findings show both countries face infrastructure issues. Inadequate infrastructure would affect service delivery and erode average revenue per subscriber (ARPS) which is detrimental to efficiency performance. Also, the responses show a difference in issues affecting the industry in the two countries. It was noted in Section 6.5.1 that the Canadian telecommunications industry would benefit from operational scale increase; the mention of scale economies by participants from Canada supports the DEA returns to scale findings. It also shows that inappropriate scale is hindering performance of the industry. Policy related issues were exclusively mentioned by participants from Nigeria, suggesting that frequent changes within the government create policy inconsistencies (e.g., spectrum issues, macroeconomic policies, tariffs and network access disputes). Another issue stated by participants from Nigeria was compliance, signifying firms are not playing by the rules. This is confirmed by a recent event in the industry in Nigeria where the regulator (i.e., Nigerian Communications Commission [NCC]) fined MTN 780 billion naira (USD5.2 billion) for non-compliance with subscriber identity module (SIM) card registration. The regulator ordered MTN to remove 5.1 million unregistered subscribers from its network but an arrangement is ongoing to settle out of court (Elebeke, 2016). It is important for firms to comply with the rules to avoid regulatory interference and to allow the industry to be market driven.

Table 7.12: Difficulties experienced in the deregulated environment.

Category	Expressed difficulties
Compliance	• 'Acceptance by industry stakeholders' • 'Anti-competitive behaviour' • 'Non-disclosure of information'
Subtotal	**3**
Technology	• 'Keep pace' • 'Technology issues'
Subtotal	**2**
Infrastructure	• 'Lack of adequate infrastructure' • 'Infrastructure deficiency' • 'Infrastructure development' • 'Power failure' • 'The services were epileptic' • 'Staff mentoring' • 'High cost of electricity to maintain appliances'
Subtotal	**7**
Policy	• 'Level playing field for small companies' • 'Lack of existing framework' • 'Bureaucratic bottleneck' • 'Frequent changes in government policies' • 'Instability in Government policies'
Subtotal	**5**
Disputes	• 'Interconnection' • 'Timely coordination and agreement'
Subtotal	**2**
Financial	• 'Have funds needed to invest in changing technologies and products' • 'Infrastructure costs' • 'Funds to build infrastructure' • 'Capital finance' • 'Finance' • 'Finance' • 'Capital' • 'Financing'
Subtotal	**8**
Scale economies	• 'Hard to compete against the well established giant' • 'Ability to develop economies of scale'
Subtotal	**2**
Grand total	**29**

Source: Survey data analysis

7.2.3 Structure of the industry and level of competition

7.2.3.1 Structure of the industry

Participants were asked to indicate the structure of the industry. Overwhelming majority of participants from the two countries identified the industry as oligopoly (Table 7.13). None of the participants indicated monopoly. 8 (22%) said it was a monopolistic competition and 3 (8%) thought it was a perfectly competititive structure. The response pattern suggests the industry is oligopolistic and corroborates the partial measure of performance analysis in Section 6.4.8 that shows the HHI of the industry (Canada: 3078; Nigeria: 3062) indicates an oligopolistic market structure. A similar structure was found in the German mobile sector (Gerpott, Rams, & Schindler, 2001).

Table 7.13: Structure of the industry.

Market Structure	**Canada n = 5**	**Nigeria n = 32**	**Total n = 37**
Monopoly	-	-	–
Oligopoly	4	22	26
Monopolistic competition	1	7	8
Perfect competition	-	3	3
Other(s) (Please specify)	-	-	–
Total	**5**	**32**	**37**

Source: Survey data analysis

7.2.3.2 Indicators of competitive intensity in the industry

To gain insight on the competitive intensity of the industry in the two countries, participants were asked to rate specific aspects of the industry as low, medium or high. The transformation of the responses into mean responses (Low = 1, Medium = 2 and High = 3) is portrayed in Table 7.14. The table shows that Canadian participants rated capital investment required high (mean = 3) and growth rate below medium (mean = 1.8) while the other areas were rated at least medium. Participants from Nigeria rated all but profitability growth above medium. In addition, Table 7.14 reveals that the number of firms was rated medium (mean = 2) by participants from Canada but participants from Nigeria rated it as slightly above medium (mean = 2.3), suggesting new entrants may be allowed to increase the number of service providers and/or competitive intensity in the industry. However, the seeming difference in rating is not significant (p-value = 0.2995; > 0.05). Furthermore, the low rating of profitability by participants from Nigeria signifies reduced profitability and confirms the observation of decline in average revenue per subscriber in Section 6.4.4. In addition, the trend in competition among firms in the industry in both countries is above medium (Canada: 2.4; Nigeria: 2.7), signifying culminating effect of deregulatory policy which is consistent with Byambaakhuu, Kwon, & Rho (2014) who enunciated increased competition among firms operating in the deregulated telecommunications industry.

Table 7.14: Indicators of industry competition.

Indicators	Average Rating (Canada)	Average Rating (Nigeria)	z-scores	p-values
Number of firms			-01.037	0.2995
Mean	2.0	2.3		
S.D	0	0.6		
Rank sum	75	628		
Expected	95	608		
Growth rate			-1.579	0.1142
Mean	1.8	2.2		
S.D	0.4	0.4		
Rank sum	69.5	633.5		
Expected	95	608		
Profitability growth			0.554	0.5795
Mean	2.0	1.8		
S.D	0.7	0.5		
Rank sum	105	598		
Expected	95	608		
Entry barriers			-0.693	0.4884
Mean	2.6	2.8		
S.D	0.5	0.4		
Rank sum	83	620		
Expected	95	608		
Competition among firms			-1.084	0.2785
Mean	2.4	2.7		
S.D	0.5	0.5		
Rank sum	74.5	628.5		
Expected	95	608		
Capital investment required			1.043	0.2968
Mean	3.0	2.8		
S.D	0	0.4		
Rank sum	110	593		
Expected	95	608		
Other(s) (Please Specify)	–	–		

Source: Survey data analysis

7.2.4 Conduct of firms in the industry

7.2.4.1 Barriers to entry

An important aspect of a deregulated telecommunications industry is low entry barrier. A lower barrier signifies high likelihood of increased competition. When asked to list the entry barriers in the industry, the types of barriers identified by participants were costs, regulatory policy, ownership rules, spectrum and licensing, project financing, small population and technology. One respondent presented a salient response and indicated:

‘Low margin’ and ‘declining margin’.

It is interesting that low and/or declining margins were identified as barriers. Strategic management and industry analysis research shows low or declining margins as a deterrent to new entrants (Thompson & Strickland, 1995). The finding of low and/or declining margins is consistent with GSMA (2015) and also confirms the partial measures of performance analysis results in Section 6.4.4 that indicates average revenue per subscriber is in decline. This depresses industry revenue and leads to margin decline. Another respondent considered the barrier from marketing perspectives and stated:

‘Positioning’ and ‘marketing mix’.

It is reasonable to expect the positioning and marketing mix as barriers because customers’ loyalty to a particular service provider would require new entrants to commit significant funds and time to winning customers from incumbent service providers. Also, participants gave considerations to high switching costs and a new provider’s lack of wider coverage. Other barriers identified by participants in both countries are: inability to access incumbents’ infrastructure, licensing costs, spectrum allocation and costs of building infrastructure. Barriers identified by participants from Nigeria but not by participants from Canada are considered unique to Nigeria and include: lack of power and technology. Chavula (2004) noted that inadequate power increases operational costs and inhibits the effective use of productive inputs. In addition, Okafor (2008) study of the power crisis in Nigeria shows that the poor state of power constrains firms’ operations and has caused some to reconsider their operations. In view of this, power inconsistency and inadequate technology may have contributed to the reason why the efficiency of the telecommunications industry in Nigeria lags behind that of Canada as noted in Section 6.5.1.

7.2.4.2 Deregulation and conduct of firms

On a scale of 1 to 5 (with 5 being the highest), participants were asked to indicate the level of impact of the deregulated environment on firms in the industry. The outcome presented in Table 7.15 provides the mean ranking. Participants from Canada indicated that deregulation has a high impact on product pricing (mean = 4), and product and service differentiation (mean = 3.8), close to moderate impacts on business focus, legal strategies and investment, a moderate impact on advertisement and promotion, and cooperation with competition, and a low impact on distribution, research and innovation. Participants from Nigeria specified that the deregulated environment has a high impact on advertisement and promotion (mean = 4), product pricing (mean = 3.9). All the other areas were described as experiencing slightly above moderate impacts (Table 7.15). Furthermore, the Mann-Whitney (Wicoxon rank-sum) test shows that the deregulatory environment has higher impact on advertisement and promotion in Nigeria than in Canada (p-value = 0.044; < 0.05), signifying that competitive intensity is of great concern for firms in the industry in Nigeria. The need to allocate more resources to advertisement and promotion provides useful clue to the lower technical and scale efficiency performances in Nigeria highlighted in Section 6.5.1. An objective of increased advertisement and promotion may include attracting new customers and/or motivating existing customers to use more telecommunications products and services, resulting in higher revenues and improved efficiency performance.

Table 7.15: Impact of deregulation on firms (organizations) in the industry.

Areas of impacts	Average Response (Canada)	Average response (Nigeria)	z-scores	p-values
Business focus			-0.240	0.8102
Mean	3.4	3.6		
S.D	1.3	1.1		
Rank sum	90	613		
Expected	95	608		
Product pricing			-0.187	0.8513
Mean	4	3.9		
S.D	0.7	1.1		
Rank sum	91	612		
Expected	95	608		
Advertising and promotion			-2.014	0.044
Mean	3	4.0		
S.D	1.2	1.2		
Rank sum	52	651		
Expected	95	608		
Distribution			-1.675	0.0940
Mean	2.6	3.7		
S.D	1.3	1.0		
Rank sum	58	608		
Expected	92.5	573.5		
Research and innovation			-0.845	0.3982
Mean	2.8	3.3		
S.D	1.3	1.4		
Rank sum	72.5	557.5		
Expected	90	540		
Product and service differentiation			0.446	0.6554
Mean	3.8	3.5		
S.D	0.4	1.2		
Rank sum	104.5	598.5		
Expected	95	608		
Cooperation with competition			-0.024	0.9810
Mean	3.0	3.1		
S.D	1.2	1.2		
Rank sum	92	574		
Expected	92.5	573.5		
Legal strategies			0.455	0.6493
Mean	3.4	3.3		
S.D	1.5	1.0		
Rank sum	99	531		
Expected	90	540		
Investment in infrastructure			-0.197	0.8440
Mean	3.4	3.6		
S.D	1.5	1.1		
Rank sum	88.5	577.5		
Expected	92.5	573.5		
Other(s) (Please specify)	–	–	-	-

Note: Respondents were allowed to rank impact of deregulation on more than one item
Source: Survey data analysis

7.2.5 Performance

7.2.5.1 Trends in the industry

Participants were asked to describe trends in the industry using specified criteria (Increase, No change, and Decrease). Responses shown in Table 7.16 indicate that out of the 34 that responded to this question, 22 (65%) believed the number of service providers increased, 8 (23%) said it did not change and 4 (12%) indicated it decreased. The finding of an increase in the number of service providers suggests a change in the structure of the industry and buttresses the HHI findings in Section 6.4.8. Thirty participants (88%) stated that the number of product/service substitutes increased, 3 (9%) said it did not change while the remaining 3% said it decreased. This result indicates customers have more product/service alternatives to choose from, forcing firms to seek to attract customers through low price and better service quality (Thompson & Stickland, 1995). 4 (12%) noted price (ARPS) increased, 5 (15%) indicated no change and 25 (73%) said price decreased. The finding that most participants indicated that price decreased affirms the observation of sharp decline in the price of telecommunications products and services in Turel, Serenko, & Bontis (2007). The cost of service provision is indicative of profitability and performance. Industry profitability will decline as costs rise, but the ability to contain cost is an indication of efficiency (Lee, Park, & Oh, 2000). Thirty participants (88%) stated that costs increased and four (12%) said no change. The finding that costs increased in both countries signifies profitability will decline unless firms are able to augment revenue or engage in efficiency and productivity improvement measures.

Network access terms and tariffs may result in disputes among service providers with the regulator playing an important role (Bruce et al., 2004). Twenty-five participants (74%) said access to networks increased whereas nine (26%) said it did not change. The inference is that access to networks increased but this may have been due to compliance to regulation requiring firms to give competition access to their networks. However, as noted in Blackman & Srivastava (2011), to increase competition it is essential that firms open up their network to competitors at fair rates, but compelling firms to do so at controlled tariffs may discourage infrastructure investment (Masse & Beaudry, 2014). Investment in infrastructure is an indication of service effectiveness which enhances efficiency and productivity (Moshi, Mwakatumbula, & Mitomo, 2013). Participants were asked to express their views on trends in infrastructure investment: 20 (59%) said investment in infrastructure increased, four (12%) indicated no change and 10 (29%) stated it decreased. This finding signals an increase in investment and is consistent with studies such as Li & Xu (2004) and Moshi, Mwakatumbula, & Mitomo (2013) that noted increased capital expenditures in deregulated telecommunications industry. While this finding affirms the observation of capital expenditures increase in Canada (see Section 6.4), it contradicts the finding of capital expenditures decline in Nigeria.

An important objective of deregulation is to increase competition, thus industry competition is an important measure of deregulatory policy effectiveness. A decrease in competition signals deregulatory policy ineffectiveness while an increase indicates success (Byambaakhuu, Kwon, & Rho, 2014). For this reason, participants were asked to indicate their opinions: 27 (79%) indicated industry competition increased, three (9%) said it did not change and four (12%) noted it decreased. This finding signifies most of the participants believe that industry competition increased in the deregulated environment which asserts the partial measures of performance findings in Section 6.4.8. Also, it is consistent with Hassan (2011) who showed industry competition increased in deregulated environment. Other studies about an increased level of competition in deregulated environment include Li & Xu (2004), Lu & Hung (2008) and Usero, Grigorios, & Asimakopoulos (2013). Another goal of deregulation is to improve services for customers (Wallsten, 2004). 23 (68%) indicated that the quality of service increased, 9 (26%) stated it did not change and 2 (6%) said it decreased (Table 7.16). These responses show that most participants perceive service quality improved.

Churn rate is described as the rate at which customers of a particular provider switch to another (Kamalraj & Malathi, 2013). Increased competition and policies regarding subscriber number portability is expected to allow subscribers to switch service providers and still retain their number(s), thus decreasing the cost of switching but increasing the prospect a customer will churn. Since an increase in churning could depress revenue and cause performance to deteriorate, it is important to understand the trend. Sixteen participants (47%) said the churn rate increased, 9 (26%), stated it did not change and 9 (26%) said it decreased. Most participants believed churning increased; this finding is consistent with Wong (2010) who revealed a churning rate of 1.6% per month (19.2% per year) in Canada and that it costs the industry an estimated $200 million per year. Also, Tecnotree (2013) shows an actual churning rate of 40% per year (3.33% per month) in Nigeria which is 2.1 times the rate in Canada. However, a common practice in Nigeria is for subscribers to own SIM cards from multiple networks, thus the churning rate may have actually reduce in Nigeria. This reasoning is supported by Pyramid Research (2010) that showed churning peaked at 48.4% in Nigeria in 2007 but declined steadily to 41.8% in 2009.

Table 7.16: How would you describe industry trends?

Areas	Responses
Number of service providers	• Increase (22) • No change (8) • Decrease (4)
Number of product/service substitutes	• Increase (30) • No change (3) • Decrease (1)
Prices charged customers for services provided (ARPU & ARPS)	• Increase (4) • No change (5) • Decrease (25)
Cost of producing services	• Increase (30) • No change (4) • Decrease (0)
Access to network	• Increase (25) • No change (9) • Decrease (0)
Investment in telecommunications infrastructure	• Increase (20) • No change (4) • Decrease (10)
Level of market competition	• Increase (27) • No change (3) • Decrease (4)
Quality of service provided	• Increase (23) • No change (9) • Decrease (2)
Churn rate	• Increase (16) • No change (9) • Decrease (9)
Other(s) (Please specify)	–

Note: Participants were allowed to rate more than one area
Source: Survey data analysis

7.2.5.2 Telecommunications industry performance rating

Participants were asked to state if they agreed that the industry performed better under deregulation. Only three (8%) disagreed and they were among participants from Nigeria. The 34 (92%) participants who agreed the industry did better consist of all five participants from Canada and 29 from Nigeria. This indicates that majority of participants have the opinion the industry performed better in the deregulated environment. This finding affirms prior studies, including Megginson et al. (1994) and Cabeza & Gomez (2007). For insights on the areas of improved performance, participants were asked to rate several areas of the industry on a scale of 1 to 5, with 5 being the highest. Table 7.17 shows the mean rating and indicates that participants from Canada viewed improvements in two areas (i.e., return on investment [mean = 2.8] and teledensity [mean = 2.6]) below 3, suggesting that these areas performed below average. Six areas (i.e., profitability, efficiency, productivity, market share, network accessibility and customer service) each had a rating of between 3 and 3.8, implying moderate level of perfomance while improvements in five areas (i.e., technological advancement, product/service quality, investment in infrastructure, new product/service development and increased competition) were rated between 4 and 4.4, suggesting above average performance in these areas.

Participants from Nigeria considered improvement in four areas (i.e., profitability, efficiency, technological advancement and productivity) below 3, indicating below average performance. Improvement in seven areas (i.e., product and service quality, return on investment, market share, network accessibility, customer service, investment in infrastructure and new product development) above 3 but below 4, suggesting a moderate performance in these areas. Teledensity and increased competition were identified slightly above 4, implying above moderate performance. While the majority of participants from both countries stated that the industry experienced improved performance, there exist some differences between the two countries. The p-values from the Mann-Whitney (Wilcoxon rank-sum) test presented in Table 7.17 shows difference in the perception of performance relating to profitability, technological advancement, teledensity and investment in infrastructure.

Table 7.17: Indicate how you would rate the performance of the telecommunications industry.

Measures	Mean Rating (Canada)	Mean Rating(Nigeria)	z-scores	p-values
Profitability			2.037	0.0416
Mean	3.8	2.8		
S.D	1.1	0.8		
Rank sum	138.5	564.5		
Expected	95	608		
Efficiency			0.873	0.3827
Mean	3.3	2.8		
S.D	1.7	0.7		
Rank sum	87.5	542.5		
Expected	72	558		
Technological advancement			2.835	0.0046
Mean	4.0	2.7		
S.D	0.7	0.9		
Rank sum	155	548		
Expected	95	608		
Productivity			1.215	0.2245
Mean	3.0	2.6		
S.D	0.7	0.6		
Rank sum	118	585		
Expected	95	608		
Product/servicequality			1.656	0.0978
Mean	4.2	3.4		
S.D	0.4	1.0		
Rank sum	130.5	572.5		
Expected	95	608		
Return on investment			-0.666	0.5054
Mean	2.8	3.3		
S.D	1.3	0.77		
Rank sum	81	622		
Expected	95	608		
Market share			1.182	0.2373
Mean	3.8	3.3		
S.D	0.8	0.7		
Rank sum	113	517		
Expected	90	540		
Network accessibility			1.684	0.0922
Mean	3.6	3.2		
S.D	0.5	0.6		
Rank sum	127	576		
Expected	95	608		
Teledensity			-3.303	0.001
Mean	2.6	4.0		
S.D	0.5	0.7		
Rank sum	25.5	677.5		
Expected	95	608		
Customer service			0.558	0.5768
Mean	3.4	3.2		
S.D	0.9	1.0		
Rank sum	107	596		
Expected	95	608		

Investment in infrastructure Mean S.D Rank sum Expected	 4.2 0.8 140.5 95	 3.1 1.0 562.5 608	2.108	0.0351
New product/service development Mean S.D Rank sum Expected	 4 1.2 125 95	 3.4 0.8 578 608	1.406	0.1596
Increased competition Mean S.D Rank sum Expected	 4.4 0.5 105 95	 4.1 1.0 598 608	0.478	0.6330
Other(s) (Please specify)	–	–	-	-

Note: Participants were allowed to rate more than one area
Source: Survey data analysis

The deregulated environment increased competition, thus satisfying a major regulatory objective of increased competition (OECD, 1999). The mean response (Canada: 4.4; Nigeria: 4.1) signifies that the deregulated environment increased competition in the industry in the two countries. In addition, the p-value of the nonparametric test suggests similarity in the perception of the effect of deregulation on the concentration of the industry, signifying support for the HHI finding in Section 6.4.8 that showed the industry in both countries as having oligopoly structure. Profitability perception which is moderate in Canada but is below moderate in Nigeria suggests that the deregulated environment has negative effect on profitability in Nigeria than in Canada. This finding may be related to the sharp decline in average revenue per subscriber in Nigeria noted in Section 6.4.4. The perception of efficiency performance of the industry in the two countries is statistically comparable but participants from Canada did express slighty higher mean responses, seemingly indicating that the industry did better in the dregulatory environment in Canada than in Nigeria. However, the Mann-Whitney (Wilcoxon rank-sum) test showed the mean response is not statistically different which may imply similar views of the industry's efficiency in the two countries. This is in line with the DEA finding in Section 6.5.1 that revealed the industry in both countries exhibited technical and scale inefficiencies in the period of study. Nonetheless, the above moderate mean response in Canada gives the impression the industry displayed better efficiency performance and affirms DEA efficiency outcome reported in Section 6.5.1.

The high rating of technological advancement by participants from Canada implies improvement in this area, but participants from Nigeria viewed the impact of deregulation on this area low. In addition, the mean response differs significantly (p-value = 0.0046; < 0.05), indicating that the deregulated environment may have spurred more innovation and technology use in the industry in Canada than in Nigeria. Increased use of technology is considered integral to productivity improvement (Ng, 2012); the presumption is that better technology in Canada infers higher productivity but this is inconsistent with the DEA MPI analysis that showed Canada with a lower total factor productivity growth compared to Nigeria (Section 6.5.3) but the difference is not statistically significant (Section 6.6). Additionally, deregulation resulted in more products and better service quality in Canada and Nigeria, but the rating by Nigerian participants is inconsistent with Hassan (2011) who noted that inadequate infrastructure impedes service quality in Nigeria. Unexpectedly, mean responses from Canadian participants show a lower rating for return on investment (ROI) compared to the mean rating by Nigerian participants but the p-value reveals both are comparable. Since return on investment is asset turnover multipled by profit margin (Jansen, Ramnath, Yohn, 2012), the finding may suggest that turnover and/or margin performance are lower in Canada due to higher average capital expenditures (Table 6.1B).

Deregulation has above moderate influence on market share, network accessibility and cost of service in the two countries. Teledensity performance is below average in Canada but above average in Nigeria, denoting better teledensity improvement in Nigeria. This finding augments the partial measures of performance resultss in Section 6.4.1. Unlike the slightly above moderate rating of investment in infrastructure by participants in Nigeria, the high rating of the impact of deregulation on investment in infrastructure by participants from Canada suggests that the Canadian telecommunications industry performed better on this measure than Nigeria. This observation is consistent with the results in Appendices 1D and 1N that shows higher capital expenditures in Canada. The ratio of capital expenditures between the two countries was 2.2 in 2001 but increased to 6.1 in 2013. The appendices also indicate that Canada experienced capital expenditures increase between 2001 and 2013 but that Nigeria experienced a decline. Another area of difference is new product development but the null hypothesis that they are comparable could not be rejected (p-value = 0.16; < 0.05) (Table 7.17). Nevertheless, the higher mean response on this measure by Canadian participants may indicate that the deregulatory environment spurred greater level of new product development and introduction in Canada.

7.2.5.3 Competitive strategies

To understand the strategies of firms in the industry, participants were asked to identify the competitive strategies that their firms use. Participants selected from Porter's (1985, pp. 12–15) three main generic strategies: 'cost leadership', 'differentiation' and 'focus'. Participants from Canada emphasized cost leadership the most (90%), followed by product differentiation (60%) and focus strategy (40%), suggesting that the dominant strategy in the Canadian telecommunications industry is cost optimization while the secondary strategy is product differentiation. This contradicts the position in Simon (2013) that indicates customer focus as the main strategy. Participants from Nigeria identified product differentiation the most (51%), followed by focus strategy (26%) and cost leadership (23%). It is not surprising that product differentiation is the dominant strategy and focus is the secondary strategy in the Nigerian telecommunications industry. The high level of competition in the industry in Nigeria necessitates firms to distinguish their product/service from competiton. Also, the incidence of churning in the industry may have prompted firms to embrace a customer focus strategy as the secondary strategy in order to segment and effectively tailor services to customers' unique needs and curtail churning risks.

Summary

This chapter presents the results of the survey questionnaires completed by participants from the telecommunications industry in Canada and Nigeria. Particpants from the industry provided useful insights that complement the efficiency and productivity findings. Participants revealed that the industry is maturing in Canada but it is emerging in Nigeria, implying limited opportunity for growth in Canada. It was also noted that the industry received support (e.g., information and contract/dispute resolution) from the regulatory agency. Additionally, the top six reasons for deregulating the industry were identified as universal accessibility, service quality improvement, promoting competition, economic development, promoting investment and technological trends. The literature suggested addressing government deficit is paramount in the decision to deregulate, but this research finds that it is the least identified reason for deregulating the industry. Also, policies affecting the industry are similar (e.g., competition and deregulatory policies). However, there is a difference in the level of impacts. The view of participants that operating in the deregulated environement has been a success enhances the total factor analysis conclusion that the industry experienced improved efficiency and productivity in the period of study (Section 6.5.1 and Section 6.5.3). Issues plaguing the industry differ between the two countries. In Canada, the industry is grappling with technological change, infrastructure finance and economies of scale. The industry in Nigeria is also experiencing financing issues; however, policy inconsistencies, inadequate infrastructure and compliance issues are unique to it. In addition, the results of the analysis revealed that the industry in the two countries is an oligopoly structure with trends that show an increase in the number of service providers and products, and a decline in average revenue per subscriber amid rising costs and infrastructure investment.

Chapter 8
Conclusion and Implications of this Study

8.1 Introduction

This research empirically examined the efficiency and productivity performance of telecommunications industry in deregulated environments and comparatively evaluated the cases of Canada and Nigeria. The absence of empirical research on the experiences of the two countries is the motivation for conducting this research. Using panel dataset consisting of industry data from 19 countries over a 13-year period, two broad research objectives were addressed. The first was to understand how deregulatory policies influenced the competitiveness of the industry. To achieve this objective, the research identified the force(s) driving telecommunications industry deregulation; explored the similarities and differences in the deregulatory milieu between the two countries; and identified the impact of operating in a deregulated environment on the industry's competitive intensity. The second objective was to understand the performance of the industry. To attain this objective, comparative analysis of the efficiency and productivity performance of the industry was carried out; environmental factors that influence efficiency were assessed and the direction of influence and statistical significance were identified. The research also ascertained the applicability of the SCP model to the deregulatory outcomes in the two countries. The findings in this research provided answers to the research questions.

This research is presented in eight chapters. Chapter 1 introduced this research. Chapter 2 provided information on the evolution of the industry and highlighted the significance of the industry. Chapter 3 provided the the theoretical review and framework. It was used as the stage for understanding regulation and deregulation. The examination of literature provided insightful information on the rationale behind regulation and deregulation and the approaches often applied to enact them. The reviews showed social and economic reasons and the desire to protect the public as the bases for the prominent roles various governments have played in allowing a monopoly telecommunications industry. However, as noted in the chapter, there were mechanisms put in place to prevent the monopoly from misusing its power. Nonetheless, the literature examined revealed the ineffectiveness of regulated monopolies contributed to the quest for deregulated operating environment. Furthermore, using historical narratives, the chapter summarized events that culminated in the industry's deregulation in the two countries. Also, the chapter provided the conceptual and theoretical framework on which this research rests. It delved into market structure and presented an array of theoretical constructs on market structure. Chapter 4 reviewed the literature on deregulated telecommunications industry efficiency and productivity analysis. It elaborated on the concepts of efficiency and productivity and their measurement. Also, the chapter discussed empirical researches that have evaluated telecommunications industry efficiency and productivity in different settings and contexts. While some studies related that deregulation increase competitive intensity and that this bring about performance improvement, others infer that it impede efficiency and productivity performance.

The research methodology and data presented in Chapter 5 detailed the research design and methodology, the DEA model, the MPI, the Tobit model and the considerations for involving industry participants. Chapter 6 was used to present and discuss the results of the DEA and the Tobit model. The chapter started with a partial factor analysis discussion and revealed that no single country was best in all categories of the partial measures of performance, hence the total factor analysis involving DEA efficiency and productivity analysis of the industry. The result showed an overall improvement in the Canadian telecommunications industry's technical efficiency, pure technical efficiency, scale efficiency and total factor productivity productivity over the period of study. Nigeria also displayed an improvement in all but pure technical efficiency. The Mann-Whitney test results in the chapter revealed that Canada displayed higher technical and scale efficiency scores but that the total factor productivity growth in the two countries are comparable. In addition, the random effect (RE) panel Tobit model identified the influence of environmental variables on efficiency scores and showed that the number of years in deregulation (NYRS) has an insignificant negative association with technical and scale efficiencies. However, the effect of its quadratic term is positive but also insignificant. Labour productivity (SubEmp) positively influences technical efficiency and its effect on scale efficiency is negative and statistically insignificant. Change in real GDP per capita (CRGDPPC) showed a negative and statistically insignificant effect on technical and scale efficiencies. Its quadratic term revealed a positive and significant effect on operational scale efficiency.

In addition, the model revealed that an increase in revenue to subscriptions (RevSub) improves technical and scale efficiencies. Also, the model showed that capital expenditure to revenue (CapexRev) ratio has insignificant influence on technical efficiency but statistically significant negative effect on operational scale efficiency. The level of concentration (HHI) was found to have no significant effect on technical efficiency and scale efficiency. Level of inflation (CPI) was found to have an important positive effect on technical and scale efficiency. The influence of the level of development (LDev) variable on technical efficiency is positive and insignificant. Its effect on scale efficiency is negative and insignificant. Efficiency lags have statistically significant positive effect on technical and scale efficiency. The interaction between labour productivity and capital intensity revealed a statistically significant negative influence on technical efficiency but a statistically insignificant positive association with scale efficiency. Chapter 7 presented the results of the survey questionnaires completed by the industry participants involved in the study. The participants provided information complementary to the DEA findings. The insights provided showed that the telecommunications industry in Canada is maturing while that in Nigeria is emerging and that the growth in both countries has slowed. The general view of the participants was that the industry benefitted from deregulation. The final chapter (Chapter 8) presents the major findings, the contribution to the body of knowledge (theory and practice), policy implications, limitations, recommendations and suggestions for future research.

8.2 Purpose and research objective revisited

The purpose and objectives of this research were articulated in the preceding seven chapters. The two broad research question and three sub-questions through which each was viewed were addressed. The research questions and findings are presented in this section.

8.2.1 RQ_1: How have deregulatory policies influenced the competitiveness within the telecommunications industry in the two countries?

This research question was meant to discern the influence of deregulatory policies on the competitiveness of the telecommunicatons industries. This objective was addressed through quantitative analysis of secondary data and a discussion of the results of the partial factor analysis and total factor analysis in Chapter 6 and the presentation of the results and discussion of the completed survey questionnaires in Chapter 7. Results from the analysis of the secondary data showed increased level of competition in the industry in the two countries. This is supported by the participants' identification of deregulatory policy as having an above moderate impact on the industry's competitive intensity. Sub-questions to RQ_1 and the findings of this research are:

8.2.1.1 $RQ_{1.1}$: What are the driving forces of telecommunications industry deregulation in the Canadian and Nigerian context?

1. The industry participants identified reasons for deregulating the industry as universal service/wider access to telephone services, service quality improvement, promote competition, economic development, promote investment, maintain reasonable rates, and technological trends. Contrary to insinuations in Akhtar (2009) that an increase in competition is the main reason for telecommunications industry deregulation, the finding in this research indicates increased competition and an array of reasons (i.e., wider access, better service quality, economic development, investment promotion, technological trends etc.) as motivations for deregulating the industry. This is consistent with telecommunications industry reforms and structures discussed in OECD (2002b) and Blackman & Srivastava (2011).
2. Deregulation and competition policies were identified as impacting the industry. Thus, they are considered major driving forces shaping the industry. Tax policy was identified, but was mostly considered an influencing factor in the Canadian case. GSMA (2014) shows that a high tax burden removes investment incentives and reduces the capacity to raise capital to finance new investments. Another important policy is licensing policy but this mainly relates to Nigeria. However, Masse & Beaudry (2014) note that this is a concern in Canada's search for a fourth player in the industry. Restrictive spectrum licensing policy hinders investment and innovation (GSMA, 2014).

8.2.1.2 $RQ_{1.2}$: What are the similarities and differences in Canada's and Nigeria's deregulatory milieu?

1. The review of literature showed political ideologies influence deregulatory decisions. In Canada and Nigeria the moves to deregulate the industry

suggest an ideology rooted in political conservatism which favours individual liberty, fiscal discipline and free market. The view was that a regulated environment constrains choices for customers and impedes the full functioning of market forces, but that customers are better served in a deregulated environment where competition instills market discipline and moves firms in the industry to innovate and improve performance (Lacobucci, Trebilcok, & Winter, 2006).

2. Both countries have a regulatory agency (Canada: CRTC; Nigeria: NCC) tasked with attaining deregulatory objectives. In addition, unlike Canada where monopoly was held provincially, NITEL held a national monopoly of the industry in Nigeria prior to deregulation. Also, CRTC is armed with the 'forbearance' clause that gives it the the ability to stay the application of regulatory provisions if doing so is consistent with the Canadian telecommunications policy objectives.
3. A significant majority of the participants agreed that the industry has been successful in the deregulated environment. This corroborates the DEA efficiency and productivity results. While the industry in both countries is experiencing some difficulties, the nature of the difficulty differs. In Canada, the difficulties identified were changing technology, infrastructure financing and scale economies. In Nigeria, the difficulties identified were financial, policy instability, infrastructure issues and compliance. Additionally, the industry in both countries appears to have issues related to finance.
4. The subscriptions increase in both countries suggests better accessibility due to improved economic conditions and affordability. This finding harmonizes with Wallsten (2001) that indicates correlation between per capita income and subscriptions per capital. However, the high teledensity in Canada implies greater accessibility but signals limited growth potential. In addition, unlike Canada, subscriptions in Nigeria grew at a higher rate than revenues, generating greater price decline.
5. Decline in average revenue per subscriber (ARPS) enhances affordability and subscriptions growth; a scenario that benefits customers and satisfies the deregulatory objectives (i.e., universal/wider access to telephone services, maintain reasonable rates etc.). However, continuous pressure on revenue hinders performance but this is being addressed as the industry in Canada

utilizes cost and product differentiation strategy while Nigeria uses product differentiation and focus strategy.

6. Capital investment is essential to improving network infrastructure and expanding service to customers. The resultant increases in revenues and labour productivity would generate efficiency and productivity improvement, making the industry competitive (European Telecommunications Network Operator's Association, 2013). The result of the survey questionnaires showed increased collaboration is paramount to reducing infrastructure costs and that it enables the industry to offer services through technologically advanced platforms. Also, it reduces infrastructure duplication and capacity underutilization which contributes to improvements in the performance of the industry (GSMA, 2014).

8.2.1.3 $RQ_{1.3:}$ What impacts does operating in a deregulated environment have on the industry's competitiveness?

1. The industry in Canada is mature while that in Nigeria is emerging but experiencing slow growth. These environments foster competition as reflected by the level of concentration (HHI) of the industry in both countries in 2013 (Canada: 3078; Nigeria: 3062) which is a decline from the HHI in 2001. The increased competitive intensity in the two countries discussed in Section 6.4.8 is affirmed by the survey findings that showed government policies have an above moderate impact on competition. However, as the competitive intensity increases, average revenue per subscriber (ARPS) will decline, eroding profitability and subjecting the industry to lower efficiency and productivity performances.
2. Both countries experienced CRS technical efficiency and scale efficiency improvements and productivitity growth. However, the findings also reveal lower technical and scale efficiency scores and a deteriorated VRS technical efficiency for Nigeria. The inferior efficicency performance of the industry in Nigeria may be due to the ineffectiveness of managers in utilizing inputs and the industry's inappropriate operational scale. In addition, the total factor productivity growth of the industry in the two countries are statistically comparable, but Nigeria underperformed Canada on technical and scale efficiencies. This implies that to be competitive, Nigeria will have to reduce inputs in an amount greater than in Canada or to increase outputs in an

amount greater than in Canada. The VRS technical efficiency also reveals another setback for the industry in Nigeria. The VRS technical efficiency shows that managers in both countries did not optimize resource allocation, implying that both countries would benefit from training and development targeted at enhancing managerial acumen. However, the lower VRS technical efficiency in Nigeria signifies a precarious situation. Participants from Nigeria identified training opportunities as a service provided by the regulator. Thus, the industry may work with the regulator in establishing a training framework that delivers the competencies required to foster managerial effectiveness in allocating resources.

8.2.2 $RQ_{2:}$ How has the performance of the industry been in deregulated environment?

This research question was meant to reveal the efficiency and productivity performance of the industry. This was addressed through partial factor analysis and total factor analysis. The DEA reveals inefficiency in the two countries of focus (i.e. Canada and Nigeria) but both experienced efficiency improvement in the period of study. The total factor productivity growth which was evaluated using DEA-based MPI suggests that the two countries attained productivity improvements in the study period. Specific details of the findings were presented in Chapter 6. Sub-questions to RQ_2 and the findings of this research are:

8.2.2.1 $RQ_{2.1:}$ What are the performances (i.e., efficiency and productivity) of the industry in the two countries and how do they compare?

The partial factor analysis findings show that:

1. Canada displayed a higher teledensity but slowed growth compared to Nigeria. This indicates increased accessibility in the two countries but the growth potential is dim in Canada. Because teledensity signifies subscriptions per capita, the higher teledensity in Canada (2013: 128.74) compared to Nigeria (2013: 97.15) signifies industry saturation limited growth opportunities for firms in the industry.
3. SubEmp improved in both countries but Canada exhibited a superior performance due to using technology that has allowed it to better deploy productive inputs and to contain employment growth. Another measure of labour productivity is revenue to employment (RevEmp) ratio which also

improved in the two countries. Canada displayed higher RevEmp but growth in Nigeria is superior. The improvement on these measures provide evidence of increased labour productivity in the deregulated environment and is consistent with Nadiri & Nandi (1999) study that indicate increased labour productivity in deregulated environment.

4. Capital expenditure to employment (CapexEmp) ratio in Canada is eight times that in Nigeria: for every dollar in capital expenditure spending per employment in Nigeria, Canada would spend $8. This may have contributed to the increase in labor productivity in Canada. However, similar to Nigeria, the Canadian telecommunications industry was found to be inefficient, suggesting it may not have benefitted greatly from a higher CapexEmp. In addition, it was observed that both countries invested in telecommunications infrastructures but exhibited negative Capex to subscriptions growth. This may signify that subscriptions are rising faster than investment in the industry as firms seek to bolster profitability amid increased competition and declining average revenue per subscriber. While this preserves short-term performance, in the long term, performance will deteriorate due to capacity constraints and the inability of the industry to respond to customers' needs (GSMA, 2013).

The total factor analysis findings relating to efficiency performance are:

1. Both countries experienced efficiency improvements in the study period but displayed technical efficiency scores of less than 1, implying they were technically inefficient and could further increase efficiency by reducing inputs or increasing outputs. Additionally, the CRS technical efficiency gaps between Canada and Nigeria shrank, suggesting better CRS technical efficiency improvements in Nigeria.
2. The VRS technical efficiency in both countries is below 1. However, the two countries are dissimilar. The VRS technical efficiency improved in Canada but declined in Nigeria. The decline in Nigeria indicates deterioration in managerial effectiveness.
3. Both countries were scale inefficient as their scale efficiency scores were less than 1. However, Canada displayed a modest scale efficiency decline whereas Nigeria exhibited a remarkable scale efficiency improvement in the study period. Nonetheless, both countries were scale inefficient. Although, the average scale efficiency in Canada is higher, Nigeria

outperformed Canada in the last two years of the study. This suggests that unlike Nigeria, Canada is departing from the most productive scale size and that scale inefficiency is increasingly contributing to its technical inefficiency.

4. The non-parametric Mann-Whitney test conducted on each of the efficiency scores (CRS TE, VRS TE and SE) is statistically significant, confirming that Canada exhibited better efficiency scores than Nigeria. This finding is similar to findings in Hu & Chu (2008) that show wealthy areas in Asia–Pacific displayed higher efficiency scores than less wealthy areas in the region.
5. Both countries were distinctively inefficient and require long-term solutions in tackling the identified inefficiencies. The short-term focus should be on improving managerial competencies (e.g., training and skills development) and motivating managers through incentives tied to enhanced performance. In the long term, the focus should be on operational scale adjustment to attain most productive scale size. Interestingly, the returns to scale in both countries are increasing resturns to scale, indicating that the scale adjustment would require size increase.

The total factor analysis findings relating to productivity growth are:

1. It is possible to attain total factor productivity growth through improvement in either technical change or efficiency change or both. Thus, a country seeking to enhance productivity may concentrate on technology utilization or efficiency improvement or both. This finding harmonizes with the productivity improvement theory that productivity enhancement is attainable through technological progress and efficiency improvement (Banker et al., 2010). Furthermore, New Zealand and the US are the benchmarks and peers for Canada and Nigeria and a host of other countries. Therefore, in seeking improvement measures, Canada and Nigeria would benefit from dissecting the US or New Zealand models.
2. The productivity analysis revealed both countries experienced productivity growth in the deregulated environment but it has slowed. While the average total factor productivity growth in Nigeria seemed higher, the Mann-Whitney (Wilcoxon Rank-sum) test showed that it is not statistically significantly higher. This implies that the total factor

productivity growth in the two countries in the period of study is comparable.

3. The total factor productivity growth decomposition revealed that the Canadian telecommunications industry experienced technical and efficiency change progressions. However, its total factor productivity growth was mainly due to improvement in efficiency. The decomposition of the efficiency change shows a negligible contribution from scale, hence the noted improvement in efficiency was mainly due to managerial effectivenes. Unlike the Canadian telecommunications industry with technical and efficiency change improvements, the Nigerian telecommunications industry experienced technical change retardation but efficiency change progression. Howevr, similar to Canada, the total factor productivity growth in Nigeria was due to efficiency change but the improvement in efficiency was mainly due to enhanced operational scale. In addition, the technical regress in Nigeria suggests it lags behind in using new technologies and may have underinvested in telecommunications infrastructures. The long-term implications for the industry are: reduced capabilities in responding to changes in customers' needs, poor quality of service, and a higher rate of customer dissatisfaction which would culminate in plausible deterioration in performance. Nonetheless, the finding signifies that Nigeria could attain better total factor productivity growth by optimising existing technologies. If existing technologies are inadequate, the industry should emphasize the adoption of new technologies to improve performance (Banker, Chang, & Majumdar, 1998; Petrović et al., 2012).

8.2.2.2 $RQ_{2.2}$: What influence do environmental factors have on efficiency performance of the industry?

The main findings about the influence of environmental factors on efficiency are:

1. Telecommunications industries with higher RevSub will experience improved technical efficiencies and operate closer to the most productive scale size or have better scale efficiency than those with lower RevSub. Higher RevSub which drives technical and scale efficiencies could be attained by offering innovative products and services that command a

premium price and/or that will motivate current customers to upgrade or bundle services. This will increase revenue per subscription and contribute to a higher RevSub with a positive influence on technical efficiency and operational scale.

2. The telecommunications industries in countries with low economic growth may display technical efficiency performance that is comparable to those in countries experiencing high economic growth. However, it is possible that countries with high economic growth will display superior scale efficiency but it would be marginal. Higher economic growth signifies wealth and does not imply increased disposable income that influences affordability and usage.
3. Higher CapexRev has no effect on technical efficiencies (CRS TE and VRS TE). However, it detracts scale efficiency; indicating that scale inefficiency could be mitigated by avoiding capacity underutilization. Capacity underutilization may occur if current capacity is not fully utilized or if the industry invests in capital assets and new infrastructure but employees lack the requisite training and knowledge in using them effectively.
4. Labour productivity enhances technical efficiency. Its influence on scale efficiency is insignificant. Increasing telecommunications industry efficiency would require improved labour productivity which could be attained through innovative production techniques, training and skills development, and better management.
5. Level of concentration is positively linked with CRS technical efficiency and scale efficiency but negatively associated with VRS technical efficiency. However, its effect on all three efficiency measures isstatistically insignificant. This indicates that the level of competition has no effect on technical efficiency and operational scale performance of the industry.
6. The number of years in deregulation has no important negative effect on technical and scale efficiencies, suggesting that the number of years in deregulation has little to do with technical and scale efficiency performances. This finding indicates that efficiency may fluctuate over time as the industry reorganizes productive inputs and/or adjusts

operational scale in response to changes in regulatory policies and operating environment. However, the square of the number of years in deregulation has a positive but insignificant association with efficiencies, signifying that technical and scale efficiencies may strengthen as the number of years in deregulation elongates. Nonetheless, the influence is not consequential to technical and scale efficiency improvements.

7. Inflation is positively associated with technical and scale efficiencies. The enhancement to technical and scale efficiency levels may be due to the ability of the industry to increase/decrease price at a rate higher/lower than inflation/deflation in the economy.
8. A country's level of development does not seem to have significant influence on the technical and scale efficiency of the industry. This indicates that telecommunications industry in developed and developing countries may display similar capabilities in input utilization, managerial effectiveness, and operational scale.
9. Efficiency lags positively influence technical and scale efficiencies. The magnitude of the coefficients suggest that efficiency lags are the most important drivers of technical and scale efficiencies, implying that past periods' technical efficiency and operational scale performances have substantial influence on future periods' performances.
10. The complementary relationship between labour productivity and capital intensity impairs technical efficiency. Its influence on scale efficiency is positive but immaterial. The impairment in technical efficiency may be related to increased hiring and/or training of employees when new infrastructures and technologies are acquired.

8.2.2.3 $RQ_{2.3}$: Ascertain the applicability of the structure-conduct-performance (SCP) model to the deregulatory outcome in the two countries.

This research also sought to ascertain the applicability of the structure-conduct-performance model to deregulatory outcomes. The findings are that:

1. The partial factor analysis indicated impoved efficiency and productivity performances while the industry concentration declined, signifying that lower concentration benefitted the industry. This consistent with prior empirical studies (e.g., Dabler, Parker, Saal, 2002) that identified increased competition and improved performance in deregulated telecommunications industry.

Furthermore, responses from industry participants pointed to a link between structure, conduct and performance. However, the Tobit model results showed HHI has a positive effect on CRS technical efficiency and operational scale performance and could infer that a higher level of industry concentration results in a higher technical efficiency and scale performance but its influence is stastistically insignificant. In addition, its effect on pure technical efficiency (i.e., VRS technical efficiency) is negative and may indicate diminishing effect on managerial effectiveness, however, it is not statistically significant. These findings do not result in validating or denying the SCP model.

8.3 Other findings

Aside from the findings related to the research questions, other findings from this research that have implications are:

1. The average efficiency score under VRS technical efficiency is greater than under CRS technical efficiency. This finding is in congruence with established DEA theory that efficiency scores under variable returns to scale are higher than under constant returns to scale because scale impact is eliminated under variable returns to scale (Gokgoz & Demir, 2014). This finding signals reliability and consistency of the DEA model in this research with prior empirical studies.
2. This research finds that efficiency and productivity differences among countries diminished during the study period. Similar results have been reported in Erber (2005). The performance of the sample of countries and categories revealed efficiency and productivity improved and that middle income countries narrowed performance difference with high income countries and OECD countries on efficiency measures (i.e., CRS technical efficiency, VRS technical efficiency, and scale efficiency). Also, middle income countries attained faster scale efficiency improvement and outperformed high income countries and OECD countries on the total factor productivity growth measure. This suggests that high income countries and OECD countries are more effective than middle income countries in allocating productive inputs and may have operated closer to the most

productive scale size, their productivity growth lag behind middle income countries.

3. The three categories of countries (i.e., HICs, MICs and OECD) have efficiency scores of less than 1. Further examination revealed that the high income countries (HICs) and OECD countries categories are marginally inefficient (CRS TE < 1; 0.9 < VRS TE < 1) but middle income countries (MICs) category is distinctly inefficient (CRS TE < 1; VRS TE < 0.9). This finding implies that high income countries and OECD countries could address the technical inefficiency through a slight change in input and output configuration but not so for middle income countries. In addition, the sources of inefficiency in all three categories are pure technically inefficiency and scale inefficiency but the pure technical inefficiency contributed mostly to the inefficiency, suggesting that in the short term, enhanced managerial acumen and incentives to managers to engage in activities pertinent to improving efficiency performance would benefit the industry. In the long term, the focus should be on moving the industry closer to the most productive scale size through scale adjustment.
4. This research showed that operating in a deregulated environment improves efficiency performance. However, there is evidence of efficiency decline from 2001 values in some countries (Brazil and South Korea experienced CRS technical efficiency decline; Brazil, Nigeria and South Korea experienced VRS technical efficiency decline; and Australia, Canada, China and South Korea experienced scale efficiency decline). This signifies that deregulated environment generates impacts that vary across countries and validates the observation of non-uniform adaptation in competitive environment noted in Torres & Bachiller (2013).
5. Technical change did not contribute greatly to total factor productivity growth in middle income countries but efficiency change which was 10.3% per year did. This level of efficiency change was attained through scale efficiency improvement of 3.3% per year and pure technical efficiency change of 6.8% per year. Similar to middle income countries, the source of total factor productivity growth in OECD countries was mainly efficiency improvement of 2.5% per year that was attained through scale enhancement of 0.8% per year and pure technical efficiency progress of 1.7% per year. On

the contrary, high income countries category though showed total factor productivity growth, its technical change regressed. The total factor productivity growth in high income countries was attained through improved efficiency but the efficiency change was the result of equivalent contributions from operational scale enhancement and improved managerial effectiveness.

6. The sample of countries in the panel showed total factor productivity growth of 5.7% per year. Since no technical change occurred, the total factor productivity growth was exclusively due to efficiency improvement. Further decomposition of the efficiency change indicated scale improvement of 2.1% per year and managerial effectiveness of of 3.6% per year. A similar study but with focus on Asia–Pacific and dependence on firm level data instead of industry data, shows a lower total factor productivity growth (0.2% per year), higher technical change progression (3.4% per year) and efficiency retardation (3.1% per year) caused by decline in managerial effectiveness (1% per year) and operational scale deterioration (2.2% per year).

8.4 Contributions of this research

8.4.1 Contributions to theory

This research contributes to the discussion on the motivation and rationale for deregulation and the performance of telecommunications industry. Several studies have examined the telecommunications industry's performance in developed and developing economies, but no known studies have placed African countries in the context of other countries as performed in this research. In addition, this research provides empirical evidence of efficiency and productivity improvements and their sources. It is construed that the interaction between structure, conduct and performance is not unidirectional; this resulted in SCP model refinement in this research. The refined model is an integrated and empirically relevant framework for understanding the interplay between structure, conduct and performance. In addition, the refined model made the linkages between structure, conduct and performance explicit and provides interaction with external environmental variables. The finding in this research revealed inconsistency in the performance of the industry in the countries studied and provided insufficient evidence to confirm or refute the SCP model. Another contribution of this research is its consistency with prior research and affirmation that a country's decision to deregulate the telecommunications industry is influenced by an array of factors.

8.4.2 Contributions to research methodology

This research contributes to the understanding of the efficiency and productivity performances of telecommunications industry. It used a diverse set of tools and applied both quatitative and quanlitative data in a mixed method approach. The data used in the DEA are current and the primary data collected through the survey questionnaire were designed to capture greater insights from industry practitioners. Unlike other research in the field that relied on secondary data only, the approach used in this study involves primary and secondary data to provide a complete picture of the industry. Furthermore, the advantage of the approach adopted is that they complemented each other and mitigated weaknesses associated with using each alone. In addition, the Tobit model which was used to assess the influence of environmental variables on efficiency performance gives evidence that the industry is affected by external factors. Furthermore, this research provides empirical evidence of improved efficiency and productivity performances of telecommunications industries in deregulated environments. In addition, the approach used is tranferrable and easy to implement should there be an interest to replicate this research in the quest to understand the telecommunications industry in countries other than those covered in this research or in studies focused on investigating the performance of industries other than the telecommunications industry.

8.4.3 Contributions to the telecommunications industry

This research contributes to the industry's understanding of events leading up to deregulation and the competititive intensity that deregulation brings. In addition, this research has identified for the industry how efficiency and productivity could be attained and the environmental variables that influence performance. Furthermore, this research has identified that declining revenue makes the industry inefficient and has also drawn attention to the value of infrastructure investment through partnerships on infrastructure funding and development to minimize costs and to increase labour productivity, efficiency and productivity.

8.4.3.1 Implications for managers in the telecommunications industry

Chapter 1 touched on the competitiveness of the telecommunications industry. The industry continues to experience pressure on price due to increased competitive intensity. It is essential for managers in the industry to possess knowledge about how events in the industry are unfolding and their impact on the industry. This research provides managers with information on efficiency and productivity and the changing business environment in order to develop a strategic response that leads to increased efficiency and productivity. The response may include input minimization, output maximization, managerial effectiveness and operating closer to the optimal scale. Furthermore, productivity growth is attainable through technological innovation and efficiency improvement measures. This will require investment in infrastructure and technology to reduce costs, increase labour productivity and enhance efficiency (Calabrese, Campsi, & Mancuso, 2002). Additionally, this research provides information on areas that should be focused on for better performance to be attained. Hence, the areas of deficiency identified could serve as means for evaluating managerial competencies, effectiveness and performance. Because organizational resources are limited, it is important for managers of firms in the industry to understand the competitive environment and allocate resources in ways that maximize value. In addition, managers in telecommunications industries that are distinctly inefficient should realize that eliminating the inefficiency would require a long-term rather than a short-term focus. However, they could set short-term goals that include reallocating inputs, training managers to acquire decision-making skills and/or hiring managers who already possess those skills. The long-term focus should entail reviewing and making adjustments to the operational scale. If the review necessitates increased operational scale, a decision such as working with the regulatory authority for issuing more spectrum licences should be explored for firms in the industry to expand services and to extend their geographical presence and for new firms to enter the industry. However, if the evaluation reveals that scale reduction is neccessary, measure that discourage scales enlargement should be pursued.

8.4.3.2 Implications for policy

The background and literature review revealed several forces contribute to telecommunications industry deregulation and that a deregulated environment results in performance improvement. The findings in this research showed that participants from the industry believe that operating in the deregulated environment benefitted the industry, implying that policies favouring deregulation should be sustained. Because regulatory authorities in various countries guage the industry to see if it meets expectations, this research could serve as a useful tool for assessing the industry prior to policy changes. Another policy implication is that regulatory policies in the two countries should focus on adjusting the operational scale of the industry. The size increase required could be attained through issuing new licences and spectrums in a competitive bidding process that is fair to all participants. Furthermore, the findings in this research indicate that the telecommunications industry in Canada experienced minute technological progression whereas that in Nigeria experienced technological deterioration. Also, the results showed that the average country in the sample experienced low to neglible technological change in the period of study. Since the industry could attain higher productivity growth through technological innovation (Madden, Savage, Ng, 2003) policy change in favour of innovative technology adoption will benefit the industry. The policy change should promote technology acquisition and offer tariffs and incentives through tax breaks to firms seeking to import new technology and/or invest in research and development activities that enhance the technological capability of the industry.

Additionally, regulatory policies should encourage rather than stifle innovation. Government regulatory policies should be geared toward support for technological development and innovation. They should stimulate investment in capital expenditure and the acquisition of innovative technologies that allow firms in the industry to produce value added services that customers will be willing to pay a premium for. This will increase the overall industry profitability through revenue increase and cost reduction from improved labour productivity with a positive impact on performance. Also, the model used to evaluate environmental variables showed that economic growth somewhat influences scale efficiency. As part of an inclusive measure, governments should consider implementing macroeconomic measures that facilitate economic growth. The decline in average revenue per subscriber (ARPS) is linked to too much competition and has been noted as removing incentives for investment in the industry (GSMA, 2013). This research finds a general decline in the average revenue per subscriber (ARPS) in all of the countries except Australia and Canada. Beacause too much competition puts pressure on revenue per subscription and leads to poor performance, deregulatory policies should seek to maintain competition at a level not detrimental to the performance of the industry (OECD, 2003b). Taking contrary actions would result in inferior performance and cause firms to leave the industry, increasing industry concentration and counteracting the principles behind deregulation.

8.4.3.3 Implications for practice

This research has practical implications for the two countries of focus. First, it details current performances of the industry and provides insights into areas needing improvements. Thus, firms in the industry are better informed on what needs to be done to enhance efficiency and productivity. Second, this research identified New Zealand and the US as peers for Canada and Nigeria. Hence in seeking performance improvements Canada and Nigeria may work together to discuss mutual areas of interest and learn from the experiences of New Zealand and/or the US. In addition, Canada and Nigeria would benefit from exploring relationships with New Zealand and/or the US and adopting models that seem to have worked in those countries. Third, the research identified the telecommunications industries in Canada and Nigeria as being distinctly inefficienct and that both countries require short-term and long-term focus. In the short term, technical efficiency could be enhanced through better allocation of inputs, improved managerial capabilities, training initiatives, and a redesign of the incentive to focus attention on the effective utilization of inputs. In the long term, attention should be directed at scale efficiency imrprovement. Fourth, the findings in this research show that improvement in performance occurs in deregulated environment. Given that a number of countries around the world are yet to deregulate their telecommunications industry, this research could be used as evidence of the benefits of deregulation.

8.5 Limitations of the study

Chapter 4 detailed the measures taken to ensure the validity and reliability of this research despite the noticeable limitations. First, the study utilized secondary data from the ITU, World Bank, OECD Communications outlook, regulatory agencies and statistical bureau in each country. However, it is recognized that accounting requirements and disclosures differ among the countries and may bias the efficiency and productivity results. Nonetheless, the data are reliable and the monetary inputs and outputs for each country are expressed in US dollars with the price difference accounted for. Second, the outcome of the survey questionnaire did not reflect the regulators' views because those who responded positively to the invitation to participate were mostly from firms in the industry. The Canadian regulatory agency (CRTC) expressly declined to participate and informed the researcher to access the necessary information online. Third, DEA efficiency and productivity scores are relative. Hence, increasing or decreasing the number of countries may change the results. Finally, this research used a panel dataset over a 13-year period (2001–13) although it is recognized that telecommunications industry deregulation occurred earlier in Canada than in Nigeria. While this limits the generalization of the result, it does not make it invalid in that the focus of this research is maintained and the practice is consistent with studies (e.g., Karayazili, 2004; Petrović et al., 2012) that have examined telecommunications industry efficiency across multiple countries. More so, to provide better insight, the experiences of the two countries were discussed in the context of 17 other countries.

8.6 Future research

This research applied data envelopment analysis (DEA) which is a non-paramentric method to analyze the efficiency and productivity and did establish evidence of improved performance of the industry in the two countries in the period of study. The use of DEA is suitable in the context of this research because it allowed for multiple inputs and outputs without priori assumptions. However, the efficiency scores generated are relative to the benchmark, and DEA requires no statistical tests and does not have the ability to deal with measurement error (Coelli et al., 2005). In view of this, future research should consider using parametric stochastic frontier analysis (SFA) which requires assumptions about the functional form of the model but does allow statistical tests to be perfomed to determine the appropriateness of the model. The results of the outcome of DEA and SFA should be compared to provide insight on whether the two methodological approaches provide similar findings. This research focuses on telecommunications industry performance in deregulatory environment. It did not empirically investigate the impact of speed and scope of deregulation on the efficiency and productivity performances. Furture research should investigate this area. In addition, this research focused on technical and scale efficiencies but the outcome reveals that performance improvement is incumbent on resource reallocation. Hence, future research should endeavour to investigate the allocative efficiency and cost efficiency of the industry so as to yield information on cost savings that will accrue to the industry should it attain efficiency status by optimizing inputs.

Furthermore, the finding in this research that showed that Canada attained improved efficiency through pure technical efficiency change but Nigeria mainly through scale efficiency change hints at differences in managerial practices and effectiveness between the two countries. While this research was not specific on the kind of management practice that may have generated improved total factor productivity growth in Canada, future research should endeavour to identify the management practices that resulted in better performance in Canada. Additionally, this research utilized rigorous econometric analysis in the examination of the effect of environmental variables on efficiency performance. While it applied descriptive analysis to provide a concise summary of the survey data, it used nonparamentric Mann-Whitney (Wilcoxon rank-sum) test to allow inferences to be made about the industry. Econometric analysis was noted to also allow for inferences to be made but the sample size in this research is not large enough to yield robust econometric models notwithstanding the fact that it would broadened the scope of the research beyond its intended focus. In view of this, future research should consider a survey of larger population and apply econometric analysis. Also, telecommunications service recipients were not included in the study because the intention was to complement the analysis of the efficiency and productivity of the industry with information gathered from industry participants with knowledge of the industry. Given the deregulatory objective of protecting service recipients from abuse by the monopoly, future research should consider involving service recipients to get an understanding of their views and experience in the deregulated environment.

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APPENDIX 1: TELECOMMUNICATIONS INDUSTRY DATA

APPENDIX 1A: Telecommunications Industry Data for Australia

	Input 1	Input 2	Input 3	Output 1	Output 2	Partial Measures of Performance							
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	4,292	21,192	84,800	19,902	109.16	250	234,693	939	0.22	203	50,617	18,619	5,314
2002	7,057	23,070	88,700	20,279	117.40	260	228,629	879	0.35	306	79,563	19,504	4,970
2003	5,068	24,807	91,400	23,590	124.69	271	258,101	951	0.21	204	55,451	22,737	4,841
2004	5,346	26,850	99,500	28,286	133.40	270	284,286	1,053	0.19	199	53,725	29,482	4,576
2005	5,141	28,540	100,400	30,814	139.94	284	306,911	1,080	0.17	180	51,202	32,780	4,642
2006	4,890	29,700	102,300	30,211	143.49	290	295,322	1,017	0.16	165	47,801	34,360	4,226
2007	6,611	31,020	95,000	33,693	148.94	327	354,661	1,086	0.20	213	69,591	39,034	4,248
2008	6,389	31,490	90,500	32,258	148.19	348	356,443	1,024	0.20	203	70,594	47,495	4,193
2009	5,833	32,909	90,300	30,076	151.71	364	333,068	914	0.19	177	64,600	40,691	4,174
2010	6,172	33,125	86,000	37,210	150.35	385	432,674	1,123	0.17	186	71,767	51,283	4,201
2011	7,265	34,362	90,000	42,117	153.81	382	467,961	1,226	0.17	211	80,722	58,512	4,149
2012	9,214	34,809	99,700	46,198	153.15	349	463,366	1,327	0.20	265	92,415	66,256	4,076
2013	9,852	35,290	92,200	35,310	152.60	383	382,972	1,001	0.28	279	106,858	67,671	3,744

Source(s): ILO (2015); ITU (2003; 2015); OECD (2011; 2013)

APPENDIX 1B: Telecommunications Industry Data for Belgium

	Input 1	Input 2	Input 3	Output 1	Output 2	Partial Measures of Performance							
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	1,710	12,829	21,762	8,495	124.71	589	390,374	662	0.20	133	78,592	23,078	5,357
2002	1,419	13,033	19,290	8,863	126.14	676	459,449	680	0.16	109	73,539	25,007	5,100
2003	1,371	13,481	23,291	11,059	129.92	579	474,825	820	0.12	102	58,855	30,703	4,982
2004	1,408	13,933	23,921	12,341	133.70	582	515,916	886	0.11	101	58,840	35,548	4,673
2005	1,469	14,399	22,445	12,624	137.42	642	562,447	877	0.12	102	65,446	36,928	4,661
2006	1,376	14,575	21,284	11,137	138.18	685	523,264	764	0.12	94	64,636	38,936	4,530
2007	1,451	15,585	18,651	11,800	146.68	836	632,676	757	0.12	93	77,819	44,450	4,819
2008	1,618	16,076	19,230	11,885	150.11	836	618,062	739	0.14	101	84,129	48,561	4,608
2009	1,536	16,411	19,309	11,142	152.01	850	577,021	679	0.14	94	79,543	44,999	3,850
2010	1,633	16,794	18,947	10,402	153.79	886	549,005	619	0.16	97	86,188	44,361	4,315
2011	1,986	17,130	19,031	10,261	155.06	900	539,156	599	0.19	116	104,350	47,802	4,173
2012	1,552	16,961	18,910	9,350	152.42	897	494,425	551	0.17	92	82,075	44,818	3,272
2013	2,397	16,912	18,601	9,292	151.23	909	499,545	549	0.26	142	128,883	46,927	3,824

Source(s): Barnes (2014a; 2014b); BIPT (2012; 2013; 2014); OECD (2013); The World Bank (2006)

APPENDIX 1C: Telecommunications Industry Data for Brazil

Year(s)	Input 1 CAPEX (USD Millions)	Input 2 Subscriptions (Thousands)	Input 3 Employment	Output 1 Total Revenue (USD Millions)	Output 2 Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
						Partial Measures of Performance							
2001	23,536	66,177	93,494	36,478	37.39	708	390,161	551	0.65	356	251,741	2,925	3,361
2002	6,763	73,692	93,500	33,555	41.08	788	358,872	455	0.20	92	72,331	2,580	3,961
2003	4,522	85,578	69,475	30,139	47.08	1,232	433,816	352	0.15	53	65,082	2,699	3,221
2004	6,261	105,184	76,120	35,227	57.16	1,382	462,777	335	0.18	60	82,245	3,377	3,204
2005	7,288	126,063	81,597	41,766	67.72	1,545	511,860	331	0.17	58	89,316	4,459	3,187
2006	7,313	138,719	102,920	46,492	73.73	1,348	451,732	335	0.16	53	71,054	5,519	3,535
2007	8,053	160,380	112,954	58,091	84.41	1,420	514,284	362	0.14	50	71,294	6,905	3,401
2008	11,930	191,877	128,357	46,020	100.06	1,495	358,527	240	0.26	62	92,940	8,117	3,194
2009	7,495	210,883	132,327	58,826	108.99	1,594	444,552	279	0.13	36	56,641	8,014	3,279
2010	9,068	239,071	152,100	60,800	122.47	1,572	399,737	254	0.15	38	59,619	10,425	2,948
2011	11,985	277,383	195,000	62,737	140.85	1,422	321,727	226	0.19	43	61,462	12,260	2,830
2012	11,930	292,629	200,000	63,881	147.30	1,463	319,405	218	0.19	41	59,651	11,474	2,658
2013	8,553	316,138	214,694	62,831	157.78	1,473	292,655	199	0.14	27	39,840	11,209	2,405

Source(s): ITU (2003; 2015); MarketLine Industry Profile (2015a); OECD (2015a); Pyramid Research (2011); Simon (2011); Ramboll Management (2007)

APPENDIX 1D: Telecommunications Industry Data for Canada

Year(s)	Input 1 CAPEX (USD Millions)	Input 2 Subscriptions (Thousands)	Input 3 Employment	Output 1 Revenue (USD Millions)	Output 2 Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
						Partial Measures of Performance							
2001	6,120	31,775	124,652	24,864	102.23	255	199,469	783	0.25	193	49,093	23,197	3,746
2002	4,839	32,494	119,933	24,649	103.61	271	205,521	759	0.20	149	40,345	23,704	3,908
2003	3,709	33,903	117,134	25,906	107.03	289	221,163	764	0.14	109	31,664	27,121	3,186
2004	4,427	35,583	118,038	28,650	111.21	301	242,719	805	0.15	124	37,504	30,819	3,027
2005	4,979	35,165	118,285	31,046	108.83	297	262,470	883	0.16	142	42,091	34,909	3,538
2006	6,510	36,985	117,974	34,067	113.55	314	288,764	921	0.19	176	55,180	39,183	3,392
2007	7,977	38,559	116,997	37,142	117.24	330	317,460	963	0.21	207	68,180	42,938	2,463
2008	11,449	40,343	116,449	38,423	121.35	346	329,954	952	0.30	284	98,314	44,660	3,526
2009	7,143	42,520	116,608	36,621	126.44	365	314,051	861	0.20	168	61,257	41,657	3,415
2010	8,155	44,219	115,735	40,441	130.04	382	349,428	915	0.20	184	70,463	46,241	3,272
2011	9,227	45,114	116,302	41,924	131.36	388	360,475	929	0.22	205	79,332	50,166	3,241
2012	9,289	45,446	115,040	41,001	130.77	395	356,411	902	0.23	204	80,743	51,552	3,174
2013	8,471	45,281	111,338	39,249	128.81	407	352,521	867	0.22	187	76,086	51,289	3,078

Source(s): CRTC (2006; 2010; 2014); OECD (2013); ITU (2015)

APPENDIX 1E: Telecommunications Industry Data for Chile

	Input 1	Input 2	Input 3	Output 1	Output 2	Partial Measures of Performance							
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	1,340	8,568	19,855	3,534	54.78	432	177,992	412	0.38	156	67,500	4,454	5,106
2002	800	9,711	19,391	3,173	61.39	501	163,645	327	0.25	82	41,232	4,306	4,954
2003	717	10,520	16,815	3,116	65.77	626	185,314	296	0.23	68	42,642	4,597	4,727
2004	717	12,580	14,238	3,095	77.80	884	217,387	246	0.23	57	50,334	5,791	4,634
2005	904	14,005	16,291	5,296	85.72	860	325,115	378	0.17	65	55,518	7,080	4,452
2006	1,428	15,834	19,312	5,894	95.94	820	305,190	372	0.24	90	73,969	8,307	4,128
2007	1,603	17,415	30,334	6,688	104.47	574	220,472	384	0.24	92	52,851	9,904	4,005
2008	1,930	18,326	31,059	7,276	108.88	590	234,251	397	0.27	105	62,141	10,622	3,835
2009	1,407	20,015	31,591	6,555	117.79	634	207,500	328	0.21	70	44,524	9,746	3,648
2010	1,920	23,310	36,513	6,677	135.91	638	182,866	286	0.29	82	52,584	11,655	3,550
2011	2,328	25,682	36,897	7,494	148.38	696	203,097	292	0.31	91	63,101	14,033	3,488
2012	2,287	27,222	39,548	7,829	155.86	688	197,952	288	0.29	84	57,839	15,059	3,353
2013	2,337	26,865	38,931	8,306	152.47	690	213,354	309	0.28	87	60,030	15,410	3,210

Source(s): Barnes (2015a; 2015b); Economic Indicators of Countries (2014); ITU (2015);
Foreign Invesment Committee (CIECHile) (2013); OECD (2011; 2013);
Entel Group (2014); Standard and Poor's (2013)

APPENDIX 1F: Telecommunications Industry Data for China

	Input 1	Input 2	Input 3	Output 1	Output 2	Partial Measures of Performance							
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	18,088	325,188	2,037,000	55,381	25.57	160	27,187	170	0.33	56	8,880	1,026	4,027
2002	14,873	420,227	1,892,914	62,981	32.82	222	33,272	150	0.24	35	7,857	1,135	3,752
2003	16,412	532,700	1,168,000	67,994	41.35	456	58,214	128	0.24	31	14,052	1,248	3,570
2004	17,178	646,580	1,237,000	73,808	49.89	523	59,667	114	0.23	27	13,886	1,401	3,522
2005	17,938	743,851	1,301,000	82,958	57.06	572	63,765	112	0.22	24	13,788	1,675	5,121
2006	19,985	828,844	1,382,000	94,420	63.22	600	68,322	114	0.21	24	14,461	2,004	5,182
2007	22,519	912,943	1,502,000	108,239	69.27	608	72,063	119	0.21	25	14,993	2,479	5,183
2008	27,779	981,604	1,595,000	122,373	74.10	615	76,723	125	0.23	28	17,416	3,192	5,111
2009	25,353	1,060,946	1,738,000	131,791	79.69	610	75,829	124	0.19	24	14,587	3,805	5,027
2010	25,397	1,153,386	1,858,000	158,000	86.22	621	85,038	137	0.16	22	13,669	4,222	4,869
2011	26,847	1,271,368	2,128,000	161,274	94.59	597	75,787	127	0.17	21	12,616	5,155	4,236
2012	35,408	1,390,308	2,228,000	170,969	102.93	624	76,737	123	0.21	25	15,892	6,118	4,156
2013	43,665	1,496,098	3,273,000	184,596	110.22	457	56,400	123	0.24	29	13,341	6,839	4,254

Source(s): Huang & Hao (2014); Normand (2010); ITU (2003; 2015);
The Economic Intelligence Unit Ltd. (2015); Yin & Chung (2010)

APPENDIX 1G: Telecommunications Industry Data for Germany

	Input 1	Input 2	Input 3	Output 1	Output 2			Partial Measures of Performance					
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	11,748	108,456	240,700	61,806	131.70	451	256,777	570	0.19	108	48,809	23,356	5060.5
2002	7,556	112,798	231,500	65,987	136.74	487	285,039	585	0.11	67	32,641	24,837	5052.02
2003	6,901	119,033	230,600	80,170	144.22	516	347,657	674	0.09	58	29,925	29,954	5058.32
2004	7,729	125,848	225,300	90,576	152.51	559	402,025	720	0.09	61	34,304	33,754	5036.98
2005	7,841	134,062	224,100	90,988	162.56	598	406,013	679	0.09	58	34,991	34,436	4563.01
2006	8,651	140,052	214,700	88,244	170.01	652	411,009	630	0.10	62	40,295	36,293	4,089
2007	10,123	149,333	204,600	91,110	181.52	730	445,310	610	0.11	68	49,479	41,068	3,757
2008	10,738	155,823	188,100	92,919	189.77	828	493,987	596	0.12	69	57,089	45,249	3,523
2009	8,566	158,700	184,200	84,815	193.77	862	460,450	534	0.10	54	46,501	40,944	4,322
2010	7,763	141,300	176,900	77,895	172.79	799	440,334	551	0.10	55	43,884	41,417	4,698
2011	8,164	142,300	176,000	79,462	173.97	809	451,489	558	0.10	57	46,384	45,351	4,230
2012	8,123	142,500	173,000	75,486	177.18	824	436,335	530	0.11	57	46,951	43,282	4,338
2013	8,185	148,734	170,000	72,758	184.43	875	427,991	489	0.11	55	48,149	45,322	4,236

Source(s): European Commission (2014); ITU (2015); OECD (2015a; 2013)
MarketLine Industry Profile (2015b; 2015c); Statista (2015)

APPENDIX 1H: Telecommunications Industry Data for India

	Input 1	Input 2	Input 3	Output 1	Output 2			Partial Measures of Performance					
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	6,081	45,076	484,741	21,191	4.25	93	43,716	470	0.29	135	12,545	452	4,125
2002	8,543	54,420	503,889	16,454	5.05	108	32,655	302	0.52	157	16,954	469	3,720
2003	3,418	75,690	525,996	19,259	6.92	144	36,615	254	0.18	45	6,498	544	3,532
2004	5,861	98,418	549,633	21,379	8.86	179	38,896	217	0.27	60	10,663	615	3,596
2005	8,607	140,317	593,207	29,943	12.45	237	50,476	213	0.29	61	14,510	710	3,500
2006	9,765	206,820	662,371	34,801	18.09	312	52,540	168	0.28	47	14,742	780	3,424
2007	10,990	272,870	731,063	44,598	23.54	373	61,004	163	0.25	40	15,032	1,011	2,642
2008	12,335	384,790	847,460	39,620	32.76	454	46,751	103	0.31	32	14,556	959	2,679
2009	8,769	562,150	1,031,914	34,931	47.23	545	33,850	62	0.25	16	8,498	1,082	2,532
2010	20,335	787,280	1,266,049	37,158	65.30	622	29,350	47	0.55	26	16,062	1,300	2,506
2011	3,897	926,698	1,411,044	30,264	75.89	657	21,448	33	0.13	4	2,762	1,413	2,483
2012	3,208	895,662	1,378,766	32,572	72.42	650	23,624	36	0.10	4	2,326	1,376	3,395
2013	5,575	915,337	1,399,229	28,639	73.10	654	20,468	31	0.19	6	3,985	1,399	3,130

Source(s): ITU (2003; 2015); Jain (2008); Malik (2010); Mani (2011); Normand (2010);
Simon (2011); Telecom Regulatory Authority of India (TRAI) (2012)

APPENDIX 1I: Telecommunications Industry Data for Indonesia

	Input 1	Input 2	Input 3	Output 1	Output 2	Partial Measures of Performance							
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	2,896	13,740	167,355	6,398	6.48	82	38,228	466	0.45	211	17,303	662	4,497
2002	2,407	19,450	175,912	7,319	9.04	111	41,608	376	0.33	124	13,680	859	4,941
2003	1,605	26,553	186,553	8,301	12.17	142	44,497	313	0.19	60	8,604	1,020	5,239
2004	1,439	40,713	278,475	13,700	18.40	146	49,195	336	0.11	35	5,168	1,069	5,392
2005	2,239	60,418	333,248	14,870	26.91	181	44,620	246	0.15	37	6,718	1,114	5,709
2006	1,900	78,624	412,691	12,518	34.53	191	30,332	159	0.15	24	4,604	1,403	5,761
2007	4,254	112,916	475,740	15,785	48.89	237	33,181	140	0.27	38	8,942	1,682	5,454
2008	3,169	170,956	414,752	12,623	72.98	412	30,434	74	0.25	19	7,641	1,844	5,141
2009	3,129	198,487	444,063	11,250	83.58	447	25,334	57	0.28	16	7,046	2,098	5,105
2010	1,846	252,221	355,155	11,724	104.80	710	33,010	46	0.16	7	5,197	2,722	4,838
2011	1,995	288,423	322,030	11,483	118.30	896	35,658	40	0.17	7	6,196	3,408	4,804
2012	2,425	319,947	282,160	11,219	129.60	1,134	39,761	35	0.22	8	8,593	3,584	4,730
2013	1,515	343,950	225,345	8,990	137.65	1,526	39,894	26	0.17	4	6,725	3,480	4,814

Source(s): Barnes (2013a; 2013b; 2015a; 2015b); EXIM Bank of Malaysia (2014); ITU (2015); The World Bank (2006)

APPENDIX 1J: Telecommunications Industry Data for Japan

	Input 1	Input 2	Input 3	Output 1	Output 2	Partial Measures of Performance							
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	23,479	136,145	399,139	153,923	107.08	341	385,637	1,131	0.15	172	58,823	33,113	5,594
2002	19,155	141,891	353,025	128,668	111.33	402	364,474	907	0.15	135	54,260	31,727	5,463
2003	20,280	146,874	330,876	138,257	115.00	444	417,852	941	0.15	138	61,292	34,279	5,364
2004	23,032	151,082	298,495	133,807	118.25	506	448,271	886	0.17	152	77,159	36,941	5,264
2005	18,851	154,537	267,244	131,494	120.95	578	492,038	851	0.14	122	70,540	36,235	5,998
2006	20,899	155,855	293,996	129,019	121.90	530	438,845	828	0.16	134	71,087	34,462	6,386
2007	18,355	158,574	303,149	129,065	123.88	523	425,748	814	0.14	116	60,549	34,353	6,051
2008	23,065	158,822	335,986	136,505	124.02	473	406,283	859	0.17	145	68,648	38,351	6,044
2009	25,140	183,090	324,701	150,859	142.99	564	464,610	824	0.17	137	77,424	39,520	5,423
2010	16,936	188,906	329,864	152,292	147.50	573	461,681	806	0.11	90	51,342	43,859	5,202
2011	18,680	197,430	330,000	167,976	154.46	598	509,018	851	0.11	95	56,606	47,075	5,011
2012	20,081	205,355	374,184	169,544	160.98	549	453,104	826	0.12	98	53,666	47,118	4,792
2013	20,161	208,907	362,063	168,261	164.06	577	464,729	805	0.12	97	55,684	38,847	4,628

Source(s): Barnes (2013a; 2013b); ITU (2015); Telecommunications Bureau (2008); European Telecommunications Network Operator's Association (ETNO) (2014)

APPENDIX 1K: Telecommunications Industry Data for Kenya

	Input 1	Input 2	Input 3	Output 1	Output 2			Partial Measures of Performance					
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	268	909	52,895	697	2.83	17	13,168	766	0.39	295	5,070	398	4,088
2002	263	1509	57,149	1,617	4.57	26	28,299	1,072	0.16	174	4,602	395	4,622
2003	239	1919	60,000	1,445	5.66	32	24,091	753	0.17	125	3,992	414	3,957
2004	1,111	2845	100,000	1,387	8.17	28	13,869	487	0.80	390	11,105	431	4,424
2005	758	4899	156,250	1,601	13.69	31	10,247	327	0.47	155	4,852	499	4,745
2006	974	7634	187,500	1,435	20.77	41	7,654	188	0.68	128	5,195	568	5,046
2007	1,257	11813	212,500	2,531	31.29	56	11,912	214	0.50	106	5,917	784	5,602
2008	1,363	16950	218,750	1,828	43.72	77	8,354	108	0.75	80	6,229	804	6,613
2009	289	20029	215,625	1,925	50.29	93	8,928	96	0.15	14	1,340	833	6,247
2010	492	25350	237,500	1,295	61.97	107	5,451	51	0.38	19	2,072	958	5,481
2011	455	28364	246,875	1,244	67.49	115	5,041	44	0.37	16	1,842	901	4,715
2012	332	30983	266,420	1,244	71.76	116	4,671	40	0.27	11	1,245	1,066	4,498
2013	281	32034	273,882	1,232	72.22	117	4,499	38	0.23	9	1,025	1,186	4,914

Source(s): Deloitte (2011); Export Processing Zone Authority (2005); ITU (2003; 2015); The World Bank Group (2015a; 2015b; 2015c; 2015d)

APPENDIX 1L: Telecommunications Industry Data for Mexico

	Input 1	Input 2	Input 3	Output 1	Output 2			Partial Measures of Performance					
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	8,540	35,532	94,675	23,843	33.73	375	251,845	671	0.36	240	90,201	6,529	7,878
2002	4,425	40,903	90,516	24,142	38.33	452	266,715	590	0.18	108	48,888	6,579	7,636
2003	3,494	46,428	90,002	23,278	42.97	516	258,643	501	0.15	75	38,825	6,229	7,695
2004	4,670	56,524	92,858	24,659	51.68	609	265,558	436	0.19	83	50,288	6,502	7,457
2005	4,364	66,641	100,892	27,697	60.18	661	274,523	416	0.16	65	43,252	7,422	7,019
2006	4,434	75,257	101,501	31,221	67.12	741	307,593	415	0.14	59	43,684	8,112	7,367
2007	3,772	86,557	109,691	33,544	76.24	789	305,804	388	0.11	44	34,392	8,761	6,276
2008	4,001	95,795	117,161	33,155	83.32	818	282,983	346	0.12	42	34,149	9,019	6,176
2009	3,011	102,699	120,072	28,329	88.21	855	235,930	276	0.11	29	25,078	7,427	5,537
2010	5,673	111,302	123,297	30,286	94.41	903	245,635	272	0.19	51	46,011	8,538	6,724
2011	4,821	114,580	127,877	30,775	95.99	896	240,664	269	0.16	42	37,698	9,311	6,870
2012	6,316	121,315	132,567	32,841	100.39	915	247,733	271	0.19	52	47,641	9,507	6,504
2013	4,415	124,799	148,000	35,653	102.02	843	240,899	286	0.12	35	29,829	10,131	6,502

Source(s): ITU (2015); OECD (2015a; 2015b); PWC Mexico (2015)

APPENDIX 1M: Telecommunications Industry Data for New Zealand

	Input 1	Input 2	Input 3	Output 1	Output 2	Partial Measures of Performance							
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	484	4,111	7,459	2,717	105.94	551	364,223	661	0.18	118	64,862	13,228	4,784
2002	400	4,214	8,100	3,080	106.72	520	380,234	731	0.13	95	49,361	16,677	6,557
2003	463	4,397	8,100	3,808	109.18	543	470,180	866	0.12	105	57,120	21,253	5,168
2004	501	4,828	8,078	4,225	118.12	598	522,965	875	0.12	104	61,996	24,446	5,596
2005	598	5,259	10,396	4,354	127.22	506	418,820	828	0.14	114	57,533	26,965	5,645
2006	674	5,650	9,647	3,615	135.02	586	374,691	640	0.19	119	69,895	25,737	6,843
2007	863	6,100	10,035	3,950	144.42	608	393,667	648	0.22	141	85,988	30,452	6,483
2008	886	6,440	10,500	3,683	151.18	613	350,716	572	0.24	138	84,346	29,875	5,860
2009	1,102	6,570	11,000	3,199	152.70	597	290,799	487	0.34	168	100,148	26,841	5,403
2010	1,112	6,580	11,378	3,511	151.24	578	308,578	534	0.32	169	97,732	31,995	4,789
2011	954	6,680	11,940	3,796	152.37	559	317,914	568	0.25	143	79,931	36,627	4,263
2012	996	6,780	12,420	4,229	153.81	546	340,527	624	0.24	147	80,221	38,818	4,295
2013	1,254	6,650	12,900	4,380	149.70	516	339,560	659	0.29	189	97,230	40,172	4,300

Source(s): Commerce Commission New Zealand (2014); ITU (2015); OECD (2013)

APPENDIX 1N: Telecommunications Industry Data for Nigeria

	Input 1	Input 2	Input 3	Output 1	Output 2	Partial Measures of Performance							
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	2,732	867	193,682	607	0.74	4	3,135	700	4.50	3,152	14,105	376	6,934
2002	2,116	2,271	198,897	2,425	1.89	11	12,193	1,068	0.87	932	10,638	349	4,082
2003	3,663	4,022	315,039	3,652	3.35	13	11,593	908	1.00	911	11,627	489	3,850
2004	2,036	10,202	325,047	6,579	8.50	31	20,239	645	0.31	200	6,263	656	3,016
2005	3,732	19,519	467,260	6,926	16.27	42	14,822	355	0.54	191	7,988	664	2,995
2006	3,781	33,858	439,866	10,155	24.18	77	23,088	300	0.37	112	8,596	885	2,974
2007	3,908	41,975	445,821	13,721	29.98	94	30,777	327	0.28	93	8,765	1,100	3,387
2008	3,799	64,296	462,115	17,335	45.93	139	37,512	270	0.22	59	8,221	1,255	3,346
2009	3,476	74,518	469,513	15,600	53.23	159	33,226	209	0.22	47	7,404	1,148	3,464
2010	3,036	88,348	479,673	8,600	63.11	184	17,929	97	0.35	34	6,329	1,137	2,779
2011	1,339	95,887	485,177	7,287	68.49	198	15,020	76	0.18	14	2,759	2,318	3,016
2012	1,712	113,196	479,812	6,597	80.85	236	13,750	58	0.26	15	3,567	2,499	2,800
2013	1,398	127,607	483,801	6,801	91.15	264	14,057	53	0.21	11	2,890	2,802	3,062

Source(s): ITU (2015); NCC (2013; 2016c; 2016d; 2016e, 2016f); Pyramid Research (2010);
The World Bank Group (2015a; 2015b; 2015c; 2015d)

APPENDIX 1O: Telecommunications Industry Data for South Africa

	Input 1	Input 2	Input 3	Output 1	Output 2	Partial Measures of Performance							
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	3,152	15,680	79,313	10,917	34.92	198	137,651	696	0.29	201	39,744	2,487	7,625
2002	3,030	18,569	86,577	10,388	40.77	214	119,991	559	0.29	163	34,996	2,355	7,250
2003	2,766	21,704	81,106	12,981	47.05	268	160,054	598	0.21	127	34,103	3,386	7,175
2004	2,580	25,679	73,151	11,802	54.95	351	161,342	460	0.22	100	35,267	4,624	7,075
2005	1,652	38,660	94,466	12,816	81.65	409	135,672	332	0.13	43	17,492	5,111	7,243
2006	1,811	44,263	107,869	13,049	92.23	410	120,970	295	0.14	41	16,785	5,368	7,221
2007	2,545	46,915	107,946	12,221	96.42	435	113,211	260	0.21	54	23,579	5,790	6,979
2008	2,152	49,495	114,479	9,368	100.31	432	81,830	189	0.23	43	18,802	5,339	6,850
2009	2,489	50,837	119,525	8,570	101.56	425	71,697	169	0.29	49	20,822	5,432	6,326
2010	2,101	54,872	120,669	9,495	108.03	455	78,690	173	0.22	38	17,411	6,874	5,762
2011	1,645	68,455	115,285	9,073	132.78	594	78,699	133	0.18	24	14,269	7,598	5,592
2012	1,425	72,809	118,651	7,757	139.10	614	65,375	107	0.18	20	12,006	7,119	5,156
2013	1,242	81,298	119,080	6,149	152.94	683	51,641	76	0.20	15	10,431	6,527	4,760

Source(s): Datamonitor (2005; 2009); Deloitte & GSM Association (2012); ITU (2015)
Department of Labour & HSRC (2008); Iset Setta (2011); MarketLine (2015d);
The World Bank (2015a; 2015b; 2015c; 2015d);
Media, Information and Communications Technologies Sector Education Training and Authority (MICTSETA) (2013);
Transport Education Training Authourity (TETA) (2015; 2014);

APPENDIX 1P: Telecommunications Industry Data for South Korea

	Input 1	Input 2	Input 3	Output 1	Output 2	Partial Measures of Performance							
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	7,874	54,821	76,287	31,110	115.76	719	407,803	567	0.25	144	103,213	10,860	5,365
2002	8,181	58,078	81,422	34,609	121.95	713	425,053	596	0.24	141	100,482	12,409	5,074
2003	6,432	58,719	77,985	35,978	122.69	753	461,348	613	0.18	110	82,477	13,752	5,058
2004	6,302	60,154	87,085	39,841	125.22	691	457,500	662	0.16	105	72,367	15,461	5,017
2005	6,036	62,247	91,009	46,318	129.31	684	508,940	744	0.13	97	66,319	18,467	5,013
2006	7,098	62,629	100,264	50,981	129.47	625	508,468	814	0.14	113	70,791	20,946	4,908
2007	7,747	67,376	96,607	54,118	138.64	697	560,191	803	0.14	115	80,194	22,561	4,120
2008	6,606	69,965	110,741	46,754	142.93	632	422,190	668	0.14	94	59,651	19,887	5,707
2009	5,252	74,838	109,729	41,107	152.17	682	374,625	549	0.13	70	47,861	17,711	3,985
2010	5,537	79,310	113,353	45,244	160.51	700	399,143	570	0.12	70	48,847	21,472	3,933
2011	6,657	81,975	117,549	46,850	164.68	697	398,557	572	0.14	81	56,629	23,779	3,687
2012	6,905	83,724	120,147	39,556	167.43	697	329,229	472	0.17	82	57,469	24,201	3,668
2013	7,088	85,014	122,060	39,835	169.28	696	326,358	469	0.18	83	58,072	25,778	4,302

Source(s): ITU (2015); OECD (2013); Standard and Poor's (2013)

APPENDIX 1Q: Telecommunications Industry Data for Turkey

	Input 1	Input 2	Input 3	Output 1	Output 2	Partial Measures of Performance							
Year(s)	CAPEX (USD Millions)	Subscriptions (Thousands)	Employment	Revenue (USD Millions)	Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
2001	9,907	38,477	80,758	19,709	60.03	476	244,054	512	0.50	257	122,672	2,001	3,798
2002	5,003	42,213	90,373	15,559	64.92	467	172,162	369	0.32	119	55,362	2,602	3,595
2003	4,076	46,804	102,141	19,277	70.98	458	188,733	412	0.21	87	39,909	3,728	3,462
2004	615	53,833	120,190	19,135	80.53	448	159,205	355	0.03	11	5,121	5,220	3,360
2005	2,109	62,587	172,706	18,815	92.39	362	108,940	301	0.11	34	12,213	6,658	3,183
2006	1,599	71,494	138,696	16,661	104.18	515	120,129	233	0.10	22	11,528	7,076	3,088
2007	2,430	80,177	187,881	20,706	115.37	427	110,210	258	0.12	30	12,931	8,767	3,021
2008	3,705	83,326	187,679	20,542	118.42	444	109,453	247	0.18	44	19,742	9,268	2,959
2009	2,708	79,314	172,050	16,874	111.33	461	98,079	213	0.16	34	15,738	8,193	2,954
2010	2,507	77,971	176,624	17,053	108.09	441	96,550	219	0.15	32	14,194	9,591	2,362
2011	2,174	80,533	147,994	15,405	110.23	544	104,092	191	0.14	27	14,692	9,767	2,272
2012	1,953	81,540	128,514	14,543	110.19	634	113,163	178	0.13	24	15,195	9,972	2,210
2013	1,547	83,213	113,977	13,287	111.05	730	116,578	160	0.12	19	13,575	10,348	2,146

Source(s): Barnes (2013a; 2013b; 2015a; 2015b); ITU (2015; 2003); OECD (2013)
Information and Communications Technologies Authourithy (ICTA) (2013)

APPENDIX 1R: Telecommunications Industry Data for United Kingdom

Year(s)	Input 1 CAPEX (USD Millions)	Input 2 Subscriptions (Thousands)	Input 3 Employment	Output 1 Revenue (USD Millions)	Output 2 Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
								Partial Measures of Performance					
2001	17,206	80,400	264,000	57,293	136.00	305	217,020	713	0.30	214	65,176	25,797	5,048
2002	12,224	85,755	259,000	58,583	143.00	331	226,190	683	0.21	143	47,195	29,386	4,641
2003	12,945	89,177	250,000	68,845	149.00	357	275,379	772	0.19	145	51,780	34,792	4,647
2004	24,381	90,436	222,000	80,965	150.76	407	364,708	895	0.30	270	109,826	39,178	4,730
2005	21,499	95,039	227,000	81,494	157.35	419	359,002	857	0.26	226	94,709	36,917	4,281
2006	19,797	98,168	225,000	84,625	161.34	436	376,110	862	0.23	202	87,988	44,113	3,935
2007	20,702	100,499	214,000	91,909	163.89	470	429,482	915	0.23	206	96,737	46,910	3,735
2008	11,371	102,139	212,000	83,022	165.25	482	391,615	813	0.14	111	53,638	34,497	3,554
2009	8,284	104,824	230,000	66,954	168.32	456	291,104	639	0.12	79	36,015	37,502	3,348
2010	7,897	114,575	204,000	62,361	182.54	562	305,691	544	0.13	69	38,711	37,142	3,497
2011	7,924	114,865	203,000	61,358	181.58	566	302,254	534	0.13	69	39,033	38,597	3,408
2012	7,768	118,154	201,000	46,797	185.48	588	232,820	396	0.17	66	38,646	41,294	3,318
2013	7,544	116,397	213,000	45,796	181.57	546	215,005	393	0.16	65	35,418	43,269	3,392

Source(s): CRTC (2013; 2014); ITU (2015); OECD (2013); Office for National Statistics (2015)

APPENDIX 1S: Telecommunications Industry Data for United States

Year(s)	Input 1 CAPEX (USD Millions)	Input 2 Subscriptions (Thousands)	Input 3 Employment	Output 1 Revenue (USD Millions)	Output 2 Subscriptions per 100 Inhabitants (Teledensity)	Subscriptions to Employment Ratio	Revenues to Employment (USD)	Revenue to Subscription Ratio (USD)	CAPEX to Revenue Ratio (USD)	CAPEX to Subscriptions Ratio (USD)	Capex to Employment (USD)	Real GDP per Capita (USD)	Industry Average HHI
								Partial Measures of Performance					
2001	130,030	320,071	1,423,900	516,530	112.32	225	362,758	1,614	0.25	406	91,319	36,443	2,050
2002	74,474	331,050	1,280,900	498,953	115.10	258	389,533	1,507	0.15	225	58,142	37,589	2,150
2003	71,724	343,570	1,166,800	492,791	118.43	294	422,344	1,434	0.15	209	61,471	38,902	2,250
2004	72,395	362,510	1,115,100	495,711	123.81	325	444,544	1,367	0.15	200	64,922	40,800	2,200
2005	79,005	378,861	1,071,300	495,378	128.20	354	462,408	1,308	0.16	209	73,747	42,927	2,425
2006	86,405	397,060	1,047,600	496,807	133.07	379	474,234	1,251	0.17	218	82,479	45,053	2,781
2007	83,836	407,718	1,030,600	504,835	135.35	396	489,845	1,238	0.17	206	81,347	46,816	2,672
2008	81,682	424,063	1,019,400	504,426	139.45	416	494,827	1,190	0.16	193	80,128	47,470	2,655
2009	68,365	427,156	965,700	503,182	139.24	442	521,055	1,178	0.14	160	70,793	46,647	3,271
2010	70,149	434,770	902,900	507,533	140.54	482	562,114	1,167	0.14	161	77,693	47,790	3,216
2011	68,002	440,723	865,300	509,957	141.38	509	589,341	1,157	0.13	154	78,588	48,774	3,169
2012	70,155	443,433	1,057,616	520,102	141.17	419	491,768	1,173	0.13	158	66,333	50,549	3,333
2013	73,083	443,931	854,500	524,896	140.26	520	614,273	1,182	0.14	165	85,527	52,202	3,036

Source(s): European Telecommunications Network Operator's Association (ETNO) (2014);
Federal Communications Commission (2011); IBISWORLD (2014); ITU (2015);
OECD (2013); MarketLine Industry Profile (2015e; 2013); US. Census Bureau (2015a; 2015b)

APPENDIX 2A: CONSTANT RETURNS TO SCALE TECHNICAL EFFICIENCY (CRS TE) SCORES

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average
Australia	0.8419	0.6833	0.7402	0.8403	0.9173	0.9847	0.9688	0.9597	0.8865	1	1	1	0.9267	**0.9038**
Belgium	1	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
Brazil	0.9582	0.788	0.9136	0.8848	0.9101	0.8633	0.8722	0.5801	0.8959	0.8078	0.6262	0.6803	0.8264	**0.8159**
Canada	0.7005	0.7152	0.824	0.7979	0.8516	0.8496	0.8344	0.8618	0.8006	0.8074	0.7625	0.7574	0.7849	**0.7960**
Chile	0.4714	0.4906	0.485	0.4813	0.6955	0.6191	0.5657	0.5485	0.7598	0.6553	0.5527	0.5941	0.6984	**0.5860**
China	0.467	0.4849	0.3566	0.257	0.3985	0.4602	0.534	0.5091	0.525	0.62	0.6172	0.5156	0.4756	**0.4785**
Germany	0.8075	1	1	1	1	1	1	1	1	1	1	1	1	**0.9852**
India	0.5316	0.2723	0.485	0.3076	0.3085	0.3481	0.4509	0.3712	0.4023	0.1821	0.8076	1	0.578	**0.4650**
Indonesia	0.3872	0.4107	0.4557	0.6352	0.5726	0.6339	0.4169	0.4893	0.4101	0.8277	0.7742	0.6433	0.8631	**0.5785**
Japan	1	0.9416	0.9263	0.9025	0.9104	0.8988	0.9531	0.8887	0.864	1	1	1	1	**0.9450**
Kenya	0.5752	0.886	0.7505	0.3974	0.307	0.2272	0.2715	0.2382	1	0.9261	0.9287	1	1	**0.6544**
Mexico	0.6503	0.7255	0.6713	0.5577	0.6121	0.721	0.9909	0.9652	0.9708	0.5539	0.6791	0.5734	0.9102	**0.7370**
New Zeland	1	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
Nigeria	0.45	0.7205	0.6429	0.4816	0.2883	0.3603	0.4317	0.5327	0.4645	0.3485	0.7127	0.5263	0.6209	**0.5062**
South Africa	0.6067	0.4891	0.5873	0.5125	0.7349	0.7603	0.5657	0.5764	0.4507	0.6392	0.8354	0.8908	1	**0.6653**
South Korea	1	0.9251	0.9716	0.8747	0.9049	0.99	0.953	0.9252	0.8875	0.9106	0.83	0.7185	0.7379	**0.8945**
Turkey	0.6217	0.4367	0.5044	1	0.8208	1	0.9814	0.6808	0.7083	0.8058	0.8658	0.9376	1	**0.7972**
United Kingdom	0.6007	0.6666	0.6954	0.7789	0.7402	0.778	0.8358	1	0.9414	0.8626	0.8519	0.6999	0.7453	**0.7844**
United States	1	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
HICs	**0.8422**	**0.8422**	**0.8643**	**0.8676**	**0.9020**	**0.9120**	**0.9111**	**0.9184**	**0.9140**	**0.9236**	**0.8997**	**0.8770**	**0.8893**	**0.8895**
MICs	**0.5831**	**0.5793**	**0.5964**	**0.5593**	**0.5503**	**0.5971**	**0.6128**	**0.5492**	**0.6475**	**0.6346**	**0.7608**	**0.7519**	**0.8082**	**0.6331**
OECD	**0.8078**	**0.7987**	**0.8182**	**0.8528**	**0.8711**	**0.9034**	**0.9236**	**0.9025**	**0.9016**	**0.8830**	**0.8785**	**0.8567**	**0.9003**	**0.8691**
All Countries	**0.6958**	**0.7031**	**0.7217**	**0.6982**	**0.7091**	**0.7359**	**0.7445**	**0.7157**	**0.7695**	**0.7616**	**0.8144**	**0.7963**	**0.8377**	**0.7464**

APPENDIX 2B: VARIABLE RETURNS TO SCALE TECHNICAL EFFICIENCY (VRS TE) SCORES

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average
Australia	0.8633	0.7907	0.8504	0.9486	1	1	1	0.9613	0.8867	1	1	1	1	**0.9462**
Belgium	1	1	1	1	1	1	1	1	1	1	1	1	1	**1**
Brazil	0.9669	0.8738	0.9757	0.993	1	0.8877	0.975	0.6898	0.9094	0.8105	0.6287	0.6809	0.8274	**0.8630**
Canada	0.701	0.7153	0.8244	0.7984	0.8538	0.8572	0.8484	0.8778	0.8157	0.8115	0.7684	0.7634	0.7938	**0.8022**
Chile	0.5344	0.5132	0.6307	0.6987	0.7576	0.6821	0.6663	0.6252	0.8795	0.6931	0.5608	0.6469	0.7611	**0.6654**
China	0.4695	0.485	0.3577	0.3527	0.3997	0.4917	0.5851	0.5693	0.6027	0.7005	0.6661	0.5729	0.5172	**0.5208**
Germany	1	1	1	1	1	1	1	1	1	1	1	1	1	**1**
India	0.5416	0.2734	0.511	0.3155	0.318	0.3564	0.4542	0.3834	0.4088	0.1916	0.8507	1	0.5849	**0.4761**
Indonesia	0.4181	0.4146	0.5104	0.657	0.6598	0.687	0.4411	0.5367	0.4108	0.8556	0.7901	0.6438	0.9088	**0.6103**
Japan	1	0.9746	0.9832	0.9988	1	0.9377	0.9814	0.8887	0.8871	1	1	1	1	**0.9732**
Kenya	1	1	1	1	1	0.7401	0.6866	0.65	1	1	1	1	1	**0.9290**
Mexico	0.6554	0.7526	0.6756	0.5827	0.614	0.7357	1	1	1	0.6041	0.7262	0.6099	0.9158	**0.7594**
New Zeland	1	1	1	1	1	1	1	1	1	1	1	1	1	**1**
Nigeria	1	0.9002	0.8587	0.6412	0.3697	0.3762	0.4347	0.5866	0.5028	0.4063	0.7846	0.5275	0.6242	**0.6164**
South Africa	0.6396	0.4913	0.5928	0.5176	0.7902	0.7989	0.5878	0.6475	0.4984	0.6962	0.8466	0.8913	1	**0.6922**
South Korea	1	1	1	0.9875	1	1	1	0.9252	0.8905	0.9222	0.9273	0.9001	0.9786	**0.9640**
Turkey	0.6258	0.4492	0.5065	1	0.8568	1	0.9883	0.6985	0.7109	0.8335	0.9006	0.9739	1	**0.8111**
United Kingdom	1	1	1	1	1	1	1	1	0.9417	1	1	1	1	**0.9955**
United States	1	1	1	1	1	1	1	1	1	1	1	1	1	**1**
HICs	**0.9099**	**0.8994**	**0.9289**	**0.9432**	**0.9611**	**0.9477**	**0.9496**	**0.9278**	**0.9301**	**0.9427**	**0.9257**	**0.9310**	**0.9534**	**0.9346**
MICs	**0.7019**	**0.6267**	**0.6654**	**0.6733**	**0.6676**	**0.6749**	**0.6836**	**0.6402**	**0.6715**	**0.6776**	**0.7993**	**0.7667**	**0.8198**	**0.6976**
OECD	**0.8650**	**0.8496**	**0.8726**	**0.9179**	**0.9235**	**0.9344**	**0.9570**	**0.9147**	**0.9177**	**0.9054**	**0.9069**	**0.9079**	**0.9541**	**0.9097**
All Countries	**0.8113**	**0.7702**	**0.8041**	**0.8154**	**0.8221**	**0.8185**	**0.8236**	**0.7916**	**0.8076**	**0.8171**	**0.8658**	**0.8532**	**0.8901**	**0.8223**

APPENDIX 2C: SCALE EFFICIENCY (SE) SCORES

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average
Australia	0.9752	0.8641	0.8704	0.8858	0.9173	0.9847	0.9688	0.9983	0.9998	1	1	1	0.9267	**0.9532**
Belgium	1	1	1	1	1	1	1	1	1	1	1	1	1	**1**
Brazil	0.9911	0.9017	0.9364	0.8911	0.9101	0.9725	0.8946	0.8409	0.9851	0.9967	0.9961	0.9991	0.9988	**0.9472**
Canada	0.9992	0.9998	0.9995	0.9993	0.9973	0.9911	0.9835	0.9818	0.9814	0.995	0.9924	0.9921	0.9888	**0.9924**
Chile	0.8821	0.9559	0.769	0.6888	0.918	0.9077	0.849	0.8773	0.8639	0.9455	0.9855	0.9183	0.9177	**0.8830**
China	0.9947	0.9997	0.997	0.7286	0.9971	0.936	0.9128	0.8942	0.8711	0.8851	0.9265	0.9001	0.9195	**0.9202**
Germany	0.8075	1	1	1	1	1	1	1	1	1	1	1	1	**0.9852**
India	0.9815	0.9958	0.9492	0.9751	0.9701	0.9766	0.9927	0.968	0.9841	0.9505	0.9493	1	0.9882	**0.9755**
Indonesia	0.926	0.9906	0.8929	0.9668	0.8679	0.9227	0.9453	0.9117	0.9983	0.9673	0.9793	0.9992	0.9498	**0.9475**
Japan	1	0.9661	0.9422	0.9037	0.9104	0.9585	0.9711	1	0.974	1	1	1	1	**0.9712**
Kenya	0.5752	0.886	0.7505	0.3974	0.307	0.307	0.3954	0.3665	1	0.9261	0.9287	1	1	**0.6800**
Mexico	0.9922	0.9639	0.9936	0.9571	0.997	0.9799	0.9909	0.9652	0.9708	0.9169	0.9352	0.9401	0.9939	**0.9690**
New Zeland	1	1	1	1	1	1	1	1	1	1	1	1	1	**1**
Nigeria	0.45	0.8003	0.7488	0.7511	0.7797	0.9579	0.9933	0.9081	0.9237	0.8576	0.9084	0.9978	0.9947	**0.8516**
South Africa	0.9487	0.9955	0.9907	0.9901	0.93	0.9516	0.9624	0.8902	0.9043	0.9182	0.9867	0.9995	1	**0.9591**
South Korea	1	0.9251	0.9716	0.8857	0.9049	0.99	0.953	1	0.9966	0.9874	0.8951	0.7982	0.7541	**0.9278**
Turkey	0.9934	0.9722	0.9957	1	0.958	1	0.993	0.9747	0.9962	0.9667	0.9614	0.9626	1	**0.9826**
United Kingdom	0.6007	0.6666	0.6954	0.7789	0.7402	0.778	0.8358	1	0.9997	0.8626	0.8519	0.6999	0.7453	**0.7888**
United States	1	1	1	1	1	1	1	1	1	1	1	1	1	**1**
HICs	**0.9265**	**0.9378**	**0.9248**	**0.9142**	**0.9388**	**0.9610**	**0.9561**	**0.9857**	**0.9815**	**0.9791**	**0.9725**	**0.9409**	**0.9333**	**0.9502**
MICs	**0.8725**	**0.9451**	**0.9172**	**0.8508**	**0.8574**	**0.8894**	**0.8978**	**0.8577**	**0.9593**	**0.9317**	**0.9524**	**0.9776**	**0.9828**	**0.9147**
OECD	**0.9375**	**0.9428**	**0.9365**	**0.9249**	**0.9453**	**0.9658**	**0.9621**	**0.9831**	**0.9819**	**0.9728**	**0.9685**	**0.9426**	**0.9439**	**0.9544**
All Countries	**0.9009**	**0.9412**	**0.9212**	**0.8842**	**0.9003**	**0.9271**	**0.9285**	**0.9251**	**0.9710**	**0.9566**	**0.9630**	**0.9583**	**0.9567**	**0.9334**

APPENDIX 2D: SCALE EFFICIENCY SCORES AND EXHIBITED RETURNS TO SCALE (RTS)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average
Australia	0.9752 (DRS)	0.8641 (CRS)	0.8704 (DRS)	0.8858 (DRS)	0.9173 (DRS)	0.9847 (DRS)	0.9688 (DRS)	0.9983 (IRS)	0.9998 (IRS)	1 (CRS)	1 (CRS)	1 (CRS)	0.9267 (DRS)	**0.9532**
Belgium	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	**1**
Brazil	0.9911 (CRS)	0.9017 (DRS)	0.9364 (DRS)	0.8911 (CRS)	0.9101 (DRS)	0.9725 (DRS)	0.8946 (DRS)	0.8409 (CRS)	0.9851 (CRS)	0.9967 (IRS)	0.9961 (IRS)	0.9991 (IRS)	0.9988 (IRS)	**0.9472**
Canada	0.9992 (IRS)	0.9998 (IRS)	0.9995 (IRS)	0.9993 (IRS)	0.9973 (DRS)	0.9911 (IRS)	0.9835 (IRS)	0.9818 (IRS)	0.9814 (IRS)	0.995 (IRS)	0.9924 (IRS)	0.9921 (IRS)	0.9888 (IRS)	**0.9924**
Chile	0.8821 (IRS)	0.9559 (IRS)	0.769 (IRS)	0.6888 (IRS)	0.918 (IRS)	0.9077 (IRS)	0.849 (IRS)	0.8773 (IRS)	0.8639 (IRS)	0.9455 (IRS)	0.9855 (IRS)	0.9183 (DRS)	0.9177 (DRS)	**0.8830**
China	0.9947 (IRS)	0.9997 (IRS)	0.997 (IRS)	0.7286 (CRS)	0.9971 (IRS)	0.936 (DRS)	0.9128 (DRS)	0.8942 (CRS)	0.8711 (CRS)	0.8851 (CRS)	0.9265 (CRS)	0.9001 (CRS)	0.9195 (CRS)	**0.9202**
Germany	0.8075 (DRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	**0.9852**
India	0.9815 (IRS)	0.9958 (IRS)	0.9492 (IRS)	0.9751 (IRS)	0.9701 (IRS)	0.9766 (IRS)	0.9927 (IRS)	0.968 (IRS)	0.9841 (IRS)	0.9505 (IRS)	0.9493 (IRS)	1 (CRS)	0.9882 (IRS)	**0.9755**
Indonesia	0.926 (IRS)	0.9906 (IRS)	0.8929 (IRS)	0.9668 (IRS)	0.8679 (IRS)	0.9227 (IRS)	0.9453 (IRS)	0.9117 (IRS)	0.9983 (CRS)	0.9673 (IRS)	0.9793 (IRS)	0.9992 (DRS)	0.9498 (DRS)	**0.9475**
Japan	1 (CRS)	0.9661 (CRS)	0.9422 (DRS)	0.9037 (CRS)	0.9104 (DRS)	0.9585 (DRS)	0.9711 (DRS)	1 (IRS)	0.974 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	**0.9712**
Kenya	0.5752 (IRS)	0.886 (IRS)	0.7505 (IRS)	0.3974 (IRS)	0.307 (IRS)	0.307 (IRS)	0.3954 (IRS)	0.3665 (IRS)	1 (CRS)	0.9261 (IRS)	0.9287 (IRS)	1 (CRS)	1 (CRS)	**0.6800**
Mexico	0.9922 (IRS)	0.9639 (CRS)	0.9936 (DRS)	0.9571 (CRS)	0.997 (IRS)	0.9799 (IRS)	0.9909 (IRS)	0.9652 (IRS)	0.9708 (IRS)	0.9169 (IRS)	0.9352 (IRS)	0.9401 (IRS)	0.9939 (IRS)	**0.9690**
New Zeland	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	**1**
Nigeria	0.4500 (IRS)	0.8003 (IRS)	0.7488 (IRS)	0.7511 (IRS)	0.7797 (IRS)	0.9579 (IRS)	0.9933 (DRS)	0.9081 (IRS)	0.9237 (IRS)	0.8576 (IRS)	0.9084 (IRS)	0.9978 (IRS)	0.9947 (CRS)	**0.8516**
South Africa	0.9487 (IRS)	0.9955 (IRS)	0.9907 (IRS)	0.9901 (IRS)	0.9300 (IRS)	0.9516 (IRS)	0.9624 (IRS)	0.8902 (IRS)	0.9043 (IRS)	0.9182 (IRS)	0.9867 (IRS)	0.9995 (DRS)	1 (CRS)	**0.9591**
South Korea	1 (CRS)	0.9251 (DRS)	0.9716 (DRS)	0.8857 (CRS)	0.9049 (DRS)	0.99 (DRS)	0.953 (DRS)	1 (IRS)	0.9966 (IRS)	0.9874 (CRS)	0.8951 (DRS)	0.7982 (DRS)	0.7541 (DRS)	**0.9278**
Turkey	0.9934 (IRS)	0.9722 (CRS)	0.9957 (IRS)	1 (CRS)	0.958 (IRS)	1 (CRS)	0.993 (IRS)	0.9747 (IRS)	0.9962 (IRS)	0.9667 (IRS)	0.9614 (IRS)	0.9626 (IRS)	1 (CRS)	**0.9826**
United Kingdom	0.6007 (DRS)	0.6666 (DRS)	0.6954 (DRS)	0.7789 (DRS)	0.7402 (DRS)	0.778 (DRS)	0.8358 (DRS)	1 (CRS)	0.9997 (IRS)	0.8626 (DRS)	0.8519 (DRS)	0.6999 (DRS)	0.7453 (DRS)	**0.7888**
United States	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	1 (CRS)	**1**

APPENDIX 2E: MALMQUIST PRODUCTIVITY INDEX (MPI) OF TFPG AND ITS COMPONENTS

		2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	Average
Australia	TC	1.0673	1.0534	1.0485	1.0057	1	1.0108	1.0199	1.0112	0.973	1	1	0.9683	**1.0132**
	SEC	0.8885	0.9437	0.9367	0.9747	0.9862	0.9728	0.9722	0.9717	1.028	1	1	0.9625	**0.9698**
	PEC	0.9159	1.0755	1.1154	1.0542	1	1	0.9613	0.92223	1.1278	1	1	1	**1.0144**
	TFPG	0.8686	1.0691	1.0955	1.0334	0.9862	0.9833	0.9532	0.9063	1.1281	1	1	0.932	**0.9963**
Belgium	TC	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
	SEC	1.017	1.0115	1.0308	1	1	1	1	1	1	1	1	1	**1.0049**
	PEC	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
	TFPG	1.017	1.0115	1.0308	1	1	1	1	1	1	1	1	1	**1.0049**
Brazil	TC	1.0484	1.0608	1.032	1.0509	1	1.0346	0.9484	1.0186	0.9905	1.0221	0.9276	0.9854	**1.0099**
	SEC	0.9932	1.0457	1.0157	1.0451	0.9941	1.0006	0.954	1.1181	0.998	1.0049	1.0008	1.0024	**1.0144**
	PEC	0.9038	1.1165	1.0177	1.0071	0.8877	1.0983	0.7076	1.3183	0.8912	0.7757	1.0831	1.2151	**1.0018**
	TFPG	0.9411	1.2386	1.0668	1.106	0.8825	1.137	0.6401	1.5015	0.881	0.7967	1.0055	1.2002	**1.0331**
Canada	TC	1.14	1.0874	1.0089	0.9518	0.9194	0.9951	0.9526	0.9969	1.0345	1.045	0.9834	0.9409	**1.0047**
	SEC	1.0002	1	1.0004	1.0014	0.9957	0.998	1.0032	1.0048	1.0082	1.0028	0.9997	0.997	**1.0010**
	PEC	1.0204	1.1526	0.9685	1.0694	1.004	0.9897	1.0346	0.9293	0.9948	0.9468	0.9935	1.0399	**1.0120**
	TFPG	1.1634	1.2533	0.9775	1.0193	0.9191	0.9829	0.9888	0.9308	1.0376	0.9922	0.9767	0.9755	**1.0181**
Chile	TC	1.1741	0.9022	0.909	0.8524	0.8931	0.929	0.9235	0.9242	0.9441	1.0802	1.119	0.7139	**0.9471**
	SEC	1.0952	1.0029	1.0438	1.4051	1.0296	1.0323	1.0493	1.0139	1.0871	1.0435	0.8257	1.1928	**1.0684**
	PEC	0.9603	1.2288	1.1079	1.0842	0.9003	0.9768	0.9383	1.4067	0.788	0.8092	1.1535	1.1764	**1.0442**
	TFPG	1.2348	1.1119	1.0512	1.2986	0.8279	0.9368	0.9093	1.3181	0.8088	0.9122	1.0658	1.0018	**1.0398**
China	TC	1.3375	1.3322	1.0606	0.9591	0.8706	0.9313	0.9885	1.1382	1.065	1.0196	0.941	0.9854	**1.0524**
	SEC	1.001	0.9958	0.9738	0.9887	0.9587	0.9144	0.9528	0.9794	0.9669	0.9959	0.9947	0.985	**0.9756**
	PEC	1.033	0.7375	0.9861	1.1331	1.2302	1.1899	0.9732	1.0586	1.1623	0.9509	0.86	0.9029	**1.0181**
	TFPG	1.3831	0.9784	1.0184	1.0744	1.0267	1.0133	0.9165	1.18	1.1968	0.9656	0.8049	0.8763	**1.0362**
Germany	TC	1.0535	1	1	1	1	1	1	1	1	1	1	1	**1.0045**
	SEC	1.26	1	1	1	1	1	1	1	1	1	1	1	**1.0217**
	PEC	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
	TFPG	1.3274	1	1	1	1	1	1	1	1	1	1	1	**1.0273**

		2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	Average
India	TC	1.1143	1.1597	1.1083	0.9313	0.8908	0.8799	0.9413	1.1695	0.975	0.9766	0.9907	0.9917	**1.0108**
	SEC	0.9964	0.9744	1.0101	1.0307	1.0097	1.0141	0.996	0.9947	1.0038	0.9926	1.043	0.9772	**1.0036**
	PEC	0.5049	1.8687	0.6174	1.0081	1.1207	1.2743	0.8442	1.0661	0.4687	4.44	1.1755	0.5849	**1.2478**
	TFPG	0.5605	2.1116	0.6912	0.9677	1.008	1.1371	0.7915	1.2402	0.4587	4.3039	1.2147	0.5668	**1.2543**
Indonesia	TC	1.1725	1.1438	1.2061	0.6973	0.9548	0.8735	0.909	1.2168	0.8851	1.0161	1.0228	1.0093	**1.0089**
	SEC	1.0562	0.9407	1.0394	1.0086	1.0027	1.0115	1.0053	1.0031	0.9986	1.0089	1.0034	0.9972	**1.0063**
	PEC	0.9915	1.231	1.2873	1.00042	1.0413	0.6421	1.2167	0.7655	2.0827	0.9234	0.8148	1.4116	**1.1174**
	TFPG	1.2279	1.3245	1.6137	0.7062	0.9968	0.5673	1.1118	0.9344	1.8408	0.9466	0.8363	1.4207	**1.1273**
Japan	TC	1.0213	1.0526	1.0219	1.0282	0.9938	1.0063	0.9988	1.0823	1.0331	1	1	1	**1.0199**
	SEC	0.9886	1.0031	0.9964	1.0201	0.9886	1.0164	1.0085	0.9683	1.0134	1	1	1	**1.0003**
	PEC	0.9746	1.0088	1.0159	1.0012	0.9377	1.0466	0.9055	0.9982	1.1273	1	1	1	**1.0013**
	TFPG	0.984	1.0652	1.0343	1.0502	0.9213	1.0704	0.9122	1.0461	1.1803	1	1	1	**1.0220**
Kenya	TC	1	1	1	0.9927	0.9648	0.8077	0.974	0.8967	1	1	1	1	**0.9697**
	SEC	1.6339	0.9013	0.5233	0.7359	0.9221	1.577	0.907	2.8671	0.9175	1.1277	1.0588	1	**1.1810**
	PEC	1	1	1	1	0.7401	0.9276	0.9468	1.5384	1	1	1	1	**1.0127**
	TFPG	1.6339	0.9013	0.5233	0.7306	0.6584	1.1816	0.8364	3.9548	0.9175	1.1277	1.0588	1	**1.2104**
Mexico	TC	1.0922	1.1877	1.0716	1.0281	0.9246	0.9105	0.9728	1.0579	0.9879	0.9864	0.9665	0.9739	**1.0133**
	SEC	0.9811	1.0064	0.959	1.0229	1.0065	0.999	0.9761	1.0336	0.9531	1.0085	1.003	1.0462	**0.9996**
	PEC	1.1484	0.8977	0.8624	1.0537	1.1983	1.3592	1	1	0.6041	1.202	0.8399	1.5016	**1.0556**
	TFPG	1.2305	1.0731	0.8862	1.1081	1.1151	1.2363	0.9495	1.0934	0.5688	1.1958	0.8141	1.5299	**1.0667**
New Zealand	TC	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
	SEC	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
	PEC	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
	TFPG	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
Nigeria	TC	0.9852	0.863	0.8499	0.9412	0.8802	0.9848	0.9236	1.1316	0.8734	1.0067	1.1061	1.0807	**0.9689**
	SEC	1.6948	1.0368	1.1342	1.0398	1.2813	1.0544	0.9445	1.0123	1.0124	1.0585	1.031	1.0048	**1.1087**
	PEC	0.9002	0.9539	0.7467	0.5766	1.0175	1.1555	1.3496	0.8571	0.8081	1.931	0.6723	1.1834	**1.0127**
	TFPG	1.5031	0.8535	0.7198	0.5643	1.1476	1.1999	1.1773	0.9819	0.7146	2.0576	0.7666	1.2851	**1.0809**
South Africa	TC	1.1327	1.057	1.0102	0.8536	0.913	0.9303	0.9071	1.0787	0.8807	1.0264	1.0121	0.9203	**0.9768**
	SEC	1.0521	1.0043	1.0002	0.9652	1.018	0.9977	0.9392	0.9749	1.0515	1.074	1.0015	1.0256	**1.0087**
	PEC	0.7682	1.2066	0.8732	1.5267	1.011	0.7357	1.1015	0.7697	1.3969	1.2161	1.0527	1.122	**1.0650**
	TFPG	0.9154	1.2809	0.8823	1.2578	0.9397	0.6828	0.9384	0.8095	1.2936	1.3406	1.0671	1.0591	**1.0389**
South Korea	TC	1	1.014	1.0109	1.0473	1	1	0.9901	1.0507	1.0069	1.0178	1.0029	0.9626	**1.0086**
	SEC	1.0209	1.0682	0.9934	1.049	1.0136	0.9988	1.0116	0.9979	0.9966	0.8897	0.8522	0.9428	**0.9862**
	PEC	1	1	0.9875	1.0126	1	1	0.9252	0.9625	1.0356	1.0055	0.9706	1.0872	**0.9989**
	TFPG	1.0209	1.0832	0.9917	1.1124	1.0136	0.9988	0.9266	1.0092	1.0393	0.9105	0.8296	0.9867	**0.9935**

		2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	Average
Turkey	TC	1.0812	1.1566	1.0117	0.9763	0.9275	0.9741	0.9542	1.1286	0.9205	0.9957	0.9901	0.9869	**1.0086**
	SEC	0.9903	1.0143	1.0046	0.9673	1.0439	0.9821	0.9879	0.9949	1.0019	0.9965	0.9945	1.0312	**1.0008**
	PEC	0.7178	1.1277	1.9742	0.8568	1.1671	0.9883	0.7067	1.0178	1.1724	1.0805	1.0815	1.0267	**1.0765**
	TFPG	0.7685	1.3228	2.0064	0.8092	1.1301	0.9455	0.6662	1.1428	1.0813	1.0721	1.0648	1.0449	**1.0879**
United Kingdom	TC	1	1	1	1	1	1	1	1.0264	0.9704	1	1	1	**0.9997**
	SEC	1.222	1.1172	1.1495	0.977	1.038	1.1217	1.1766	1.0347	0.9157	0.9816	0.788	1.0042	**1.0439**
	PEC	1	1	1	1	1	1	1	0.9417	1.0619	1	1	1	**1.0003**
	TFPG	1.222	1.1172	1.1495	0.977	1.038	1.1217	1.1766	1	0.9437	0.9816	0.788	1.0042	**1.0433**
United States	TC	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
	SEC	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
	PEC	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
	TFPG	1	1	1	1	1	1	1	1	1	1	1	1	**1.0000**
HICs	TC	1.0456	1.0110	0.9999	0.9885	0.9806	0.9941	0.9885	1.0092	0.9962	1.0143	1.0105	0.9586	**0.9998**
	SEC	1.0492	1.0147	1.0151	1.0427	1.0052	1.0140	1.0221	0.9991	1.0049	0.9918	0.9466	1.0099	**1.0096**
	PEC	0.9871	1.0466	1.0195	1.0222	0.9842	1.0013	0.9765	1.0161	1.0135	0.9762	1.0118	1.0304	**1.0071**
	TFPG	1.0838	1.0711	1.0331	1.0491	0.9706	1.0094	0.9867	1.0211	1.0138	0.9797	0.9660	0.9900	**1.0145**
MICs	TC	1.1071	1.1068	1.0389	0.9367	0.9251	0.9252	0.9465	1.0930	0.9531	1.0055	0.9952	0.9926	**1.0022**
	SEC	1.1554	0.9911	0.9623	0.9782	1.0263	1.0612	0.9625	1.2198	0.9893	1.0297	1.0145	1.0077	**1.0332**
	PEC	0.8853	1.1266	1.0406	1.0181	1.0460	1.0412	0.9829	1.0435	1.0652	1.5022	0.9533	1.1054	**1.0675**
	TFPG	1.1293	1.2316	1.0453	0.9249	0.9894	1.0112	0.8920	1.4265	0.9948	1.5341	0.9592	1.1092	**1.1040**
OECD	TC	1.0525	1.0378	1.0069	0.9908	0.9715	0.9855	0.9843	1.0232	0.9892	1.0104	1.0052	0.9622	**1.0016**
	SEC	1.0387	1.0139	1.0096	1.0348	1.0085	1.0101	1.0155	1.0017	1.0003	0.9936	0.9553	1.0147	**1.0080**
	PEC	0.9781	1.0409	1.0860	1.0110	1.0173	1.0301	0.9560	1.0149	0.9927	1.0037	1.0033	1.0693	**1.0169**
	TFPG	1.0698	1.0923	1.1019	1.0340	0.9959	1.0230	0.9569	1.0372	0.9823	1.0054	0.9616	1.0396	**1.0250**
All Countries	TC	1.0747	1.0563	1.0184	0.9640	0.9543	0.9615	0.9686	1.0489	0.9758	1.0101	1.0033	0.9747	**1.0009**
	SEC	1.0995	1.0035	0.9901	1.0122	1.0152	1.0364	0.9939	1.1037	0.9975	1.0097	0.9788	1.0089	**1.0208**
	PEC	0.9389	1.0845	1.0295	1.0202	1.0135	1.0202	0.9795	1.0291	1.0380	1.2253	0.9841	1.0659	**1.0357**
	TFPG	1.1054	1.1472	1.0389	0.9903	0.9795	1.0102	0.9418	1.2131	1.0048	1.2423	0.9628	1.0465	**1.0569**

	APPENDIX 2F: DEA SENSITIVITY ANALYSIS RESULT								
	CRS Technical Efficiency			**VRS Technical Efficiency**			**Scale Efficiency**		
	Original DEA Model	**Model 1**	**Model 2**	**Original DEA Model**	**Model 1**	**Model 2**	**Original DEA Model**	**Model 1**	**Model 2**
Australia	0.9038	0.9180	0.7095	0.9462	0.9462	0.8987	0.9532	0.9532	0.9410
Belgium	1.0000	0.9332	0.9763	1.0000	0.9861	1.0000	1.0000	0.9455	0.9763
Brazil	0.8159	0.6005	0.8141	0.8630	0.6072	0.8630	0.9472	0.9878	0.9445
Canada	0.7960	0.7956	0.7708	0.8022	0.8021	0.8015	0.9924	0.9921	0.9624
Chile	0.5860	0.5737	0.4810	0.6654	0.6369	0.6557	0.8830	0.9033	0.7424
China	0.4785	0.4772	0.4785	0.5208	0.5207	0.5208	0.9202	0.9167	0.9202
Germany	0.9852	0.9852	0.9848	1.0000	1.0000	0.9851	0.9852	0.9852	0.9997
India	0.4650	0.4650	0.4643	0.4761	0.4761	0.4761	0.9755	0.9755	0.9746
Indonesia	0.5785	0.5684	0.5160	0.6103	0.6093	0.5856	0.9475	0.9357	0.8887
Japan	0.9450	0.9226	0.9450	0.9732	0.9259	0.9732	0.9712	0.9965	0.9712
Kenya	0.6544	0.6544	0.4287	0.9290	0.9290	0.9290	0.6800	0.6800	0.4504
Mexico	0.7370	0.7197	0.7316	0.7594	0.7280	0.7594	0.9690	0.9806	0.9622
New Zealand	1.0000	1.0000	0.7530	1.0000	1.0000	1.0000	1.0000	1.0000	0.7530
Nigeria	0.5062	0.5058	0.4695	0.6164	0.6175	0.6159	0.8516	0.8532	0.7912
South Africa	0.6653	0.6463	0.5441	0.6922	0.6840	0.6800	0.9591	0.9529	0.8158
South Korea	0.8945	0.7954	0.8815	0.9640	0.8384	0.9223	0.9278	0.9514	0.9562
Turkey	0.7972	0.7755	0.7479	0.8111	0.7863	0.8106	0.9826	0.9862	0.9252
United Kingdom	0.7844	0.7628	0.7714	0.9955	0.9955	0.7851	0.7888	0.7673	0.9823
United States	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
HICs	0.8895	0.8686	0.8273	0.9346	0.9131	0.9022	0.9502	0.9494	0.9284
MICs	0.6331	0.6014	0.5772	0.6976	0.6620	0.6934	0.9147	0.9187	0.8525
OECD	0.8691	0.8485	0.8127	0.9097	0.8871	0.8826	0.9544	0.9551	0.9310
All Countries	0.7464	0.7421	0.7088	0.8223	0.7942	0.8033	0.9334	0.9349	0.8925
	Source(s): Developed for this research								

Notes:

Original DEA Model: (Inputs: Capex, Subscriotions & Employment; Outputs: Revenues & Teledensity)

Model 1 (Inputs: Capex, Subscriptions; Outputs: Revenues & Teledensity)

Model 2 (Inputs: Capex, Subscriptions & Employment; Output: Revenues)

APPENDIX 3A: CORRELATION BETWEEN CRS TECHNICAL EFFICIENCY AND EXPLANATORY VARIABLES

	CRSTE	NYRS	SubEmp	RevSub	CapexRev	CRGDPPC	HHI	CP1	LDev
CRSTE	1.0000								
NYRS	0.4181	1.0000							
SubEmp	0.3072	0.1665	1.0000						
RevSub	0.5359	0.3393	-0.2019	1.0000					
CapexRev	-0.3037	-0.2676	-0.2572	-0.0268	1.0000				
CRGDPPC	0.1827	0.1272	0.0057	0.2775	-0.0777	1.0000			
HHI	-0.0436	-0.2697	-0.0729	-0.0807	0.1086	-0.0546	1.0000		
CP1	0.3942	0.6782	0.3919	-0.0926	-0.3444	0.0808	-0.1700	1.0000	
LDev	0.5709	0.6365	0.0547	0.7072	-0.1819	0.2740	-0.0963	0.2774	1.0000

Source(s): Author’s calculations

APPENDIX 3B: CORRELATION BETWEEN VRS TECHNICAL EFFICIENCY AND EXPLANATORY VARIABLES

	VRSTE	NYRS	SubEmp	RevSub	CapexRev	CRGDPPC	HHI	CP1	LDev
VRSTE	1.0000								
NYRS	0.3584	1.0000							
SubEmp	0.2061	0.1665	1.0000						
RevSub	0.5482	0.3393	-0.2019	1.0000					
CapexRev	-0.0942	-0.2676	-0.2572	-0.0268	1.0000				
CRGDPPC	0.1904	0.1272	0.0057	0.2775	-0.0777	1.0000			
HHI	-0.0026	-0.2697	-0.0729	-0.0807	0.1086	-0.0546	1.0000		
CP1	0.2618	0.6782	0.3919	-0.0926	-0.3444	0.0808	-0.1700	1.0000	
LDev	0.5644	0.6365	0.0547	0.7072	-0.1819	0.2740	-0.0963	0.2774	1.0000

Source(s): Author’s calculations

APPENDIX 3C: CORRELATION BETWEEN SCALE EFFICIENCY AND EXPLANATORY VARIABLES

	SE	NYRS	SubEmp	RevSub	CapexRev	CRGDPPC	HHI	CP1	LDev
SE	1.0000								
NYRS	0.2173	1.0000							
SubEmp	0.2654	0.1665	1.0000						
RevSub	0.1229	0.3393	-0.2019	1.0000					
CapexRev	-0.4504	-0.2676	-0.2572	-0.0268	1.0000				
CRGDPPC	0.0357	0.1272	0.0057	0.2775	-0.0777	1.0000			
HHI	-0.0962	-0.2697	-0.0729	-0.0807	0.1086	-0.0546	1.0000		
CP1	0.3300	0.6782	0.3919	-0.0926	-0.3444	0.0808	-0.1700	1.0000	
LDev	0.1496	0.6365	0.0547	0.7072	-0.1819	0.2740	-0.0963	0.2774	1.0000

Source(s): Author’s calculations

APPENDIX 4A: CRS TECHNICAL EFFICIENCY REGRESSION RESULT WITH LAG IN THE MODEL

```
Random-effects tobit regression              Number of obs     =       227
Group variable: CountryID                    Number of groups  =        19

Random effects u_i ~ Gaussian                Obs per group:
                                                           min =        11
                                                           avg =      11.9
                                                           max =        12

Integration method: mvaghermite              Integration pts.  =        12

                                             Wald chi2(9)      =    231.30
Log likelihood  =  82.855863                 Prob > chi2       =    0.0000
```

CRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0034515	.0048237	-0.72	0.474	-.0129057	.0060027
SubEmp	.0001464	.0000611	2.39	0.017	.0000266	.0002662
RevSub	.0004675	.0000805	5.81	0.000	.0003097	.0006253
CapexRev	-.6447727	.0867787	-7.43	0.000	-.8148557	-.4746896
CRGDPPC	-4.20e-06	4.32e-06	-0.97	0.332	-.0000127	4.28e-06
HHI	5.32e-06	.0000154	0.35	0.730	-.0000249	.0000355
CP1	.0043184	.0011576	3.73	0.000	.0020496	.0065871
LDev	-.0165708	.080843	-0.20	0.838	-.1750202	.1418785
CRSTE						
L1.	.3424586	.0648509	5.28	0.000	.2153532	.469564
_cons	.0330402	.1266878	0.26	0.794	-.2152633	.2813436
/sigma_u	.1290541	.0298499	4.32	0.000	.0705494	.1875588
/sigma_e	.1122408	.0064576	17.38	0.000	.0995842	.1248974
rho	.5693427	.1158144			.3434618	.7741054

```
  0  left-censored observations
163     uncensored observations
 64 right-censored observations
```

Source(s): Author’s calculations

APPENDIX 4B: VRS TECHNICAL EFFICIENCY REGRESSION RESULT WITH LAG IN THE MODEL

```
Random-effects tobit regression              Number of obs     =       227
Group variable: CountryID                    Number of groups  =        19

Random effects u_i ~ Gaussian                Obs per group:
                                                          min =        11
                                                          avg =      11.9
                                                          max =        12

Integration method: mvaghermite              Integration pts.  =        12

                                             Wald chi2(9)      =    129.79
Log likelihood  =  42.848452                 Prob > chi2       =    0.0000
```

VRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0035386	.0057314	-0.62	0.537	-.0147719	.0076947
SubEmp	.000256	.0000764	3.35	0.001	.0001062	.0004059
RevSub	.0006133	.0001299	4.72	0.000	.0003587	.000868
CapexRev	-.6883603	.1183741	-5.82	0.000	-.9203692	-.4563513
CRGDPPC	-2.63e-06	5.81e-06	-0.45	0.651	-.000014	8.75e-06
HHI	-.0000319	.00002	-1.60	0.110	-.0000711	7.23e-06
CP1	.002298	.0013752	1.67	0.095	-.0003973	.0049933
LDev	-.0561853	.117415	-0.48	0.632	-.2863144	.1739438
VRSTE						
L1.	.4224953	.0788974	5.35	0.000	.2678593	.5771313
_cons	.2942719	.1584002	1.86	0.063	-.0161868	.6047307
/sigma_u	.1977801	.0463298	4.27	0.000	.1069754	.2885849
/sigma_e	.118539	.0077323	15.33	0.000	.1033839	.1336941
rho	.7357174	.0947814			.524822	.8845679

```
        0  left-censored observations
      133     uncensored observations
       94 right-censored observations
```

Source(s): Author’s calculations

APPENDIX 4C: SCALE EFFICIENCY REGRESSION RESULT WITH LAG IN THE MODEL

```
Random-effects tobit regression              Number of obs     =       227
Group variable: CountryID                    Number of groups  =        19

Random effects u_i ~ Gaussian                Obs per group:
                                                          min =        11
                                                          avg =      11.9
                                                          max =        12

Integration method: mvaghermite              Integration pts.  =        12

                                             Wald chi2(9)      =    202.00
Log likelihood  =  158.09394                 Prob > chi2       =    0.0000
```

SE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0014035	.0030434	-0.46	0.645	-.0073684	.0045615
SubEmp	-.0000262	.0000374	-0.70	0.483	-.0000995	.0000471
RevSub	.0002241	.0000489	4.58	0.000	.0001283	.00032
CapexRev	-.3449806	.0565411	-6.10	0.000	-.4557991	-.234162
CRGDPPC	-4.20e-06	2.68e-06	-1.57	0.117	-9.46e-06	1.06e-06
HHI	.0000152	.0000105	1.45	0.147	-5.35e-06	.0000358
CP1	.0025192	.0007068	3.56	0.000	.001134	.0039045
LDev	-.059335	.0490986	-1.21	0.227	-.1555665	.0368964
SE						
L1.	.4549557	.0612482	7.43	0.000	.3349115	.5749999
_cons	.2809304	.1022913	2.75	0.006	.0804432	.4814176
/sigma_u	.0766734	.0195025	3.93	0.000	.0384492	.1148976
/sigma_e	.0702295	.0040727	17.24	0.000	.0622472	.0782117
rho	.543781	.1298097			.2974856	.7738463

```
  0  left-censored observations
161     uncensored observations
 66 right-censored observations
```

Source(s): Author's calculations

APPENDIX 5A: CRS TECHNICAL EFFICIENCY REGRESSION RESULT WITH LAG AND INTERACTION TERM IN THE MODEL

```
Random-effects tobit regression             Number of obs     =       227
Group variable: CountryID                   Number of groups  =        19

Random effects u_i ~ Gaussian               Obs per group:
                                                          min =        11
                                                          avg =      11.9
                                                          max =        12

Integration method: mvaghermite             Integration pts.  =        12

                                            Wald chi2(10)     =    315.61
Log likelihood  =  103.76651                Prob > chi2       =    0.0000
```

CRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0053068	.0044013	-1.21	0.228	-.0139331	.0033196
SubEmp	.0005075	.0000768	6.61	0.000	.0003571	.000658
RevSub	.0004103	.0000731	5.61	0.000	.000267	.0005536
CapexRev	-.3335089	.0888795	-3.75	0.000	-.5077095	-.1593083
CRGDPPC	-2.82e-06	3.84e-06	-0.73	0.463	-.0000103	4.71e-06
HHI	2.55e-06	.0000142	0.18	0.857	-.0000253	.0000304
CP1	.0048156	.0010486	4.59	0.000	.0027604	.0068708
LDev	.0421114	.0796501	0.53	0.597	-.1139999	.1982226
CRSTE						
L1.	.3162585	.0570319	5.55	0.000	.204478	.4280389
SubEmpCapexRev	-.0020456	.0002988	-6.85	0.000	-.0026313	-.0014599
_cons	-.0104934	.1171072	-0.09	0.929	-.2400193	.2190325
/sigma_u	.1319569	.0302531	4.36	0.000	.0726619	.191252
/sigma_e	.0985863	.0057096	17.27	0.000	.0873956	.1097769
rho	.6417773	.1088068			.4176953	.8249048

```
  0  left-censored observations
163     uncensored observations
 64 right-censored observations
```

.

Source(s): Author's calculations

APPENDIX 5B: VRS TECHNICAL EFFICIENCY REGRESSION RESULT WITH LAG AND INTERACTION TERM IN THE MODEL

```
Random-effects tobit regression              Number of obs     =        227
Group variable: CountryID                    Number of groups  =         19

Random effects u_i ~ Gaussian                Obs per group:
                                                           min =         11
                                                           avg =       11.9
                                                           max =         12

Integration method: mvaghermite              Integration pts.  =         12

                                             Wald chi2(10)     =     211.98
Log likelihood  =  60.841412                 Prob > chi2       =     0.0000
```

VRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0045812	.0050053	-0.92	0.360	-.0143914	.005229
SubEmp	.0006203	.0000867	7.15	0.000	.0004503	.0007903
RevSub	.0003886	.0001114	3.49	0.000	.0001703	.0006069
CapexRev	-.2009426	.1224567	-1.64	0.101	-.4409534	.0390682
CRGDPPC	2.47e-07	4.97e-06	0.05	0.960	-9.50e-06	9.99e-06
HHI	-.0000253	.0000171	-1.48	0.139	-.0000589	8.24e-06
CP1	.0026026	.0011866	2.19	0.028	.0002768	.0049283
LDev	.0790999	.1006045	0.79	0.432	-.1180812	.2762811
VRSTE						
L1.	.3636691	.0687132	5.29	0.000	.2289937	.4983444
SubEmpCapexRev	-.0022208	.0003429	-6.48	0.000	-.0028929	-.0015486
_cons	.2464699	.1358346	1.81	0.070	-.019761	.5127007
/sigma_u	.1636582	.0387772	4.22	0.000	.0876564	.2396601
/sigma_e	.1030441	.0067612	15.24	0.000	.0897924	.1162957
rho	.71611	.1004308			.496189	.8753807

```
  0  left-censored observations
133     uncensored observations
 94 right-censored observations
```

.

Source(s): Author's calculations

APPENDIX 5C: SCALE EFFICIENCY REGRESSION RESULT WITH LAG AND INTERACTION TERM IN THE MODEL

```
Random-effects tobit regression              Number of obs     =        227
Group variable: CountryID                    Number of groups  =         19

Random effects u_i ~ Gaussian                Obs per group:
                                                           min =         11
                                                           avg =       11.9
                                                           max =         12

Integration method: mvaghermite              Integration pts.  =         12

                                             Wald chi2(10)     =     203.84
Log likelihood  =   158.3118                 Prob > chi2       =     0.0000
```

SE	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
NYRS	-.0013363	.0030392	-0.44	0.660	-.0072931	.0046205
SubEmp	-.0000507	.0000525	-0.97	0.335	-.0001536	.0000523
RevSub	.000229	.0000492	4.65	0.000	.0001325	.0003254
CapexRev	-.3677132	.0660257	-5.57	0.000	-.4971212	-.2383052
CRGDPPC	-4.32e-06	2.68e-06	-1.61	0.107	-9.57e-06	9.34e-07
HHI	.0000152	.0000105	1.45	0.147	-5.35e-06	.0000357
CPI	.0025024	.0007034	3.56	0.000	.0011238	.0038811
LDev	-.0628598	.0492276	-1.28	0.202	-.1593441	.0336245
SE						
L1.	.448893	.0617192	7.27	0.000	.3279256	.5698604
SubEmpCapexRev	.0001412	.0002134	0.66	0.508	-.000277	.0005594
_cons	.2906783	.1029379	2.82	0.005	.0889237	.492433
/sigma_u	.0764531	.0194245	3.94	0.000	.0383818	.1145244
/sigma_e	.0700344	.0040637	17.23	0.000	.0620696	.0779991
rho	.5437337	.1295632			.2978695	.7734412

```
  0  left-censored observations
161     uncensored observations
 66 right-censored observations
```

.

Source(s): Author's calculations

APPENDIX 6A: CRS TECHNICAL EFFICIENCY REGRESSION RESULT WITH LAG, INTERACTION TERM AND NYRSSQUARE IN THE MODEL

```
Random-effects tobit regression              Number of obs     =       227
Group variable: CountryID                    Number of groups  =        19

Random effects u_i ~ Gaussian                Obs per group:
                                                          min =        11
                                                          avg =      11.9
                                                          max =        12

Integration method: mvaghermite              Integration pts.  =        12

                                             Wald chi2(11)     =    315.78
Log likelihood  =   104.4785                 Prob > chi2       =    0.0000
```

CRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0189713	.0123156	-1.54	0.123	-.0431094	.0051668
SubEmp	.0005247	.0000786	6.67	0.000	.0003706	.0006788
RevSub	.0004054	.0000728	5.57	0.000	.0002628	.0005481
CapexRev	-.3428663	.0888016	-3.86	0.000	-.5169143	-.1688183
CRGDPPC	-2.28e-06	3.84e-06	-0.59	0.553	-9.81e-06	5.25e-06
HHI	5.80e-06	.0000145	0.40	0.690	-.0000227	.0000343
CP1	.0055808	.0012348	4.52	0.000	.0031606	.0080009
LDev	.0659343	.0838183	0.79	0.431	-.0983466	.2302151
CRSTE						
L1.	.3090722	.0570514	5.42	0.000	.1972534	.4208909
SubEmpCapexRev	-.0020293	.0002983	-6.80	0.000	-.0026141	-.0014446
NYRSSquare	.000341	.0002862	1.19	0.233	-.0002199	.000902
_cons	.0098625	.119023	0.08	0.934	-.2234183	.2431432
/sigma_u	.1356411	.0310405	4.37	0.000	.0748029	.1964794
/sigma_e	.0980783	.0056857	17.25	0.000	.0869346	.1092219
rho	.6566709	.106632			.4345175	.8343934

```
          0  left-censored observations
        163     uncensored observations
         64 right-censored observations
```

.

Source(s): Author’s calculations

APPENDIX 6B: VRS TECHNICAL EFFICIENCY REGRESSION RESULT WITH LAG, INTERACTION TERM AND NYRSSQUARE IN THE MODEL

```
Random-effects tobit regression               Number of obs     =       227
Group variable: CountryID                     Number of groups  =        19

Random effects u_i ~ Gaussian                 Obs per group:
                                                            min =        11
                                                            avg =      11.9
                                                            max =        12

Integration method: mvaghermite               Integration pts.  =        12

                                              Wald chi2(11)     =    214.61
Log likelihood  =  62.005822                  Prob > chi2       =    0.0000
```

VRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.025113	.0144234	-1.74	0.082	-.0533823	.0031563
SubEmp	.0006544	.0000899	7.28	0.000	.0004783	.0008305
RevSub	.0003717	.0001106	3.36	0.001	.0001549	.0005885
CapexRev	-.2219798	.1224464	-1.81	0.070	-.4619704	.0180107
CRGDPPC	1.28e-06	4.95e-06	0.26	0.797	-8.43e-06	.000011
HHI	-.0000214	.0000171	-1.25	0.211	-.000055	.0000122
CP1	.0035564	.0013448	2.64	0.008	.0009207	.006192
LDev	.1157164	.1059362	1.09	0.275	-.0919146	.3233475
VRSTE						
L1.	.3538867	.0680293	5.20	0.000	.2205517	.4872217
SubEmpCapexRev	-.0022061	.0003405	-6.48	0.000	-.0028734	-.0015387
NYRSSquare	.0005269	.0003469	1.52	0.129	-.000153	.0012069
_cons	.2972088	.1401784	2.12	0.034	.0224641	.5719536
/sigma_u	.1695526	.0397418	4.27	0.000	.09166	.2474452
/sigma_e	.1019426	.0066949	15.23	0.000	.0888208	.1150644
rho	.7344866	.0954549			.5222552	.8843592

```
  0  left-censored observations
133     uncensored observations
 94 right-censored observations
```

.

Source(s): Author's calculations

APPENDIX 6C: SCALE EFFICIENCY REGRESSION RESULT WITH LAG, INTERACTION TERM AND NYRSSQUARE IN THE MODEL

```
Random-effects tobit regression             Number of obs     =       227
Group variable: CountryID                   Number of groups  =        19

Random effects u_i ~ Gaussian               Obs per group:
                                                          min =        11
                                                          avg =      11.9
                                                          max =        12

Integration method: mvaghermite             Integration pts.  =        12

                                            Wald chi2(11)     =    204.06
Log likelihood  =  158.51243                Prob > chi2       =    0.0000
```

SE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0061724	.0082307	-0.75	0.453	-.0223043	.0099594
SubEmp	-.000047	.0000528	-0.89	0.373	-.0001505	.0000564
RevSub	.0002264	.0000493	4.60	0.000	.0001299	.000323
CapexRev	-.3717877	.0662581	-5.61	0.000	-.5016511	-.2419243
CRGDPPC	-4.13e-06	2.69e-06	-1.53	0.125	-9.41e-06	1.15e-06
HHI	.0000164	.0000107	1.53	0.125	-4.56e-06	.0000374
CP1	.0027614	.0008183	3.37	0.001	.0011576	.0043652
LDev	-.0556952	.0508537	-1.10	0.273	-.1553666	.0439762
SE						
L1.	.4470585	.0617772	7.24	0.000	.3259774	.5681397
SubEmpCapexRev	.0001505	.0002139	0.70	0.482	-.0002687	.0005697
NYRSSquare	.0001239	.000196	0.63	0.527	-.0002602	.0005081
_cons	.29934	.1041947	2.87	0.004	.0951221	.503558
/sigma_u	.0773805	.0195034	3.97	0.000	.0391545	.1156065
/sigma_e	.0699582	.0040587	17.24	0.000	.0620033	.077913
rho	.5502484	.1282124			.3054991	.7767393

```
      0  left-censored observations
    161     uncensored observations
     66 right-censored observations
```

.

Source(s): Author's calculations

APPENDIX 7A: CRS TECHNICAL EFFICIENCY REGRESSION RESULT WITH LAG, INTERACTION TERM AND CRGDPPCSQUARE IN THE MODEL

Random-effects tobit regression		Number of obs =	227
Group variable: CountryID		Number of groups =	19
Random effects u_i ~ Gaussian		Obs per group:	
		min =	11
		avg =	11.9
		max =	12
Integration method: mvaghermite		Integration pts. =	12
		Wald chi2(11) =	316.70
Log likelihood = 105.12849		Prob > chi2 =	0.0000

CRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.005694	.0044173	-1.29	0.197	-.0143519	.0029638
SubEmp	.0005069	.0000766	6.61	0.000	.0003567	.0006571
RevSub	.0003888	.0000743	5.24	0.000	.0002433	.0005344
CapexRev	-.3253615	.0888847	-3.66	0.000	-.4995723	-.1511506
CRGDPPC	-2.67e-06	4.19e-06	-0.64	0.525	-.0000109	5.55e-06
HHI	3.07e-06	.0000142	0.22	0.829	-.0000247	.0000309
CP1	.0047529	.0010514	4.52	0.000	.0026923	.0068135
LDev	.043692	.079535	0.55	0.583	-.1121938	.1995778
CRSTE						
L1.	.3187891	.0569981	5.59	0.000	.2070749	.4305032
SubEmpCapexRev	-.0020389	.0002984	-6.83	0.000	-.0026238	-.001454
CGDPPCSquare	1.08e-09	7.08e-10	1.52	0.127	-3.08e-10	2.47e-09
_cons	-.0020998	.1171256	-0.02	0.986	-.2316617	.2274621
/sigma_u	.131307	.0300798	4.37	0.000	.0723516	.1902624
/sigma_e	.0984623	.0056973	17.28	0.000	.0872959	.1096288
rho	.6400838	.1088816			.4161383	.8235939

0 left-censored observations
163 uncensored observations
64 right-censored observations

.

Source(s): Author's calculations

APPENDIX 7B: VRS TECHNICAL EFFICIENCY REGRESSION RESULT WITH LAG, INTERACTION TERM AND CRGDPPCSQUARE IN THE MODEL

```
Random-effects tobit regression                 Number of obs     =        227
Group variable: CountryID                       Number of groups  =         19

Random effects u_i ~ Gaussian                   Obs per group:
                                                              min =         11
                                                              avg =       11.9
                                                              max =         12

Integration method: mvaghermite                 Integration pts.  =         12

                                                Wald chi2(11)     =     212.52
Log likelihood  =  61.020404                    Prob > chi2       =     0.0000
```

VRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0042436	.0050208	-0.85	0.398	-.0140843	.0055971
SubEmp	.0006213	.0000865	7.18	0.000	.0004516	.0007909
RevSub	.0004013	.0001136	3.53	0.000	.0001787	.000624
CapexRev	-.2109476	.1238795	-1.70	0.089	-.4537469	.0318517
CRGDPPC	6.16e-07	4.75e-06	0.13	0.897	-8.70e-06	9.93e-06
HHI	-.0000262	.0000172	-1.52	0.128	-.0000599	7.56e-06
CP1	.0025788	.0011838	2.18	0.029	.0002586	.0048991
LDev	.0761445	.1014605	0.75	0.453	-.1227143	.2750034
VRSTE						
L1.	.36269	.0684487	5.30	0.000	.2285331	.496847
SubEmpCapexRev	-.0022169	.0003426	-6.47	0.000	-.0028884	-.0015454
CGDPPCSquare	-5.32e-10	8.54e-10	-0.62	0.534	-2.21e-09	1.14e-09
_cons	.2479382	.1361025	1.82	0.069	-.0188178	.5146943
/sigma_u	.1657312	.0392449	4.22	0.000	.0888125	.2426498
/sigma_e	.1027305	.006749	15.22	0.000	.0895026	.1159583
rho	.7224239	.099109			.5042111	.8789107

```
  0  left-censored observations
133     uncensored observations
 94 right-censored observations
```

.

Source(s): Author’s calculations

APPENDIX 7C: SCALE EFFICIENCY REGRESSION RESULT WITH LAG, INTERACTION TERM AND CRGDPPCSQUARE IN THE MODEL

```
Random-effects tobit regression              Number of obs     =        227
Group variable: CountryID                    Number of groups  =         19

Random effects u_i ~ Gaussian                Obs per group:
                                                           min =         11
                                                           avg =       11.9
                                                           max =         12

Integration method: mvaghermite              Integration pts.  =         12

                                             Wald chi2(11)     =     208.17
Log likelihood  =  161.85376                 Prob > chi2       =     0.0000
```

SE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0014976	.0030289	-0.49	0.621	-.0074342	.0044389
SubEmp	-.0000522	.0000523	-1.00	0.318	-.0001546	.0000503
RevSub	.0002069	.0000493	4.20	0.000	.0001103	.0003036
CapexRev	-.3585588	.0653125	-5.49	0.000	-.4865688	-.2305487
CRGDPPC	-4.04e-06	3.03e-06	-1.33	0.184	-9.98e-06	1.91e-06
HHI	.0000165	.0000104	1.58	0.114	-3.94e-06	.0000369
CP1	.0024155	.0007028	3.44	0.001	.001038	.003793
LDev	-.0626615	.0499734	-1.25	0.210	-.1606075	.0352846
SE						
L1.	.4507833	.061102	7.38	0.000	.3310255	.5705411
SubEmpCapexRev	.0001485	.0002112	0.70	0.482	-.0002654	.0005624
CGDPPCSquare	1.23e-09	5.28e-10	2.33	0.020	1.98e-10	2.27e-09
_cons	.2950203	.1027009	2.87	0.004	.0937302	.4963104
/sigma_u	.0787153	.0195325	4.03	0.000	.0404323	.1169983
/sigma_e	.0691374	.0039977	17.29	0.000	.0613021	.0769727
rho	.5645095	.1252413			.3223797	.784031

```
  0  left-censored observations
161     uncensored observations
 66 right-censored observations
```

.

Source(s): Author's calculations

APPENDIX 8A: CRS TECHNICAL EFFICIENCY REGRESSION RESULT WITH LAG, INTERACTION TERM AND THE TWO QUADRATIC TERMS IN THE MODEL

```
Random-effects tobit regression             Number of obs     =        227
Group variable: CountryID                   Number of groups  =         19

Random effects u_i ~ Gaussian               Obs per group:
                                                          min =         11
                                                          avg =       11.9
                                                          max =         12

Integration method: mvaghermite             Integration pts.  =         12

                                            Wald chi2(12)     =     316.87
Log likelihood  =  106.23249                Prob > chi2       =     0.0000
```

CRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0230258	.0125492	-1.83	0.067	-.0476218	.0015701
SubEmp	.0005289	.0000787	6.72	0.000	.0003746	.0006831
RevSub	.0003798	.0000739	5.14	0.000	.0002349	.0005247
CapexRev	-.3361071	.0886071	-3.79	0.000	-.5097738	-.1624404
CRGDPPC	-1.94e-06	4.24e-06	-0.46	0.648	-.0000103	6.37e-06
HHI	7.24e-06	.0000145	0.50	0.618	-.0000212	.0000357
CP1	.0057101	.0012409	4.60	0.000	.003278	.0081422
LDev	.0744411	.0846246	0.88	0.379	-.0914201	.2403023
CRSTE						
L1.	.309999	.0569008	5.45	0.000	.1984754	.4215225
SubEmpCapexRev	-.0020183	.0002976	-6.78	0.000	-.0026016	-.001435
NYRSSquare	.0004312	.000291	1.48	0.138	-.0001391	.0010015
CGDPPCSquare	1.24e-09	7.29e-10	1.71	0.088	-1.85e-10	2.67e-09
_cons	.0248728	.1195336	0.21	0.835	-.2094088	.2591544
/sigma_u	.1365705	.0312204	4.37	0.000	.0753796	.1977615
/sigma_e	.0977713	.0056601	17.27	0.000	.0866777	.1088649
rho	.6611493	.1057631			.4400389	.8369684

```
  0  left-censored observations
163     uncensored observations
 64 right-censored observations
```

Source(s): Author's calculations

APPENDIX 8B: VRS TECHNICAL EFFICIENCY REGRESSION RESULT WITH LAG, INTERACTION TERM AND THE TWO QUADRATIC TERMS IN THE MODEL

```
Random-effects tobit regression                 Number of obs     =        227
Group variable: CountryID                       Number of groups  =         19

Random effects u_i ~ Gaussian                   Obs per group:
                                                              min =         11
                                                              avg =       11.9
                                                              max =         12

Integration method: mvaghermite                 Integration pts.  =         12

                                                Wald chi2(12)     =     215.18
Log likelihood  =   62.11179                    Prob > chi2       =     0.0000
```

VRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0242791	.014519	-1.67	0.094	-.0527358	.0041777
SubEmp	.0006542	.0000897	7.29	0.000	.0004784	.00083
RevSub	.0003813	.0001127	3.38	0.001	.0001604	.0006021
CapexRev	-.2286808	.1233934	-1.85	0.064	-.4705275	.0131659
CRGDPPC	1.54e-06	4.78e-06	0.32	0.747	-7.83e-06	.0000109
HHI	-.0000221	.0000172	-1.28	0.199	-.0000559	.0000116
CP1	.0035107	.0013453	2.61	0.009	.0008741	.0061474
LDev	.1125849	.1065419	1.06	0.291	-.0962334	.3214031
VRSTE						
L1.	.353548	.0678519	5.21	0.000	.2205607	.4865353
SubEmpCapexRev	-.0022043	.0003402	-6.48	0.000	-.0028711	-.0015375
NYRSSquare	.0005122	.0003481	1.47	0.141	-.0001701	.0011945
CGDPPCSquare	-4.08e-10	8.60e-10	-0.48	0.635	-2.09e-09	1.28e-09
_cons	.2966933	.140236	2.12	0.034	.0218359	.5715508
/sigma_u	.1707529	.0399666	4.27	0.000	.0924199	.249086
/sigma_e	.1017387	.0066877	15.21	0.000	.0886309	.1148464
rho	.7380041	.0945738			.5271026	.8861723

```
      0  left-censored observations
    133     uncensored observations
     94 right-censored observations
```

.

Source(s): Author's calculations

APPENDIX 8C: SCALE EFFICIENCY REGRESSION RESULT WITH LAG, INTERACTION TERM AND THE TWO QUADRATIC TERMS IN THE MODEL

```
Random-effects tobit regression              Number of obs     =        227
Group variable: CountryID                    Number of groups  =         19

Random effects u_i ~ Gaussian                Obs per group:
                                                           min =         11
                                                           avg =       11.9
                                                           max =         12

Integration method: mvaghermite              Integration pts.  =         12

                                             Wald chi2(12)     =     208.64
Log likelihood  =  162.47205                 Prob > chi2       =     0.0000
```

SE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
NYRS	-.0101365	.008381	-1.21	0.226	-.026563	.0062899
SubEmp	-.0000454	.0000526	-0.86	0.388	-.0001484	.0000576
RevSub	.000201	.0000494	4.07	0.000	.0001042	.0002978
CapexRev	-.3650778	.0653634	-5.59	0.000	-.4931878	-.2369678
CRGDPPC	-3.69e-06	3.08e-06	-1.20	0.231	-9.73e-06	2.35e-06
HHI	.0000189	.0000107	1.76	0.078	-2.15e-06	.00004
CP1	.002874	.0008232	3.49	0.000	.0012605	.0044875
LDev	-.0494956	.0522808	-0.95	0.344	-.151964	.0529729
SE						
L1.	.447649	.0610876	7.33	0.000	.3279195	.5673786
SubEmpCapexRev	.0001647	.0002114	0.78	0.436	-.0002497	.0005791
NYRSSquare	.0002205	.0001991	1.11	0.268	-.0001698	.0006108
CGDPPCSquare	1.33e-09	5.49e-10	2.43	0.015	2.58e-10	2.41e-09
_cons	.3101194	.1042652	2.97	0.003	.1057633	.5144755
/sigma_u	.080972	.0198425	4.08	0.000	.0420814	.1198626
/sigma_e	.0689104	.003983	17.30	0.000	.0611039	.0767168
rho	.5799563	.1225615			.3399005	.7928352

```
  0  left-censored observations
161     uncensored observations
 66 right-censored observations
```

.

Source(s): Author’s calculations

APPENDIX 9A: TOBIT MODEL WITH ENDOGENOUS REGRESSORS WITH CRS TECHNICAL EFFICIENCY AS DEPENDENT VARIABLE

```
Tobit model with endogenous regressors          Number of obs    =        247
                                                Wald chi2(8)     =     261.30
Log likelihood = -3409.3753                     Prob > chi2      =     0.0000
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
RevSub	.0007581	.000109	6.96	0.000	.0005446	.0009717
CRGDPPC	-4.91e-06	.0000325	-0.15	0.880	-.0000687	.0000589
CapexRev	-.1080831	.0477819	-2.26	0.024	-.201734	-.0144323
NYRS	-.0130184	.0042432	-3.07	0.002	-.0213349	-.0047019
SubEmp	.0002527	.0000446	5.67	0.000	.0001653	.00034
HHI	9.03e-06	.0000103	0.88	0.382	-.0000112	.0000293
CP1	.0084233	.0013606	6.19	0.000	.0057565	.0110901
LDev	-.0355571	.0543355	-0.65	0.513	-.1420527	.0709384
_cons	-.2754942	.1107167	-2.49	0.013	-.4924949	-.0584935

```
Instrumented:  RevSub CRGDPPC CapexRev
Instruments:   NYRS SubEmp HHI CP1 LDev RevEmp RGDPPC CapexSub Revenue

Wald test of exogeneity: chi2(3) = 71.28            Prob > chi2 = 0.0000

            0  left-censored observations
          178     uncensored observations
           69 right-censored observations at CRSTE >= 1
```

Source(s): Author’s calculations

APPENDIX 9B: TOBIT MODEL WITH ENDOGENOUS REGRESSORS WITH VRS TECHNICAL EFFICIENCY AS DEPENDENT VARIABLE

```
Tobit model with endogenous regressors          Number of obs     =        247
                                                Wald chi2(8)      =     143.21
Log likelihood = -3478.8031                     Prob > chi2       =     0.0000
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
RevSub	.0007135	.0001424	5.01	0.000	.0004345	.0009926
CRGDPPC	.0000384	.0000404	0.95	0.343	-.0000409	.0001176
CapexRev	.0686617	.0829721	0.83	0.408	-.0939606	.231284
NYRS	-.0103246	.005776	-1.79	0.074	-.0216454	.0009962
SubEmp	.0002401	.0000611	3.93	0.000	.0001205	.0003598
HHI	.0000167	.0000139	1.21	0.227	-.0000104	.0000439
CP1	.0067035	.00179	3.75	0.000	.0031952	.0102118
LDev	-.001016	.0741195	-0.01	0.989	-.1462876	.1442557
_cons	-.1629163	.1520362	-1.07	0.284	-.4609017	.135069

```
Instrumented:  RevSub CRGDPPC CapexRev
Instruments:   NYRS SubEmp HHI CP1 LDev RevEmp RGDPPC CapexSub Revenue

Wald test of exogeneity: chi2(3) = 43.64              Prob > chi2 = 0.0000

          0  left-censored observations
        144     uncensored observations
        103 right-censored observations at VRSTE >= 1
```

Source(s): Author's calculations

APPENDIX 9C: TOBIT MODEL WITH ENDOGENOUS REGRESSORS WITH SCALE EFFICIENCY AS DEPENDENT VARIABLE

Tobit model with endogenous regressors   Number of obs = 247
Wald chi2(8) = 86.72
Log likelihood = -3355.1535   Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
RevSub	.0003429	.0000729	4.70	0.000	.0002	.0004858
CRGDPPC	-.00002	.0000201	-0.99	0.320	-.0000593	.0000194
CapexRev	-.163924	.0338005	-4.85	0.000	-.2301718	-.0976763
NYRS	-.0062479	.0030071	-2.08	0.038	-.0121417	-.0003541
SubEmp	.0000868	.0000321	2.71	0.007	.000024	.0001497
HHI	-3.35e-06	7.34e-06	-0.46	0.648	-.0000177	.000011
CP1	.0042261	.0009565	4.42	0.000	.0023515	.0061008
LDev	-.0699008	.0389335	-1.80	0.073	-.146209	.0064074
_cons	.5634312	.0788902	7.14	0.000	.4088092	.7180533

Instrumented: RevSub CRGDPPC CapexRev
Instruments: NYRS SubEmp HHI CP1 LDev RevEmp RGDPPC CapexSub Revenue

Wald test of exogeneity: chi2(3) = 40.31   Prob > chi2 = 0.0000

0 left-censored observations
176 uncensored observations
71 right-censored observations at SE >= 1

Source(s): Author's calculations

APPENDIX 10A: RANDOM EFFECT INSTRUMENTAL VARIABLE REGRESSION WITH CRS TECHNICAL EFFICIENCY AS DEPENDENT VARIABLE

```
G2SLS random-effects IV regression              Number of obs      =       246
Group variable: CountryID                       Number of groups   =        19

R-sq:                                           Obs per group:
     within  = 0.2809                                         min =        12
     between = 0.7378                                         avg =      12.9
     overall = 0.5758                                         max =        13

                                                Wald chi2(8)       =    152.77
corr(u_i, X)       = 0 (assumed)                Prob > chi2        =    0.0000
```

CRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
RevSub	.0005361	.0001308	4.10	0.000	.0002798	.0007924
CapexRev	-.0336274	.0362474	-0.93	0.354	-.104671	.0374163
CRGDPPC	-.000017	.0000197	-0.86	0.388	-.0000556	.0000216
NYRS	-.0086165	.0035182	-2.45	0.014	-.0155121	-.0017209
SubEmp	.0002044	.000047	4.35	0.000	.0001124	.0002965
HHI	8.87e-06	.0000109	0.81	0.416	-.0000125	.0000303
CP1	.0070717	.0012296	5.75	0.000	.0046617	.0094816
LDev	.0064467	.0656968	0.10	0.922	-.1223167	.1352101
_cons	-.1475039	.1332018	-1.11	0.268	-.4085746	.1135669
sigma_u	.08875378					
sigma_e	.18292018					
rho	.19056119	(fraction of variance due to u_i)				

Instrumented: RevSub CapexRev CRGDPPC
Instruments: NYRS SubEmp HHI CP1 LDev RevEmp RGDPPC CapexSub Revenue

Source(s): Author’s calculations

APPENDIX 10B: RANDOM EFFECT INSTRUMENTAL VARIABLE REGRESSION WITH VRS TECHNICAL EFFICIENCY AS DEPENDENT VARIABLE

```
G2SLS random-effects IV regression            Number of obs      =       246
Group variable: CountryID                     Number of groups   =        19

R-sq:                                         Obs per group:
     within  = 0.1491                                      min =        12
     between = 0.5678                                      avg =      12.9
     overall = 0.4288                                      max =        13

                                              Wald chi2(8)       =     69.83
corr(u_i, X)       = 0 (assumed)              Prob > chi2        =    0.0000
```

VRSTE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
RevSub	.0004548	.0002499	1.82	0.069	-.000035	.0009446
CapexRev	.1057722	.0451376	2.34	0.019	.0173042	.1942401
CRGDPPC	-.0000209	.0000224	-0.93	0.350	-.0000649	.000023
NYRS	-.0063821	.0038356	-1.66	0.096	-.0138997	.0011354
SubEmp	.0002295	.0000598	3.84	0.000	.0001123	.0003467
HHI	-1.75e-06	.0000158	-0.11	0.912	-.0000326	.0000291
CP1	.0049143	.0017965	2.74	0.006	.0013932	.0084354
LDev	.0466874	.1328767	0.35	0.725	-.2137461	.3071209
_cons	.0939364	.2499697	0.38	0.707	-.3959952	.583868
sigma_u	.13282428					
sigma_e	.12083665					
rho	.54715319	(fraction of variance due to u_i)				

```
Instrumented:   RevSub CapexRev CRGDPPC
Instruments:    NYRS SubEmp HHI CP1 LDev RevEmp RGDPPC CapexSub Revenue
```

.

Source(s): Author's calculations

APPENDIX 10C: RANDOM EFFECT INSTRUMENTAL VARIABLE REGRESSION WITH SE AS DEPENDENT VARIABLE

```
G2SLS random-effects IV regression           Number of obs     =       246
Group variable: CountryID                    Number of groups  =        19

R-sq:                                        Obs per group:
     within  = 0.2161                                    min =         12
     between = 0.1500                                    avg =       12.9
     overall = 0.1836                                    max =         13

                                             Wald chi2(8)      =     61.51
corr(u_i, X)       = 0 (assumed)             Prob > chi2       =    0.0000
```

SE	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
RevSub	.0003252	.0001195	2.72	0.007	.000091	.0005595
CapexRev	-.141621	.0282284	-5.02	0.000	-.1969476	-.0862944
CRGDPPC	-.0000225	.0000152	-1.48	0.138	-.0000523	7.24e-06
NYRS	-.0043409	.0026932	-1.61	0.107	-.0096194	.0009377
SubEmp	.0000224	.0000378	0.59	0.555	-.0000518	.0000965
HHI	5.33e-06	8.95e-06	0.60	0.551	-.0000122	.0000229
CP1	.0040815	.0010162	4.02	0.000	.0020897	.0060733
LDev	-.115849	.0598925	-1.93	0.053	-.233236	.0015381
_cons	.5401899	.1194057	4.52	0.000	.306159	.7742208
sigma_u	.08043123					
sigma_e	.13096137					
rho	.27388509	(fraction of variance due to u_i)				

```
Instrumented:   RevSub CapexRev CRGDPPC
Instruments:    NYRS SubEmp HHI CP1 LDev RevEmp RGDPPC CapexSub Revenue
```

Source(s): Author's calculations

APPENDIX 11: QUESTIONNAIRE

Deregulation

1. How would you describe the nature of the telecommunication industry in Nigeria?
   - ☐ Emerging industry
   - ☐ Mature industry
   - ☐ Declining industry
   - ☐ Other(s) (Please Specify) ………………………………………….

2. How would you classify the pattern of change in the industry?
   - ☐ Very rapid
   - ☐ Rapid
   - ☐ Moderate
   - ☐ Slow
   - ☐ Very slow

3. What are the functions performed by the regulatory agency
   a. …………………………………………………
   b. …………………………………………………
   c. …………………………………………………
   d. …………………………………………………
   e. …………………………………………………

4. What, if any are the type(s) of support your organization has received from regulatory agency? (Select all that apply)
   - ☐ Financial
   - ☐ Industry/Market analysis
   - ☐ Infrastructure development
   - ☐ Training and development
   - ☐ Provision/availability of Information
   - ☐ Contract/Dispute resolution
   - ☐ Other(s) please specify……………………………………………………

5. What would you say is/are the primary reasons for the deregulation of telecom industry (Select all that apply)
   - ☐ Promote Investment
   - ☐ Universal/Wider access to telephone services
   - ☐ Increase teledensity
   - ☐ Promote competition
   - ☐ Maintain reasonable rates
   - ☐ Service quality improvement
   - ☐ Address government deficit spending
   - ☐ Technological trend
   - ☐ Economic development
   - ☐ Sociocultural trend
   - ☐ Political trend
   - ☐ Legal & regulatory trend
   - ☐ Other (please specify) …………………………………

6. On a scale of 1 to 5 (5 being the highest), how would you rate the impact of the following policies on the deregulation of the telecommunication industry?

	1	**2**	**3**	**4**	**5**
Deregulatory policy					
Licensing policy					
Wage policy					
Trade policy					
Competition policy					
Macroeconomic policy					
Tax policy					
Other(s) (Please specify)					

7. On a scale of 1 to 5 (5 being the highest), how has government policies influenced the direction of the telecommunications industry? (Select all that apply)

	1	**2**	**3**	**4**	**5**
Innovation					
Product pricing and delivery					
Increased partnership among operators					
Network access					
Increased competition					
Reduced costs					
Increased subscriptions					
Increased investment in infrastructures					
Other(s) (Please specify)					

8. Your perception of operating in a deregulated environment could best be described as:
   - ☐ Very successful
   - ☐ Successful
   - ☐ Neutral
   - ☐ Unsuccessful
   - ☐ Very unsuccessful

9. What would you say were the difficulties experienced in the deregulated environment?
   a. ……………………………………………………
   b. ……………………………………………………
   c. ……………………………………………………
   d. ……………………………………………………
   e. ……………………………………………………

Structure of the Industry

10. Your view of the structure of the industry is?
   - ☐ Monopoly
   - ☐ Oligopoly
   - ☐ Monopolistic competition
   - ☐ Perfect competition
   - ☐ Other(s) please specify …………………………………

11. Based on your knowledge of the industry, you would rate the following information about the industry as:

	Low	**Moderate**	**High**
Number of firms			
Growth rate of the industry			
Profitability growth			
Entry barriers			
Competition among firms			
Capital requirement			
Other(s) (Please Specify)			

Conduct of firms in the industry

12. What are the entry barriers in the industry?
    a. ……………………………………….
    b. ……………………………………….
    c. ……………………………………….
    d. ……………………………………….
    e. ……………………………………….

13. On a scale of 1 to 5 (5 being the highest), your perception of the level of impact of deregulated environment would be:

	1	**2**	**3**	**4**	**5**
Business focus					
Product Pricing					
Advertising & Promotion					
Distribution					
Research and innovation					
Product & service differentiation					
Cooperation with competition					
Legal strategies					
Investment in infrastructure					
Other(s) (Please specify)					

Performance

14. How would you describe industry trends in the following areas?

	Increase	**Decrease**	**No change**
Number of service providers			
Number of product/service substitutes			
Prices charges customers for service provided (ARPS)			
Cost of producing services			
Access to network			
Investment in telecommunications infrastructure			
Level of market competition			
Quality of services provided			
Churn rate			
Other(s) (Please specify)			

15(a) Would you say that the telecommunications industry has performed better under deregulation?

- ☐ Yes
- ☐ No

(b) If **YES,** on a scale of 1 to 5 (5 being the highest), indicate how you would rate the performance of the industry in the following areas

	1	**2**	**3**	**4**	**5**
Profitability					
Efficiency					
Technological advancement					
Productivity					
Product/service quality					
Return on investment (ROI)					
Market share					
Network accessibility					
Teledensity					
Customer service					
Investment in infrastructure					
New product/service development					
Increased competition					
Other(s) (Please specify)					

16. Your organization could best be described as using which of the following strategies?
    - ☐ Cost leadership strategy
    - ☐ Product differentiation strategy
    - ☐ Focus strategy
    - ☐ Other(s) (Please specify)…………………………………

Background

17. Which of the following best represents the number of years you have been with the firm?
    - ☐ 1–5 years
    - ☐ 6–10 years
    - ☐ 11–15 years
    - ☐ 16–20 years
    - ☐ Over 20 years

18. Which of the following fits the description of your position/title?
    - ☐ Manager
    - ☐ Supervisor
    - ☐ Coordinator
    - ☐ Director
    - ☐ Chief Executive Office
    - ☐ Other

19. Which of the following best describes your educational attainment?
    - ☐ Less than high school
    - ☐ High school
    - ☐ National Diploma
    - ☐ HND/University Degree
    - ☐ Master/PhD

20. Which of the following telecommunications service(s) does your organization currently provide to customers? (Select all that apply)
    - ☐ Wireless/mobile phone service (GSM)
    - ☐ CDMA
    - ☐ Fixed/Wireless service
    - ☐ Other (Please Specify)…………………….

APPENDIX 12: PARTICIPANT INFORMATION SHEET

USQ
AUSTRALIA

University of Southern Queensland

The University of Southern Queensland

Participant Information Sheet

HREC Approval Number:

TO: Participant

Full Project Title: Deregulation in the Telecommunications Industry and its Impact: The Case of Nigeria

Principal Researcher: Abayomi Oredegbe

Other Researcher(s): None

I would like to invite you to take part in this research project.

1. <u>**Procedures**</u>

- **Purpose and Objectives of the Research**
  By studying the deregulation of the telecommunications industry and its impact, the research will examine how deregulation of the industry has influenced the competitiveness of firms in the industry. Specific questions that will be addressed include the driving forces behind deregulation and the impact of deregulatory policies on the performance of firms in the industry. The research will also seek to understand the level of competition in the industry and how the structure of the industry has evolved from monopoly. The research will lead to an understanding of the influence of environmental change on the competitive strategies of firms in the industry in areas relating to resource allocation and strategic behaviours. The quest for this understanding will lead to the exploration of trends and paradigm shift in the in the Nigerian telecommunications firms and the industry couple with recommendations on policy directions that could be used to enhance the competitiveness and long term sustainability of firms and industry as a whole.

- **Methodology**
  Quantitative and qualitative data will be collected from firms in the industry using a survey questionnaire. Purposive sampling will be used to identify participants to complete the survey questionnaire. The survey questionnaire will take approximately 30 to 40 minutes to complete and respondents will be asked questions in areas such reasons for deregulation, the change in the structure of the industry, its impact on firms' performance and strategic behaviours, and implications. The data will then be analyzed using descriptive statistics.

- **Monitoring of the Research**
  To ensure compliance with ethics protocol, research participants will be asked to voluntarily indicate their willingness to participate in the study. Although there are no identifiable risks associated with this research, participants are not obligated to answer all of the questions in the survey questionnaire and interviews. Also, participants will have the choice of disengaging from the research at any stage of the research. Furthermore, research participants will be assured of data security as the data collected will be kept in a secure location that is accessible only to the researcher. Once the research is concluded, each research participants will be given access to the research output if they asked for it.

- **Benefits to Participants**
  The research will shed lights on the continuous shifts in the sector's micro and macro environmental conditions without losing sight of the impact it has had and/or is having on firms in the industry and their relative competitiveness. The study will benefit participants in that it will elaborate on how deregulation has shaped the structure, conduct, and performance of firms in the industry. The practicality of this research rests on finding out if the competitive strategies employed by firms in the industry are working? If not, why? It is the view of this research that this information will position telecommunications firms on the path to sustainability in the long run.

- **Potential Risks**
  There are no identifiable risks associated with this research

2. **<u>Voluntary Participation</u>**

Participation is entirely voluntary. **If you do not wish to take part you are not obliged to.** If you decide to take part and later change your mind, you are free to withdraw from the project at any stage. Please note that due to anonymity of research participants, it is unfortunate that there will be no opportunity for withdrawal of consent to participate in the study once the survey questionnaire is completed and returned to the researcher. However should you decided to withdraw during the interview, any information obtained from you at this stage will be destroyed.

Your decision whether to take part or not to take part, or to take part and then withdraw, will not affect you personally nor will it affect your relationship with the researcher.

The researcher encourages you to notify him should you decide not to participate in the research.

Should you have any queries regarding the progress or conduct of this research, you can contact the principal researcher:

Abayomi Oredegbe
PhD Candidate, Faculty of Business, Education, Law and Arts
University of Southern Queensland
646 Hogan Avenue
P.O. Box 2848, The Pas
Manitoba, Canada
R9A1M6
Tel: 1-(204)-623-6585
Email: aoredegbe@ucn.ca

If you have any ethical concerns with how the research is being conducted or any queries about your rights as a participant please feel free to contact the University of Southern Queensland Ethics Officer on the following details.

Ethics and Research Integrity Officer
Office of Research and Higher Degrees
University of Southern Queensland
West Street, Toowoomba 4350
Ph: +61 7 4631 2690
Email: ethics@usq.edu.au

APPENDIX 13: CONSENT LETTER

USQ

AUSTRALIA

University of Southern Queensland

The University of Southern Queensland

Consent Form

HREC Approval Number:

TO: Participant

Full Project Title: Deregulation in the Telecommunications Industry and its Impact: The Case of Nigeria

Principal Researcher: Abayomi Oredegbe

Student Researcher: Abayomi Oredegbe, PhD(c)

Associate Researcher(s): None

- I have read the Participant Information Sheet and the nature and purpose of the research project has been explained to me. I understand and agree to take part.
- I understand the purpose of the research project and my involvement in it.
- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.
- I confirm that I am over 18 years of age. *Omit if participants are under age of 18.*
- I understand that while information gained during the study may be published, I will not be identified and my personal results will remain confidential. *If other arrangements have been agreed in relation to identification of research participants this point will require amendment to accurately reflect those arrangements.*
- I understand that the tape will be transcribed and will only be accessible to the researcher only. Also, I understand that once the research is concluded the researcher will erase the tape's content

  (if tape is to be retained, insert details of how and where the tape will be stored, who will have access to it and what limits will be placed on that access)
- I understand that I will be audio taped / videotaped / photographed during the study. *Omit this point if not.*

  Participants under the age of 18 normally require parental or guardian consent to be involved in research. The consent form should allow for those under the age of 18 to agree to their involvement and for a parent to give consent. Copy and paste another signature field if necessary.

Name of participant…………………………………………………………………......

Signed……………………………………………………**Date**……………………….

If you have any ethical concerns with how the research is being conducted or any queries about your rights as a participant please feel free to contact the University of Southern Queensland Ethics Officer on the following details.

Ethics and Research Integrity Officer
Office of Research and Higher Degrees
University of Southern Queensland
West Street, Toowoomba 4350
Ph: +61 7 4631 2690
Email: *ethics@usq.edu.au*

APPENDIX 14: ETHICS APPROVAL

OFFICE OF RESEARCH
Human Research Ethics Committee
PHONE +61 7 4631 2690| FAX +61 7 4631 5555
EMAIL ethics@usq.edu.au

UNIVERSITY OF SOUTHERN QUEENSLAND AUSTRALIA

19 November 2013

Mr Abayomi Oredegbe
PO Box 2846
The Pas
Manitoba R9A1M6
Canada

Dear Abayomi

The USQ Human Research Ethics Committee has recently reviewed your responses to the conditions placed upon the ethical approval for the project outlined below. Your proposal is now deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research (2007)* and full ethical approval has been granted.

Approval No.	**H13REA237**
Project Title	Deregulation in the telecommunications industry and its impact: The case of Nigeria
Approval date	20 November 2013
Expiry date	20 November 2016
HREC Decision	**Approved**

The standard conditions of this approval are:

(a) conduct the project strictly in accordance with the proposal submitted and granted ethics approval, including any amendments made to the proposal required by the HREC
(b) advise (email: ethics@usq.edu.au) immediately of any complaints or other issues in relation to the project which may warrant review of the ethical approval of the project
(c) make submission for approval of amendments to the approved project before implementing such changes
(d) provide a 'progress report' for every year of approval
(e) provide a 'final report' when the project is complete
(f) advise in writing if the project has been discontinued.

For (c) to (e) forms are available on the USQ ethics website:
http://www.usq.edu.au/research/ethicsbio/human

Please note that failure to comply with the conditions of approval and the *National Statement (2007)* may result in withdrawal of approval for the project.

You may now commence your project. I wish you all the best for the conduct of the project.

Annmaree Jackson
Ethics Committee Support Officer

Copies to: aoredegbe@ucn.ca

APPENDIX 15: CRTC LETTER OF DECLINE

Oredegbe, Abayomi

From:	CRTC DONOTRESPOND/NEPASREPONDRE <crtcdonotrespond@crtc.gc.ca>
Sent:	February-06-15 4:17 PM
To:	Oredegbe, Abayomi
Subject:	Case ID: 694545
Attachments:	1.DOCX; 2.RTF; 3.RTF

Dear Mr. Oredegbe:

Thank you for contacting the CRTC to request someone fill out the questionnaire on the regulatory environment in Canada.

I have consulted with Telecom staff in Gatineau and they have advised me that it would not be appropriate for CRTC staff to fill out a survey on ourselves. In review of the survey/questionnaire, it appears that most of the information can be obtained by reviewing our website. In particular the questions about our mandate and regulatory objectives may be found at the following links:

http://www.crtc.gc.ca/eng/acrtc/acrtc.htm
http://www.crtc.gc.ca/eng/publications3.htm
http://www.crtc.gc.ca/eng/publications6.htm
http://www.crtc.gc.ca/eng/statutes-lois.htm

I regret that we are unable to complete the questionnaire, in whole or in part.

In answer to your subsequent question about your professors contacting the CRTC, they may do so using our toll free number 877-249-2782 and may ask for me directly.

I trust you find this information helpful.

IMPORTANT NOTE: To respond to this message, please click here and follow the prompts:
https://services.crtc.gc.ca/pub/rapidscom/Default-Defaut.aspx?lang=en&caseid=694545&key=42562.9576310185

Sincerely,

Cheryl Grossi
Client Services | Services à la clientèle
Canadian Radio-television and Telecommunications Commission | Conseil de la radiodiffusion et des télécommunications canadiennes
Winnipeg, MB, Canada R3C 3Z3
Telephone | Téléphone 1-877-249-2782 / TTY | ATS 1-877-909-CRTC (2782)
Outside Canada | Hors Canada 819-997-0313 / TTY | ATS 819-994-0423
Facsimile / Télécopieur 819-994-0218
Government of Canada | Gouvernement du Canada
http://www.crtc.gc.ca
Follow us on Twitter https://twitter.com/CRTCeng | Suivez-nous sur Twitter (@CRTCfra): https://twitter.com/CRTCfra
Like us on Facebook: http://www.facebook.com/crtceng | Aimez-nous sur Facebook : http://www.facebook.com/crtcfra