

Strategic Framework for Enhancing National Technological Competitiveness: Focus on Indian Telecom Sector

by

Sudhir Kumar Mittal

**Bharti School of Telecom Technology and Management
and
Department of Management Studies**

Submitted

**In fulfillment of the requirements of the degree of
Doctor of Philosophy**

to the



Indian Institute of Technology Delhi
October 2014

Dedicated to
The Almighty Ocean of Love
and my Father
Late Sh. Prakash Chandra Mittal

CERTIFICATE

This is to certify that the thesis titled “**Strategic Framework for Enhancing National Technological Competitiveness: Focus on Indian Telecom Sector**”, which is being submitted by Sudhir Kumar Mittal to the Indian Institute of Technology Delhi for the award of the degree of Doctor of Philosophy (Ph.D.), is a record of bona fide original research work carried out by him. He has worked under our guidance and supervision, and has fulfilled the requirements for the submission of the thesis, which has attained standard required for a Ph.D. degree of the Institute. The results presented in this thesis have not been submitted elsewhere for the award of any degree or diploma.

(Prof. Kirankumar S. Momaya)
Research Supervisor
Shailesh J. Mehta School of Management,
Indian Institute of Technology Bombay
Powai, Mumbai – 400076
India

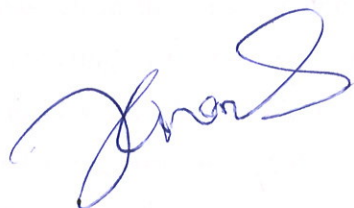
(Prof. Sushil)
Research Supervisor
Department of Management Studies
Indian Institute of Technology Delhi
Hauz Khas, New Delhi – 110016
India

Dated:

Dated:

CERTIFICATE

This is to certify that the thesis titled “**Strategic Framework for Enhancing National Technological Competitiveness: Focus on Indian Telecom Sector**”, which is being submitted by Sudhir Kumar Mittal to the Indian Institute of Technology Delhi for the award of the degree of Doctor of Philosophy (Ph.D.), is a record of bona fide original research work carried out by him. He has worked under our guidance and supervision, and has fulfilled the requirements for the submission of the thesis, which has attained standard required for a Ph.D. degree of the Institute. The results presented in this thesis have not been submitted elsewhere for the award of any degree or diploma.



(Prof. Kirankumar S. Momaya)
Research Supervisor
Shailesh J. Mehta School of Management,
Indian Institute of Technology Bombay
Powai, Mumbai – 400076
India



(Prof. Sushil)
Research Supervisor
Department of Management Studies
Indian Institute of Technology Delhi
Hauz Khas, New Delhi – 110016
India

Dated:

Dated:

Acknowledgements

Right from my MBA days at IIT Delhi long back, I had developed deep respect and a unique disciple-guru relationship with none other than Prof. Sushil, who has unparalleled clarity of thinking, expression, subject knowledge, research acumen, academic discipline, highly flexible and accommodative approach, and relating real life abstract phenomenon with the concrete subjects of management and research. I am highly indebted to him, not only for his expert guidance and relentless support, but also for teaching me how to enjoy doing my research. Many thanks to you, Prof. Sushil.

Being a technologist myself, I have always been interested to find opportunities to enhance the technological competitiveness of our country, India. In this light I had been discussing these aspects with Prof. Kirankumar Momaya for years, and finally I decided to take up the research in this area. I don't have words to express my sincere gratitude to him for his motivating ideas, his invaluable research feedback, his contributions in the related research papers, his guidance to identify the relevant resources for my research, setting up of Strategy and Competitiveness Lab., and the list goes on endlessly. Many thanks to you, Prof. Momaya.

I am extremely thankful to the Bharti School of Telecom Technology and Management along with the Department of Management Studies for devising such a unique joint research program in the area of telecom management. I am particularly grateful to the members of the SRC (Student Research Committee) Prof. D.K. Banwet, Prof. Subrat Kar (Bharti School and Department of Electrical Engg.), and Dr. Mahim Sagar. Their critical yet valuable inputs and support at various stages had indeed helped improvise my research work to quite an extent.

I am also grateful to all the other faculty members of the Department of Management Studies, particularly Prof. Kanika Bhal, Prof. S.K. Jain, Prof. S.S. Yadav, Prof. Vinayshil Gautam, Prof. P.K. Jain, Prof. Ravi Shankar, Prof. M.P. Gupta and Prof. Seema Sharma, who had been source of learning in some way or the other.

I am also grateful to my fellow researchers Dr. R. Umamaheswari, Dr. Saboochi Naseem, Dr. M.M. Chaturvedi, and Mr. Divij Jain for constantly supporting, helping, guiding and motivating me to complete my research. I also extend my heartfelt gratitude to all the

respondents of my preliminary as well as main research questionnaire, who spared time from their busy schedule to share their perspectives and information which formed the very basis of this research. My special thanks to Ms. Rejani for the unwavering supported extended to me at various stages of my research.

My academic and research pursuit has largely been an outcome of the unconditional support and encouragement of my mother, Mrs. Usha Mittal and my wife, Mrs. Sonali Mittal, who remained by my side all the times and motivated me always to complete my research with unparalleled excellence. Their consistent check on my progress and earnest prayers helped me sail through thick and thin. They have indeed been the spirits behind all my endeavors. My kids Shivansh and Gaurangi have shown exemplary patience and maturity, not just bearing my absence but by being more responsible and independent in their chores, which really helped me concentrate on my work. I take this opportunity to gratefully acknowledge their love and support in my academic career along with my professional career.

I am also grateful to the institute administration and departments' staff for all the support and facilitating my research work.

I thank my late father Sh. Prakash Chandra Mittal for seeding the genes of academic excellence in me, and above all, I thank the Almighty Ocean of Love for all the learning opportunities and blessings bestowed on me. I wish that my work be of value to both practitioners and researchers at large.

New Delhi

(Sudhir Kumar Mittal)

Abstract

Innovation is often seen as the main process behind the long term competitiveness of countries helping them significantly contribute in the world production, trade and sustaining positive external balances. However, it is a challenge for many countries to systematically work towards establishing a self-sustaining system where the technological innovations consistently contribute towards the competitiveness of the country and its growth. Many countries, in a concerted manner or otherwise, have established some or the other system for national innovation process. India faces a similar challenge to catch-up with the top innovation levels and there is a need to identify the specific steps to be taken to get there.

The main research motivation is to i) understand the paradox that India is lagging far behind in terms of technological competitiveness as compared to other developed and developing countries despite having the largest youth population, talent, aspirations, skills, and significant investments in institutions including those for higher education and R&D; and ii) suggest the measures to enhance the same. As compared to the other similar leagued countries, India fares quite low in statistics related to Researchers, Gross Domestic Expenditure on R&D (GERD), Patents, Science & Technology Index, Knowledge Index, Innovation Index, and Telecom Equipment Export (statistics from World Bank, UNDP, UNESCO, UN Comtrade, ITU, GCR 2012-13, WCY 2012, NCR 2011-12, WIPO 2012). The research focuses further on telecom sector because of its potential to enhance productivity across masses in information era. The lag in the technological competitiveness for India is all the more serious in telecom sector. Thus, the overall objective of the research is to suggest a strategic framework to enhance the national technological competitiveness with focus on Indian telecom sector.

The research work has been carried out in eight phases. The first phase laid out the foundation of the study by an extensive literature review spanning the areas of technological competitiveness, policy interventions and strategies to enhance technological competitiveness, role of industry and business associations, and telecom sector specific aspects of technological competitiveness and policy implications. During phase two of research design and conceptualization, all the macro and micro variables are clearly identified based on the literature review, and a high level conceptualization of the research framework

is done. During phase three, a detailed study has been conducted to understand the current state of technological competitiveness (including telecom sector) and related rankings of the top 30 countries of the world in terms of GDP. This set of top 30 countries consists of 19 developed and 11 developing countries, and represents 86.20% of world GDP and 64.77% of world population, thereby fairly representing the overall world situation. During phase four, a four step approach has been followed to formulate a research framework using expert opinions, viz. i) Verification of Macro Variables; ii) Verification of Interrelations among Macro Variables; iii) Synthesis of Research Framework using Total Interpretive Structural Modeling (TISM); and iv) Hypotheses Formulation. This involved a preliminary questionnaire survey involving the industry experts (112 responses). The conceptualized framework included the qualitative interpretations of all the paths in the model. Insights gained from these methods and the corresponding research framework, were used to formulate several hypotheses of difference and hypotheses of association.

During phase five, the research framework and corresponding hypotheses were taken as a basis to conduct an opinion survey for empirical validation. A five step process has been used in this phase, viz. i) Questionnaire Design; ii) Data Collection and Observation; iii) Construct Validity and Reliability Tests (Principal Component Factor Analysis, and Chronbach Alpha); iv) Univariate Analysis (Statistics used – range, minimum, maximum, mean, median, standard deviation, variance, skewness, and kurtosis); and v) Testing Hypotheses of Difference (One way Analysis of Variance – ANOVA). There were 327 responses obtained which were classified into different categories based on i) Working Experience; ii) Country; iii) Organization Type; and iv) Industry Sector. The next phase (6) involved the detailed analysis for the empirical validation of the framework. Correlation and step-wise regression analysis are used to test the hypotheses of association for all the macro and micro variables. While correlation has been used to ascertain the relationships among the variables, step-wise regression forms the basis of the hypotheses testing. Structural equation modeling (SEM) technique is used to test the conceptual model and delineate the relationships and paths. The statistical analysis of the data has been carried out using statistical software, viz. SPSS 16.0 and AMOS 18.0. Once the research framework has been empirically validated, it is important to bring out the qualitative interpretation of the same by applying the framework in specific contexts of case studies. The phase seven involved the interpretation of the framework through cases studies with top two countries have been

selected each from the developed (US and Japan) and developing (China and India) worlds. The case analysis for the identified countries has been done based on the secondary data from major international institutions, reports and other sources. Based on the application of these surrogate measures, relationship interpretation of the validated model is undertaken and specific recommendations and suggestions are put forward.

Finally, in the last phase (8), the learning from various techniques and methodologies adopted in the study have been triangulated and synthesized. For this work data, theory, and methodological triangulations have been adopted. Major findings suggest that in Indian Telecom context, the aspects which have been established as main driving forces (in the decreasing order of importance) are supportiveness of institutions for technological competitiveness (specially influencing the strategies of supporting actors), availability of resources for technological innovation, and focus on technological innovation oriented strategies by supporting actors (specially influencing the strategies of business actors). The other moderately significant driving aspects have been established as (in the decreasing order of importance), focus on technological innovation oriented strategies by business actors, and availability of resources for technological innovation. Under the aspects of supportiveness of institutions for technological competitiveness, significance of the following specific sub-aspects has been established (in the decreasing order of importance), viz. i) Policies related to technical education, R&D investments, subsidies, grants and taxation; ii) Values, norms, culture, ethics and beliefs; iii) IPR laws and enforcement; and iv) Policies related to foreign direct investments, export and import of technology. Under the aspects of focus on technological innovation oriented strategies by supporting actors, significance of the following specific actors have been established (in the decreasing order of importance), viz. i) Academic institutes and universities; and ii) Venture capital funds and other business funding agencies. Under the aspects of focus on technological innovation oriented strategies by business actors, significance of the following specific actors have been established (in the decreasing order of importance), viz. i) Domestic private firms; and ii) Locally hosted domestic-foreign joint venture firms. Under the aspects of availability of resources for technological innovation, significance of the human resources has been established as the most important aspect.

The study is a novel attempt at presenting a strategic framework to enhance the technological competitiveness at country level and especially in the context of Indian telecom sector.

Contents

<i>Certificate</i>	i
<i>Acknowledgements</i>	iii
<i>Abstract</i>	v
<i>Contents</i>	ix
<i>List of Figures</i>	xvii
<i>List of Tables</i>	xxi
<i>List of Appendices</i>	xxvii
<i>Nomenclature</i>	xxix

Chapter 1: Introduction to the Study

1.1 Background.....	1
1.2 Context of the Research.....	2
1.3 Motivation for Research.....	4
1.4 Research Questions and Objectives.....	6
1.5 Scope of Research.....	7
1.6 Overview of Methodology.....	8
1.7 Organization of Thesis.....	9
1.8 Concluding Remarks.....	12

Chapter 2: Literature Review

2.1 Introduction.....	13
2.2 Technological Competitiveness.....	13
2.2.1 Three Views of Strategic Thinking for Managing Competitiveness.....	15
2.2.2 Globalization of Technology.....	19
2.2.3 Importance of Technology Development, Innovation and National Innovation System.....	24
2.2.4 Sectoral System of Innovation.....	29

2.2.5	Measuring Technological Competitiveness and Strength of National Innovation System.....	32
2.3	Policy Interventions and Strategies to Enhance Technological Competitiveness	40
2.4	Role of Industry and Business Associations.....	51
2.5	Telecom Sector specific aspects of Technological Competitiveness and Policy Implications	53
2.6	Key Learning and Summarization from Literature Review	58
2.7	Gaps Identified from Literature Review	63
2.8	Concluding Remarks	64

Chapter 3: Research Design and Conceptualization

3.1	Introduction.....	65
3.2	Conceptualization and Theoretical Basis	65
3.3	Research Variables.....	72
3.4	Research Methodology	77
3.4.1	Phase I: Literature Review.....	77
3.4.2	Phase II: Research Design and Conceptualization.....	78
3.4.3	Phase III: Background Study	79
3.4.4	Phase IV: Research Framework Formulation through Expert Opinions.....	79
3.4.5	Phase V: Opinion Survey for Validation of the Framework.....	82
3.4.6	Phase VI: Empirical Validation of the Framework.....	84
3.4.7	Phase VII: Interpretation of the Framework through Case Studies.....	85
3.4.8	Phase VIII: Synthesis of Learning.....	86
3.5	Concluding Remarks	87

Chapter 4: Background Study

4.1	Introduction.....	89
4.2	Methodology.....	89
4.3	Competitiveness Comparison	92

4.3.1	Comparison on Economic Parameters	93
4.3.2	Comparison on Telecom Subscription Parameters	97
4.3.3	Comparison on Overall Competitiveness Indices from Independent Reports	103
4.3.4	Comparison on Technological Readiness Index and Communication Index from Independent Reports.....	108
4.3.5	Comparison on Technological Competitiveness Indices from Independent Reports	111
4.3.6	Comparison on Research Capability Parameters	117
4.3.7	Comparison on Intellectual Property Parameters	126
4.3.8	Comparison on Telecom Equipment Trade Parameters.....	145
4.4	Composite Indices Definition and Comparison.....	149
4.4.1	Composite Overall Competitiveness Index (COCI).....	149
4.4.2	Composite ICT Competitiveness Index (CICI).....	152
4.4.3	Composite Technological Competitiveness Index (CTCI)	154
4.4.4	Composite Telecom Technological Competitiveness Index (CTTCI)	155
4.5	Matrix Analysis on Composite Indices	158
4.5.1	Analysis on Overall Competitiveness (COCI) and ICT Readiness (CICI) Matrix .	158
4.5.2	Analysis on Overall Competitiveness (COCI) and Technological Competitiveness (CTCI)	161
4.5.3	Analysis on Overall Competitiveness (COCI) and Telecom Technological Competitiveness (CTTCI)	163
4.5.4	Analysis on Technological Competitiveness (CTCI) and Telecom Technological Competitiveness (CTTCI)	166
4.6	Concluding Remarks	168

Chapter 5: Research Framework Formulation through Expert Opinion

5.1	Introduction.....	171
5.2	Verifying the Macro Variables	172
5.2.1	Methodology.....	172

5.2.2	Results and Discussion	173
5.3	Studying and Verifying the Interrelations among the Macro Variables	176
5.3.1	Methodology	176
5.3.2	Results and Discussion	177
5.4	Synthesizing the Research Framework	181
5.4.1	Methodology	181
5.4.2	Results and Discussion	183
5.5	Hypotheses Formulation	192
5.5.1	Hypotheses of Difference	192
5.5.2	Hypotheses of Association	200
5.6	Concluding Remarks	206
 Chapter 6: Opinion Survey for Validation of the Framework		
6.1	Introduction	211
6.2	Questionnaire Design, Pre-Testing and Finalization	211
6.3	Questionnaire Distribution, Data Collection and Observations	215
6.3.1	Questionnaire Distribution	215
6.3.2	Data Collection and Observations	216
6.4	Validity Analysis	222
6.4.1	Face or Content Validity	223
6.4.2	Criteria Related Validity	224
6.4.3	Construct Validity – Factor Analysis	224
6.5	Reliability Analysis	231
6.6	Univariate Analysis	232
6.6.1	Univariate Analysis of Macro Variables	233
6.6.2	Univariate Analysis of Micro Variables	233
6.7	Testing Hypotheses of Difference	235
6.7.1	Hypotheses of Difference based on Country	236

6.7.2 Hypotheses of Difference based on Organization Type.....	240
6.7.3 Hypotheses of Difference based on Industry Sector	244
6.8 Concluding Remarks	248

Chapter 7: Empirical Validation of the Framework

7.1 Introduction.....	251
7.2 Testing Hypotheses of Association	252
7.2.1 Correlation Analysis	252
7.2.2 Step-wise Regression Analysis.....	256
7.3 Structural Equation Modeling	282
7.3.1 Analyzing Structural Relationships amongst Macro Variables.....	282
7.3.2 Analyzing Structural Relationships amongst Macro Variables for Indian Telecom Sector	286
7.3.3 Analyzing Structural Relationships amongst Micro Variables	291
7.3.4 Analyzing Model Fit for Macro and Micro Models	295
7.4 Summary of Interpretations	298
7.5 Concluding Remarks	300

Chapter 8: Interpreting the Framework through Case Studies

8.1 Introduction.....	301
8.2 Methodology.....	302
8.3 Cases from the Developing Countries	304
8.3.1 China	304
8.3.2 India.....	312
8.4 Cases from the Developed Countries.....	319
8.4.1 United States.....	319
8.4.2 Japan.....	326
8.5 Discussion on Comparative Analysis	332

8.6	Concluding Remarks	336
-----	--------------------------	-----

Chapter 9: Synthesis of Learning

9.1	Introduction.....	339
9.2	Learning from Background Study	339
9.3	Learning from Expert Opinion and Framework Formulation	342
9.4	Learning from Opinion Survey	343
9.5	Learning from Case Study	346
9.6	Triangulation and Synthesis	348
9.6.1	Data Triangulation.....	349
9.6.2	Theory Triangulation	351
9.6.3	Methodological Triangulation.....	353
9.6.4	Triangulation Summary	353
9.7	Concluding Remarks	355

Chapter 10: Summary and Conclusions

10.1	Introduction.....	357
10.2	Achievement of Research Objectives	357
10.2.1	Assessment of Technological Competitiveness for Leading Countries	358
10.2.2	Identification and Verification of Key Research Variables and their Interrelations	359
10.2.3	Development of Empirically Validated Research Framework.....	360
10.2.4	Applying the Framework for Select Cases.....	362
10.3	Major Recommendations and Implications for Key Stakeholders	363
10.3.1	Institutional Actors (Government).....	363
10.3.2	Supporting Actors	364
10.3.3	Business Actors	365
10.4	Significant Research Contributions	365

10.5	Limitations of the Study and Future Directions.....	367
10.6	Concluding Remarks	368
<i>References</i>		371
<i>Appendices</i>		A-1 - A-16
<i>Brief Resume</i>		