Quantitative Predictive Capacity of Human Development Index in Wireless Telephony Operations

By: Andrey Fendyur and Vasyl Taras

Fendyur, A., & Taras, V. (2013). Quantitative Predictive Capacity of Human Development Index in Wireless Telephony Operations. *International Journal of Applied Management Science, 5*(1):66-79. https://doi.org/10.1504/IJAMS.2013.051637

Abstract:

The present study explores effects of human development (as measured by the human development index, or HDI) on the wireless telephony operations. The novelty and contributions of the paper are: 1) HDI, as a proxy for human development, can be a predictor for analysing and forecasting wireless telephony use per capita; 2) the predictive capacity of HDI on wireless telephony expansion is found to be more than that of pure monetary indicators such as GDP per capita; 3) a lower density of fixed lines per capita is not associated with a higher mobile use per capita. The findings can be used both in academia for informing students about factors influencing mobile use, and in industry for analysis and decision making in companies in telecommunication sector as well as companies that rely on telecommunication technologies in their operations.

Keywords: mobile telephony | forecasting | marketing operations | human development index | HDI | quantitative analysis

Article:

1 Introduction

1.1 Wireless telephony as a business research topic

Telephony in general and wireless telephony in particular has received little attention in research as a social and economic phenomenon (Lasen, 2002). According to Geser (2004), there was no analysis done on its aggregate impact on the society and economy. Compared to the research hype on the internet, research on the antecedents and effects of telephony has been relatively limited (Castells, 1998; Geser, 2004). For example, Geser (2004) awarded the 'Mega-Innovation' status only to the internet, but not to wireless telephony, although at the time of his research, and largely today, mobile telephony was more widespread and its role as a means of communicating for businesses and individuals was substantial and bigger than that of the internet. Yet, Geser (2004) pointed out that the wireless telephony had been disseminated wider and in more strata of society and economy, and spending on mobile telephony was higher than that for the internet provider services. As noted by Townsend (2000), "the advent of inexpensive

mass-produced mobile communications … has avoided scholarly attention, perhaps because it seems pedestrian compared to the nebulous depths of the cyberspace. Yet the cellular telephone, merely the first wave of an imminent invasion of portable digital communications tools to come, will undoubtedly lead to fundamental transformations…" (p.89).

The penetration of wireless phones was so fast and wide, that they made a profound impact not only on the business sector, but also the society as a whole. For example, the number of mobile phones in use surpassed the number of TV sets in 2001 (Katz and Aakhus, 2002). That means, the mobile telephony industry became not only a service for the businesses, but also a self-sufficient commercial industry – much like automobiles, agriculture, or entertainment. Thus, knowing predictors for mobile telephony deployment in various markets is of academic and business interest and findings of this line of research would be of practical importance – both for research and for practitioners.

A review of literature on the topic shows that industrial analysts and academics typically use GDP per capita as a predictor of market potential and its ability to adopt new technology. However, the mobile telephony expansion has happened worldwide, independent of cultural or economic environment. As pointed out by Fortunati (2002), even in countries that notorious for heir 'technophobia' and where 'computers and other modern technologies have a difficult stand', such as Italy, have quickly adopted mobile telephony. Similarly, Geser (2004) indicated that mobiles because well-accepted in Scandinavian countries, where for cultural reasons consumers tend to be inverted and do not communicate much. Lasen (2002) highlighted mobile phones because of wide-spread even in illiterate populations of poor countries – which, of note, spurred economic activity and telecommunication services consumption. In fact, in poor countries with a high rate of illiteracy mobile phones appear to substitute computers. Also, Lasen (2002) and Geser (2004) indicated that a wider use of mobiles in Europe versus the USA might due to less involvement in driving which, in turn, leaves more time available for communicating while on a train or other public transportation means.

Understanding antecedents of mobile telephony use is also important because growing evidence shows that mobile phones may also be substituting personal computers and where the internet access is good enough to use mobile phones for e-mail, document sharing and other online applications. The trend is particularly evident in the past few years that have been denoted by the exploding popularity of smartphones capable of performing most functions of personal computers. That can open new horizons for the mobile telephony industry and make competition within it more intense. Thus, understanding the drivers of mobile telephony is critical for forecasting trends in the telecommunication industry and sectors that depend on it. As noted by Geser (2004), "[o]n the theoretical level, this situation calls for the development of highly elaborated analytical concepts and typologies suited for grasping the major differences in usage patterns, as well as the various symbolic meanings attributed to mobile phones, messages and users; on the methodological level, it implies the need for survey studies, as well as ethnographic approaches, for assessing such variables empirically in quantitative as well as qualitative ways" (p.15). The present study employs quantitative analysis and explores factors that affect mobile telephony use.

2 Literature review

2.1 Telephony as an industry and the use of telephony in business

Telephony played a big role in shaping contemporary business operations. According to Geser (2004), fixed line telephony sustained organisational structure of businesses and consolidated operational environment. As noted by Lasen (2002), "Telephone is a key element in the building of corporate empires" (p.30). Apart from easing the violation of laws and facilitating exchanges without leaving traces (Aronson, 1977), telephony permits the physical separation of the offices from the factories, allowing managers to keep the control of the production process. Therefore, the telephone plays a key role in the urban concentration of financial and business activities (Berrah et al., 2011; Heikkinen et al., 2008). The telephone helped in the development of larger metropolitan systems with a more diversified and complex structure; it is also a central element in the workplace as it facilitates communication inside skyscrapers, the symbols of corporate capitalism that arose in the beginning of the 20th century (Lasen, 2002). Therefore, telephony plays an important role in maintaining operational unity of companies.

Emergence of wireless (mobile) telephony helped to overcome the limitation of fixed-line telephony (Fortunati, 2000). Geser (2004) noted that as "the significance of the mobile phone lies in empowering people to engage in communication, which is at the same time free from the constraints of physical proximity and spatial immobility" (p.30). The boom of mobile telephony worldwide was no surprise as wireless communication addressed both business and social needs. Therefore, the two main reasons for mobile telephony density in a particular society are:

1. business needs that could be tracked through analysing density of mobile networks vs. GDP per capita
2. social needs that could be analysed through human development index (HDI) across nations.

That the present study is based on the assumption that HDI is a better predictor of mobile network density in a given market due to the composite nature of the indicator: HDI comprises both the national wealth component (e.g., GDP per capita) and social capital components (e.g., life expectancy, education level).

The degree of economic development, usually measured through GDP/capita, is related to the fixed line and wireless telephony use per capita and is the function of the institutional development (Castells, 1998; Fortunati, 2000; Katz and Aakhus, 2002; Aronson, 1977; Lenski et al., 1995). Given the importance of economic development, this factor should be retained in the model, possibly as a moderator variable. Prior research has indicated that GDP/capita may influence other factors related to economic development, including the industrial productivity growth rate.

2.2 Human development index

Castells (1998), Fortunati (2000), Katz and Aakhus (2002), Aronson (1977) and Lenski et al. (1995) suggested that the economic development and technology use proliferation and are

subject to availability of skilled workforce and human development. This proposition is based on the presumption that better efficiency and productivity result from skilled workforce versus less trained workforce. Nowadays, many industrial technologies require trained workers to operate facilities (Ghazanfari et al., 2008). That assumes the role of personnel training and education in increasing industrial technologies penetration of the market. A proxy for the human development could be the HDI which incorporates measures of education and training availability (UN Development Program Report, 2009).

The HDI is a composite measurement, ranking countries by means of incorporating three elements:

1. life expectancy at birth
2. knowledge, education, competence and intellectual development measured through aggregation of adult literacy rate of a particular country (2/3 weight), plus combined primary, secondary, and tertiary gross enrolment ratio (1/3 weight)
3. standard of living, expressed through the natural logarithm of GDP (USD) per capita adjusted to purchasing power parity.

The index is calculated and published by the United Nations Development in its Human Development Report since 1990. Values below 0.5 and above 0.8 indicate 'low development' and 'high development' respectively. Though critics express concerns about the HDI's simplicity and other limitations, the index is a well-known and widely accepted indicator of human development.

2.3 Innovative role of wireless telephony

According to Geser (2004), cell telephony possesses innovative potential in the evolutionary prospective. That is framed by two factors:

1. physical proximity needed for interpersonal communication
2. stable dwelling places required for development of complex ways to exchange information and solve challenges.

Several implications can be drawn from those factors:

1. implied variability among different groups (geographically, industry-wise, etc.) since the different availability of physical proximity options enables various types of developments (both in society and in economy)
2. more complex and developed forms of cooperation and organisational structure (including industrial entities) could be developed if participants interacted closely for long periods of time.

In other words, good communications could trigger social and industrial development. That has been the case since agriculture enabled people to reside in settlements, and continuous communications played a major role in the emergence of civilisations, like those of the ancient Egypt, Mesopotamia, and India (Lenski et al., 1995; Townsend, 2000). Nowadays, the

implication of the two principles listed above implied that better communications were features of more balanced human-economy development (Patino et al., 2010). The dimension of balanced human-economy development is different from pure monetary measurement of development: the balanced human-economy development is incorporated in HDI, which consists of three components. Contrary to HDI, the monetary measurement of development is specified as GDP per capita.

3 Hypotheses

Based on the literature reviewed above, the following hypotheses have been developed and tested:

Hypothesis 1 Compared to pure economic development indicators such as GDP/capita, HDI is a better predictor of mobile telephony use density.

An influential role of the income per capita for the HDI (which is reflected in the natural logarithm of GDP per capita PPP included in HDI formula) triggered our interest in testing existence of possible mediation/moderation influences of 'GDP per capita PPP' on the use of HDI as a predictor for 'Mobiles per capita' criterion variable. That caused to develop Working Hypothesis 2:

Hypothesis 2 Monetary indicators, such as GDP PPP, can mediate/moderate the effect of HDI on mobile use density.

Furthermore, literature on the topic suggested that the widespread of the wireless telephony use per capita could be attributed to the low density of fixed line network (Geser, 2004). The fixed line definition refers to a land line that requires wires for transmitting the signal. The logic behind that assumption was based on the substantial investment need for development of fixed line networks in so-called industrialising nations. 'Industrialising nations' is a term used to refer to rapidly industrialising countries, which recently started their growth from beginning levels of infrastructure and economy indicators. To skip that investment need and accelerate development, the industrialising nations often choose to build modern wireless telephony networks instead of traditional fixed lines. Therefore, Hypothesis 3 aimed at testing that assumption:

Hypothesis 3 There is a negative correlation between the fixed line and mobiles phone use: the lower the fixed line density, the higher the wireless telephony density.

4 Method

4.1 Data

Data used in the research came from United Nations Development Indicators and World Telecommunication Development Report databases (UN Development Program, 2009; UN Documents, 2009; World Telecommunication Development Report, 2002; CIA Factbook, 2010). Mobile phone use (mobiles per capita) variable was calculated as the number of mobile phones

per country divided by the population size. HDI and GDP/Capita data were obtained from the UNDP.

Top 122 data points were considered, to be representative of the general countries population: small countries with special conditions for wireless telephony operations (such as small island countries where wireless penetration is limited due to geographical reasons.

Table 1. Principle descriptive characteristics of variables

Variables	Mean	Standard deviation	Number of cases
Mobiles/capita	0.83	0.40	122
HDI	0.76	0.17	119
GDP per capita	14852	14726	122
Fixed line/capita	0.20	0.18	162

The methodology employed for detecting predictive capacity of indicators included descriptive analysis of the data, parametric correlation study, non-parametric correlation study, simultaneous and stepwise OLS regressions. The major research methodology for moderation check was multiple regression analysis and the Sobel test that has been commonly used for mediation detection. There were two main reasons for that selection. First, the multivariate regressions method is the first-choice method to identify influence of predictor variable on the criterion variable given they all are continuous numerical, especially if interaction effects suspected (Aiken and West, 1991; Hair, 2009). Second, the multivariate regression is an effective and objective quantitative instrument in itself (Aiken and West, 1991; Hair, 2009; Cohen and Cohen, 1983). The Sobel test is also a must do method for mediation assessment (Preacher and Hayes, 2004; Preacher and Leonardelli, 2006). Thus, the conventional regression relationship analysis was performed coupled with analysis of probable mediation or moderation effects. The traditional regression analysis is complemented with the multiple regression analysis to illustrate more precise and accurate nature of findings obtained through multiple regression analysis: the use of multiple regression analysis allows identify moderation effects. The Sobel test serves the same role, showing mediation effects presence. Otherwise, wrong inferences can be obtained and wrong conclusions drawn about which factors (if) influenced the industrial production growth rate in 2009.

Parametric correlations (see Table 2) provided initial evidence of a statistically significant strong positive correlation (Pearson's correlation coefficient) between the number of mobiles per capita and GDP/capita ($r = 0.697$) and between the number of mobiles per capita and HDI ($r = 0.814$). In line with the working hypothesis, the correlation between the number of mobiles per capita and HDI was stronger than between the number of mobiles per capita and GDP per capita (0.814 versus 0.697, both significant at $p < 0.01$ level).

Table 2. Parametric (Pearson's r) bivariate correlations, selected variables

Variables	Mobiles/capita	HDI	GDP/capita
Mobiles/capita	1	.81*	.70*
HDI	.81*	1	.78*
GDP/capita	.70*	.78*	1

Note: *Correlation is significant at the 0.01 level (two-tailed).

The number of valid cases used (119) in the analysis provides a sustainable prevention of deviations in findings against possible problems with a violation of the normal distribution assumption essential for regression (Hair, 2009): the central limit theorem might be valid at that number of data points. This step refers to the discussion on The Central Limit Theorem as summarised by Field (2009). In brief, there are two groups of evidence in statistics science: first, that The Central Limit Theorem works and second, that it does not. If it does not, that questions validity of linear parametric regression findings. Although very few researchers are interested in such details of statistics, to prevent this still not settled dispute spoil our paper we did both the parametric correlation study and the non-parametric correlation study. If findings of both the parametric and non-parametric correlation study are same, and that enables to consider the dataset robust enough for parametric regression analysis (Field, 2009).

Table 3. Non-parametric bivariate correlations, selected variables

Non-parametric correlation coefficient	Variables	Mob per capita	HDI	GDP per capita
Kendall's tau_b	Mob per capita	1.000	.613*	.655*
	HDI	.613*	1.000	.843*
	GDP per capita	.655*	.843*	1.000
Spearman's rho	Mob per capita	1.000	.815*	.845*
	HDI	.815*	1.000	.964*
	GDP per capita	.845*	.964*	1.000

Note: *Correlation is significant at the 0.01 level (two-tailed).

Thus, to check out the reliability of the findings from parametric (based on normality of distribution assumption) correlation study, we performed a non-parametric correlation study (non-parametric techniques are rank-based and do not assume normality of distribution). The non-parametric correlation study results are presented in Table 3. Two non-parametric correlation coefficients were used to provide more verification to parametric correlation study results.

Kendall's tau b and Spearman's rho non-parametric correlation coefficients confirm that HDI is a strong and statistically significant predictor of the number of mobiles per capita. In the current non-parametric study, the value of the correlation between GDP/capita and the number of mobiles/capita is more (0.655 versus 0.613 for Kendall's tau b and 0.845 versus 0.815 for Spearman's rho, all significant at $p < 0.01$ level). That is different from the parametric study results described above. The difference could be attributed to the lower sensitivity of non-parametric tests versus parametric ones (Hair, 2009). Therefore, the non-parametric correlations confirm reliability of the finding on HDI's significance as a predictor for the number of mobiles per capita. Taking into account a higher sensitivity of parametric correlation coefficients versus non-parametric ones, we believe it is more appropriate to use Pearson's correlation coefficient to rank strength of effect of HDI versus GDP per capita on the number of mobiles per capita. The second reason for that decision comes from the theory's support (not only monetary (GDP/capita) but also human development reasons lead to a certain number of mobiles per capita, therefore, a combinatory (monetary human development) indicator (HDI) is a better predictor that only monetary (GDP/capita) one). Pearson's correlation coefficient for HDI (0.814) is higher than that for GDP/capita (0.697). That supports the theory-based working Hypothesis 1.

The bivariate correlation study (Pearson's r) between the 'Mobiles/capita' and 'Fixed lines/capita' indicators produced results that failed to support Hypothesis 3: the two indicators correlate positively and the correlation coefficient was high ($r = 0.721$) and significant ($p < 0.01$). Our failure to find support for Hypothesis 3 leads to a conclusion that the deficit of fixed lines in industrialising nations was not the cause for proliferation of the wireless telephony. In fact, the finding pointed out at the role of general development level of infrastructure and GDP/capita in increasing the density of fixed line and mobile telephony coverage: the higher the GDP/capita, the higher is the fixed line and mobile telephony coverage density. That finding is both theoretically and practically interesting. It can be used both in scholar research on telecom/development and in industry for forecasting telecom operations/investments on particular markets.

To isolate the effect of each predictor, we performed both simultaneous and step-wise regression. The purpose of the simultaneous regression analysis was to identify predictive capacity of the model with both HDI and GDP/capita. Stepwise regression allows for analysing the effect of each factor in more depth as some effects may be suppressed when all independent variables are added to the model simultaneously. Further details on step-wise regression can be found in most multivariate statistical analysis textbooks (e.g., Hair, 2009).

The stepwise regression analysis was performed to identify statistically the most effective predictor of those two. The results are presented in Table 4.

Although GDP/capita is highly correlated with the criterion variable of Mobiles/capita (Pearson's $r = 0.697$, significant at $p < 0.01$ level, Table 2), GDP/capita becomes insignificant as a predictor if HDI is present in the simultaneous model. Along with a higher correlation coefficient of HDI with Mobiles/capita (Pearson's $r = 0.814$, significant at $p < 0.01$ level, Table 2), the findings support Hypothesis 1: HDI, as a proxy for human development, is a better predictor of mobiles used per capita than a pure monetary predictor 'GDP/capita'.

Table 4. Simultaneous and stepwise regression models

Parameter/model	Simultaneous	Stepwise
Predictors included in model	HDI, GDP/capita	HDI
R^2	0.672	0.663
Adjusted R^2	0.667	0.660
F change	118.963	229.955
Significance of F change	< 0.01	< 0.01
Standardised coefficients	HDI: 0.693 GDP/capita: 0.155	HDI: 0.814
t-values	HDI: 8.191 GDP/capita: 1.830	15.164
p	HDI: < 0.01 GDP/capita: 0.07	< 0.01
df	2,116	1,117

The stepwise regression analysis was used to further test that conclusion. The stepwise regression is considered more parsimonious and keeps only important predictor(s) in the model (Hair, 2009). Results of the stepwise regression analysis (Table 4) support that conclusion, too: GDP/capita is not included as a predictor in the model, while HDI is; both models explain similar amount of variance in the 'Mobiles/capita' criterion variable (67% and 66%, see Table 4)

but the stepwise model consists of only 1 predictor (HDI, more parsimonious); HDI has a higher beta value if GDP is out of model ($beta_{HDI} = 0.693$ in the simultaneous model and 0.814 in the stepwise one, all significant at $p < 0.01$ level). F change is also more definite if only HDI is included in the model (230 vs. 119, $p < 0.01$). That conclusion also fits in line with Hypothesis 1 that HDI, as a proxy for human development, is a better predictor of mobiles used per capita than a pure monetary predictor 'GDP/capita'.

Then, we did moderation research with the multiple regression method. The suggested moderator was 'GDP per capita'. Results and brief interpretation will be provided in Tables 5 and 6.

'Mobiles/capita' criterion variable study demonstrated support of the moderation effect of 'GDP/capita' variable on HDI. The model with the interaction term (model 3 in the Table 5) demonstrates a significant *R*2 increase (to 73.7% from 70.6% of the variance explained) and F change (df1, 151) = 20.961, significant at $p < 0.01$ level. The interaction term is significant at $p < 0.01$ level ($t = –4.578$, Table 6). Thus, the moderation effect of 'GDP/capita' on HDI toward the wireless telephony use per capita density gets support from the multiple regression study.

Table 5. Models summary

Model	Predictors (constant included)	R^2	F change	df
1	HDI	0.666	300.838*	1,515
2	HDI, GDP/capita	0.706	20.691*	1,150
3	HDI, GDP/capita, interaction term 'HDI' * 'GDP/capita'	0.737	20.961*	1,149

Note: *$p < 0.01$

Table 6. Selected parameters for predictors

Model	Predictor	Beta	t-value
1	HDI	0.816	17.345*
2	HDI	0.619	9.933*
	GDP/capita	0.282	4.549*
3	HDI	0.599	10.261*
	GDP/capita	4.085	4.905*
	Interaction term 'HDI' * 'GDP/capita'	–3.794	–4.578*

Note: *$p < 0.01$

Next, we checked for possible mediation effects of 'GDP/capita' on HDI in influencing the wireless telephony use per capita density. The most common method used in literature for that purpose is the Sobel test (Preacher and Hayes, 2004; Preacher and Leonardelli, 2006). The Sobel test differs from the direct effect regression test in a number of ways since it checks for the presence of mediation effect in the model. The direct effect assumes that a change in the predictor variable cause a change in the criterion variable (path C). The mediation effect assumes presence of the third variable between the predictor and the criterion variables. Under the mediation concept, the predictor variable has no direct effect on the criterion variable but causes a change in the mediator variable (path A). The resulting mediator variable's change causes the change in the criterion variable (path B). The Sobel test checks for significance of paths A and B. If they are significant, there is the mediation effect (Preacher and Hayes, 2004; Preacher and Leonardelli, 2006).

There are several variations of the test due to inclusion/exclusion of the error term. According to literature mentioned, they produce same results. We show outcomes from all variations of the test to compare findings. We used the Sobel test and the online software for calculation provided by Preacher and Leonardelli (http://www.people.ku.edu/~preacher/sobel/sobel.htm). The summary of results is shown in Table 7.

Table 7. The Sobel test findings

Input parameter	Value	Test version	Test statistic	*SE*	*p*
a	66,145.11	Sobel test	12.03	0.10	< 0.01
b	0.00002	Aroian test	12.03	0.10	< 0.01
s_a	5,496.43	Goodman test	12.03	0.10	< 0.01
s_b	0.00				

All variations of the Sobel test showed the same inferences: there is a mediation effect of 'GDP/capita' on 'HDI' in determining the wireless telephony use per capita density ($p < 0.01$).

The results presented above prove the initial finding of higher importance of HDI in predicting degree of mobile telephony use per capita in a given market (through the number of mobiles per capita as the dependent variable). The complex influence of GDP/capita (moderation and mediation) on the predictive capacity of HDI is shown. That novel predictor could be used for both academic research, business planning and forecasting in academia, public policy and the wireless telephony industry.

5 Discussion and conclusions

The present study compared predictive validity of a number of factors that may influence the wireless telephony use across markets. In addition to testing direct effects, more complex models involving, moderating and mediating interactions were considered. The predictor variables represented different phenomena (GDP/capita and human development) although the two categories are relevant to mobile phone use and inter-related to certain extent. In this way, we made sure that the phenomena studied are inter-connected but represent distinct categories.

The factors were selected on the grounds of economic and operations theory. Inclusion of the factors into the analysis was justified by theory and supported through references to respective directions of research and scholars working in those areas. Predictors selected for analysis were GDP/capita to incorporate possible influence of the institutional development stage and monetary issues and HDI to incorporate the role of human development in mobile industry penetration across markets. On the basis of relevant research into related literature, several hypotheses were put forth and tested. The hypothesis contrasted the role of a pure monetary aspect versus the role of human factor for mobile telephony use. That type of contrast has been yet novel in studying mobile telephony use across national markets.

Hypothesis 1 propositioned that the human development level (through its proxy HDI) plays role in the wireless telephony use per capita across markets. The results of the analysis provided strong support for the hypothesis: HDI was found to be a significant and the most substantive predictor for the 'mobiles/capita' criterion variable. HDI was a significant predictor in the simultaneous regression model versus insignificant GDP/capita. This finding revealed that

human factor is more important than disposable income in predicting mobile phone use. Since the human factor impacts mobile telephony use, it may indicate the need to involve more societal and sociological research in explaining patterns and trends in mobile telephony use. In particular, this finding may be used (if empirical evidence collected in future research) to explain and forecast mobile telephony use within nations, such as among various territories or even within-city areas. That understanding may be used in marketing to better match promotion of mobile telephony various services, in capital investment in infrastructure, and in operations management to plan for capacity maintenance. Moreover, that finding can be used in the firm valuation for merger and acquisition deals, where growth potential may be valued as an intangible asset. Finally, that may justify contributions of telecom companies in community education and be a good argument for the corporate social responsibility (CSR) proponents.

As per Hypothesis 2, the results indicated that the effect of HDI on mobile phone use is moderated and mediated by GDP/capita. The hypothesis was supported by the multiple regression moderation and the Sobel test mediation analysis. That is in line with the existing theory: human development is subject to investments in human development, also GDP is a component of the HDI. This finding may lead to further research aiming at quantifying the effects of investments in education made by telecommunication sector. As indicated in the above passage, that may play role in justifying and promoting the CSR. For policy makers and public sector, this finding may be a support argument for increasing education spending to shift economy from resource extraction-based basis to the educated society. In other words, investments in education promote high-tech consumption and change the structure of economy.

Hypothesis 3 implied that a lack of the fixed line penetration stimulates the wireless telephony use per capita across markets. The results did not support Hypothesis 3. The explanation of the phenomenon may be in the area of institutional (infrastructure) development, whose proxy could be GDP/capita. Since both the fixed line and the wireless telephony require substantial investments in network set-up (sunk costs), the higher degree of development implies more opportunities and more resources available for any telephony network set-up. Furthermore, a higher degree of institutional development may indicate more stability in the country and facilitate investments in pricey infrastructure, both fixed line and mobile telephony. Thus, markets with higher GDP/capita may command more resources for any telephony development, and that results in high positive correlation between the fixed line and wireless telephony use per capita. Further research may be needed to fully understand the phenomenon and the present study provides a starting point for further research.

To sum up, our study provides the following insights into the question of mobile phone use. First, the mobile telephony use in not only a technical or disposable income phenomenon but also it is an industry influenced by human development. Therefore, societal and sociological research should be applied as well to achieve better understanding of the industry by scholars and more forecasting accuracy by business. Second, the study produced evidence that investments in increasing human development boost telecom industry and may lead to changing the economy structure, a desirable outcome for resource extraction dependent economies. Third, mobile telephony industry may be prone to commit investments in stable markets with low risks of losing these investments in the network due to institutional instability, although this finding may sound opposite to stereotypes and need further empirical research to establish support for it.

6 Limitations and future research

While the model tested in the present study was more complex than those typically considered in earlier work, it likely omitted a number of relevant factors. More rigorous analysis using structural equation modelling may be needed to fully understand the phenomenon. Future research may consider using SEM to test more complex models of wireless telephony use and its relations with other phenomena.

Fundamental theoretical research into the wireless telephony use per capita rate would be a promising pursuit as well. The fact of both moderation and mediation influence from GDP/capita toward HDI raises the question as to what interaction was more powerful in practise and why? How to separate the unique incremental variation attributed to each of those interactions? Are there transformations which can clear data from one of those interactions?

Another interesting future research area would be to identify if other high-tech industries demonstrate a similar pattern of human development impact or these findings are limited to the mobile telephony only.

A promising research stream will be a subgroup analysis to reveal general for all market trends and unique for subgroups of countries. This research will need though to establish a theoretically sound division of countries since it looks like split on GDP/capita basis may be not enough. Indeed, earlier approaches to split nations on developed, developing and industrialising may miss to comprehend many important factors impacting the industry. Development of such a framework may lead to a descent scholar contribution.

The findings may provide evidence of value in making investments in human development. However, quantification of that effect would be a complex and extensive research stream. Though, such research is long-expected and highly welcome by society.

Finally, the study results may serve as support of encompassing more aspects in operational management – i.e., network deployment and maintenance planning and forecasting may need to incorporate knowledge about HDI in that particular territory.

These and other potential future research options imply the need to keep researching into mobile telephony industry, not to be neglected due to domination of the internet in information and communication technology. This reason is specifically valid due to emerging convergence of mobile telephony and the internet.

References

Aiken, L. and West, S. (1991) *Multiple Regression: Testing and Interpreting Interactions*, Sage Publications, Newbury Park, CA.

Aronson, S. (1977) *The Social Impact of the Telephone*, MIT Press, Cambridge, MA.

Berrah, L., Montmain, J., Mauris, G. and Cliville, V. (2011) 'Optimizing industrial performance improvement within a quantitative multi-criteria aggregation framework', *International Journal of Data Analysis Techniques and Strategies*, Vol. 3, No. 1, pp.42–65.

Castells, M. (1998) *The Information Age: Economy, Society, and Culture*, Blackwell, Oxford.

CIA Factbook (2010) available at https://www.cia.gov/library/publications/the-world-factbook/ (accessed on 17 June 2010).

Cohen, J. and Cohen, P. (1983) *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*, Erlbaum, Hillsdale, NJ.

Field, A. (2009) *Discovering Statistics Using SPSS*, 2nd ed., Sage Publications, Thousand Oaks.

Fortunati, L. (2000) *The Mobile Phone: New Social Categories and Relations*, University of Trieste, Trieste, Italy.

Fortunati, L. (2002) 'Italy: stereotypes, true and false', in Katz, J.E. and Aakhus, M.A. (Eds.): *Perpetual Contact: Mobile Communication, Private Talk, Public Performance*, pp.42–62, Cambridge University Press, Cambridge.

Geser, H. (2004) *Towards a Sociological Theory of the Mobile Phone*, Release 3.0, May, University of Zurich, available at http://www.socio.ch/mobile/t_geser1.pdf (accessed on 26 December 2009).

Ghazanfari, M., Mohamadi, S. and Alizadeh, S. (2008) 'Data-mining application for country segmentation based on the RFM model', *International Journal of Data Analysis Techniques and Strategies*, Vol. 1, No. 2, pp.126–140.

Hair, J. (2009) *Multivariate Data Analysis*, 7th ed., Prentice Hall, Upper Saddle River, NJ, USA.

Heikkinen, M., Matuszewski, M. and Hammainen, H. (2008) 'Scenario planning for emerging mobile services decision making: mobile peer-to-peer session initiation protocol case study', *International Journal of Information and Decision Sciences*, Vol. 1, No. 1, pp.26–43.

Katz, J. and Aakhus, M. (2002) 'Introduction: framing the issues', in Katz, J.E. and Aakhus, M.A. (Eds.): *Perpetual Contact: Mobile Communication, Private Talk, Public Performance*, pp. 1–14, Cambridge University Press, Cambridge.

Lasen, A. (2002) *The Social Shaping of Fixed and Mobile Networks: A Historical Comparison*, DWRC, University of Surrey, Guildford, Surrey, UK.

Lenski, G., Nolan, P. and Lenski, J. (1995) *Human Societies: An Introduction to Macro Sociology*, 7th ed., McGraw-Hill, New York.

Patino, S., Kim, J. and Daim, T. (2010) 'Forecasting wireless communication technologies', *International Journal of Applied Management Science*, Vol. 2, No. 2, pp.169–197.

Preacher, K. and Leonardelli, A. (2006) 'Calculation for Sobel test: interactive calculation tool for mediation tests', available at http://www.people.ku.edu/~preacher/sobel/sobel.htm (accessed on 5 November 2009).

Preacher, K. and Hayes, J. (2004) 'SPSS and SAS procedures for estimating indirect effects in simple mediation models', *Behavior Research Methods, Instruments, and Computers*, Vol. 36, No. 4, pp.717–731.

Townsend, A. (2000) 'Life in the real-time city: mobile telephones and urban metabolism', *Journal of Urban Technology*, Vol. 2, No. 7, pp.85–104.

UN Development Program Report (2009) *Human Development Report 2009*, available at http://www.hdr.undp.org/en/media/HDR_2009_EN_Complete.pdf (accessed on June 17, 2010).

UN Documents (2009) Available at http://www.hdr.undp.org/en/statistics/indices/hdi/question,68,en.html (accessed on 11 November 2009).

World Telecommunication Development Report (2002) *Reinventing Telecoms' & Trends in Telecommunication Reform 2002 'Effective Regulation*, ITU 15. 3., available at http://www.itu.int/newsroom/wtdc2002/backgrounder.html (accessed on June 17, 2010).