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EMPIRICAL CONSIDERATION OF THE EFFECTS OF BIT/DATA CAP ON TELECOMMUNICATIONS OPERATORS

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Abstract

This article considers a case where a regulatory agency introduces a qualitative incentive into competition. Due to severe competition, telecom operators use charging schemes to increase revenues and introduce differentiated services to meet individual demands. This means that include many factors for differentiation. It is hard to explain or justify the pricing of that services differentiated only by price and quantity. For agency oversight, we use logit and probit model which can set a threshold of Bit/Data cap at standard deviation level and 5GB level derived from sample basic statistics. Basic statistics show that downlink speed under a data cap is about 24Mbits/s, and other variables show that operators tend to set lower than standard deviation level. This implies that customers using data cap plan receive lower quality of service. The estimation at 5GB level suggests that setting the cap at 5GB would be statistically more significant than the case of the cap at standard deviation level, and would be justified even for fixed line data. This implies that the cap of 5GB in the mobile market seems to be calculated, justified, and set by the operators. The irrationality of this implication is that most operators set the same amount of the cap, even though the capacity, density, and quality of their networks are different. A 5GB cap could be justified as long as their services are offered by bundling. This article concludes that the agency could determine to what extent the threshold of the cap seems appropriate. Estimation in this article suggest that the Price-per-Mbit/s price could be an effective indicator and regulatory instrument of bit/data cap because this variable has statistically significant sensitivity.

Key words: Telecommunications, Regulations, Bit/Data Cap, Incentive

JEL Classification: L43, L86, L96

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1. INTRODUCTION

Innovation in telecommunications encourages competitive markets, and contributes to a decline in overall revenue 5.1 percent. The margin of the early 2000's economic bubble plays a role of buffer even in the face of the recent economic crisis in the telecommunications industry[1]. A bit/data cap is a conventional way to limit data use and avoid data traffic congestion. A decision on the amount of data is an arbitrary managerial decision. In virtue of competition, business practices are rarely discussed in the name of freedom of management under competition. This article focuses on the effect of the practice.

This article considers the effects of a practice implemented worldwide in the telecommunications industry. The practice sets a "cap", a quantitative limit on data use, and charges additionally when customers use more than the limit set by operators.

This article examines the validity of the cap through analysis of empirical data of fixed telephone services under the models we discuss here, and proposes a bridge over the problem in mobile services. The practice of the cap has been implemented over the years in fixed line telecom services. Therefore, models in this article examine factors that determine the cap. This model considers not only the effect of each factor, but also policy issues so that this practice can be supervised by the agency. In short, how a cap can be set and rationalized is examined.

Recently, telecom operators have implemented or attempted to implement bit/data caps on telecom data services. The practices are implemented in a process covering enough network capacity or geographical area to provide data services. A concern we point out here is one when all operators implement the practice uniformly. We also point out that a certain degree of uniform practice could be rational even though the practice tends to be justified in virtue of freedom of business management.

In section 2, we review the background of some aspects, especially the methodological background. Section 3 examines empirical data and considers basic statistics. Section 4 explores models. Section 5 estimates them to describe characteristics of the practices, and proposes a direction to meet the goal. Section 6 concludes the article and points out some future extensions.

[1] OECD Communications outlook 2011

2. BACKGROUND

To include qualitative aspects in competition, an incentive should have objective(s) and criteria (parameters) to be set. In view of economics,

> "(Q)ualitative policy refers, in our terminology, to changing details of social organization rather than foundations… Changes in social organization, even if they refer to less important aspects only, will, as a rule, be less frequent than quantitative changes in the value of existing instruments of economic policy" (Tinbergen, 1964).

In the quantitative world, i.e. in neoclassical economics, discussions are not simply a matter of equality between price and marginal cost in virtue of efficiency. In the telecommunications market, rate-of-return regulation may cause an asymmetric information problem between agency and monopoly operator, though it contributes to minimize total cost. Therefore over-capitalization may occur in order to earn a return on capital and discourage entry by competition (Averch-Johnson, 1962).

To deal with this, a regulatory agency sets a limit on the revenue they earn. A regulation to set such a limit is price cap regulation. The major problem of price cap regulation is the time of the initial setting of the cap. This means that price cap regulation also has an asymmetric information problem where the operator overstates its costs, and it is hard for the agency to track. The price cap itself is derived from an index, CPI. Change in individual behavior has only a small influence on the price cap. Some theoretical discussions consider it quantitatively (Armstrong and Sappington, 2007, Cabral and Riordan, 1989, and Clemenz, 1991).

As historical background, the telecom industry experienced privatization from being a nationalized monopoly to market competition in the mid-1980s. The industry faced a high cost structure which market power reduced. The case in UK was examined their experiences and price cap regulation (Beesley, 1997).

Through these experiences, the telecommunications market introduced competition and become more competitive, and now faces severe competitive circumstances. Due to severe competition, telecom operators devised charging schemes to increase revenues. Furthermore, they introduced differentiated services to meet individual demands. This means that services comprise many factors enabling differentiation. It is hard to explain or justify the pricing of differentiated services by considering only price and quantity. This is why it is necessary to also take quality into consideration. To evaluate these complicated services in broader terms, we need to have a certain standard. This article considers possible options. Therefore, the objective of the agency is to assess competitive circumstances in a qualitatively highly differentiated market. The following background shows that the standard we expected is statistically testable using empirical data.

The background for the methodology of this article is based heavily on an article (Bouissou, Laffont, and Vuong, BLV, 1986), which considers log-likelihood ratio test for noncausality; noncausality is the abstract or theoretical concept of stochastic process of quality. The definition of noncausality by BLV is as follows,

> "(I)f X, Y are two stochastic processes, then Y does not cause X at any instant."

In this definition, X involves an infinite number of random variables¸ so conditions need to be set to reduce independence properties of a finite set of variables. BLV defined the probability distribution such that Y does not cause X if qualitative data are available. The two stochastic processes in BLV are set in time, past and future, but this article sets it in relation to a certain threshold of the variable we discuss, under or over a bit/data cap. As BLV set the value of X as null when the time is before a certain defined period of time, we set the value of the cap as null when the cap was over a certain defined threshold. The probability model estimates a stationary process, which identifies the independent restriction, the threshold, to be defined. Details of the model are discussed in section 4.

3. THE DATA

To obtain qualitative data, empirical data in this article are based on OECD data which include detailed data on the cap and periodic data as a time series in OECD Communications Outlook. To discuss the characteristics and effects of the cap per se, this article focuses on a static model and data. Modification of X on theoretical assumptions contributes to adjust to static consideration, which would also work as a benchmark to capture the status quo of the market and its validity.

The empirical data cover the most recent data available on the amount of the bit/data cap, downlink and uplink access speed, and minutes to the cap, monthly payments (USDPPP), and price per Mbits/s (USDPPP)[2]. These variables are almost all available from the data source related to the cap. The data used cover all service plans offered in OECD member countries that have a bit/data cap.

This article shows possible empirical contributions to the Incentive using observed data. If competition needs the bit/data cap, the scheme or model should be simple and easy to capture

[2] All data used are shown in the Appendix. The measure of value is in USDPPP for consistency of the data.

without observing and listing lots of data and variables. To achieve this goal, assumptions and settings should be carefully defined. These normative considerations are referred to in the next section.

Table 1 shows correlations of the variables in the data. Some relationships indicate relatively high numbers as shown; between downlink speed and Monthly payment, between downlink and the cap, and between monthly payment and the cap. This suggests that the bit/data cap practice tends to affect downlink speed and monthly payments.

Table 1: Correlation of Variables

(obs=168)

	Downkb~s	Upkbits	Minute~p	USDpri~P	PMbits~P	BitcapMB
Downkbits	1.0000					
Upkbits	0.1925	1.0000				
Minutestor~p	-0.2660	-0.1388	1.0000			
USDpricemo~P	0.4648	-0.0273	-0.0441	1.0000		
PMbitsUSDPPP	-0.3978	-0.1767	0.3531	-0.0287	1.0000	
BitcapMB	0.4995	0.0187	0.2935	0.5649	-0.2042	1.0000

Source: OECD Communications Outlook 2011 & OECD Broadband Statistics Sep., 2010

Table 2 shows sample statistics of the data used in this article. The statistics show that downlink speed under data cap is about 24Mbits/s, and other variables show that operators in the status quo tend to set lower than standard deviation level. This indicates that customers in status quo using data cap plan use lower level in quality of service. This result shows the need to improve the circumstances of customers using bit/data cap plan.

Table 2: Sample Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Downkbits	185	23345.14	24617.64	512	102400
Upkbits	170	5442.637	10934.23	128	50000
Minutestor~p	185	875.689	1624.719	8.888889	9333.333
USDpricemo~P	181	48.59519	22.64153	0	145.8096
PMbitsUSDPPP	181	7.183355	11.99387	0	66.36744
BitcapMB	185	73194.59	89970.25	1000	500000

Source: OECD Communications Outlook 2011 & OECD Broadband Statistics Sep., 2010

4. THE MODEL

4.1. Normative Assumptions and Settings as an Incentive

Based on the theoretical background in section 2, for empirical analyses, not only the data used but also the assumptions and settings are important to describe how we define the characteristics of the cap and market in question.

Actual management in the market is not adjustable in real time. This means that management has "slackness". Discussions of this kind of slackness were treated as an efficiency measure (Selten, 1986, Abel-khalik, 1988, and Berg and Jeong, 1991). These arguments consider the effectiveness of slackness using probit model (Berg and Jeong, 1991), and for setting the target we discuss a threshold (Abel-khalik, 1988).

Implementing a concept of differentiation in empirical analysis suggests that an efficient upstream differentiates downstream, and decisions may differ in preferences (Villas-Boas, 2009). Furthermore, we implement a model setting the mean value as the threshold (Berry, Levinsohn, and Pakes, 1995). Unlike that article, this article introduces the value of the standard deviation, or one derived from basic statistics, as the threshold.

4.2. The Simple OLS Model

To describe bit/data cap in practice, we build a model of how charges and speeds affect the amount of the cap. We consider a simple mechanism to build a regulatory tool to capture the characteristics of the practice, and obtain better network services, that do not restrict operators' behaviors. The simple OLS model is as follows;

$$DC_i = \alpha_0 + \alpha_1 DL_i + \alpha_2 UP_i + \alpha_3 MIN_i + \alpha_4 MON_i + \alpha_5 PBIT_i + u,$$

where

DC: Data Cap (MB)
DL: Downlink Speed (kbits/s)
UP: Uplink Speed (kbits/s)
MIN: Minutes to reach the bit/data cap (min.)
MON: Monthly payment (USDPPP)
PBIT: Price per Mbit/s (USDPPP).

4.3. The Logit and Probit Model

To consider the cap and its incentive, a certain amount of the cap would be determined. In statistical view, we consider the case where the agency sets the amount of the cap level at the standard deviation level, STDDEV, obtained from statistical data.

Following the theoretical background in section 2, we set DC as a latent variable and assume DC* =1 if DC becomes more than the standard deviation level, and DC*=0 if DC is less than the level, shown as follows;

$$DC > STDDEV \Leftrightarrow \alpha_0 + \alpha_1 DL + \alpha_2 UP + \alpha_3 MIN + \alpha_4 MON + \alpha_5 PBIT + u > 0$$

$$\Leftrightarrow u > -\alpha_0 - \alpha_1 DL_i - \alpha_2 UP - \alpha_3 MIN_i - \alpha_4 MON_i - \alpha_5 PBIT_i .$$

To obtain DC*=1, we assume its probability, P(DC*=1),

$$P(DC^* = 1) = P(DC > STDDEV) = P(u > -\alpha_0 - \alpha_1 DL - \alpha_2 UP - \alpha_3 MIN - \alpha_4 MON - \alpha_5 PBIT)$$

$$= 1 - F(-\alpha_0 - \alpha_1 DL - \alpha_2 UP - \alpha_3 MIN - \alpha_4 MON - \alpha_5 PBIT)$$

$$P(DC^* = 0) = P(DC \le STDDEV) = P(u \le -\alpha_0 - \alpha_1 DL - \alpha_2 UP - \alpha_3 MIN - \alpha_4 MON - \alpha_5 PBIT)$$

$$= F(-\alpha_0 - \alpha_1 DL - \alpha_2 UP - \alpha_3 MIN - \alpha_4 MON - \alpha_5 PBIT)$$

where $F(\cdot)$is the cumulative distribution function. So 5GB can be set instead of STDDEV in the model.

5. THE RESULTS AND ESTIMATION

The result and estimation of the simple OLS model are shown in table 3. The model shows a certain fit, the rate of adjusted R-squared being 0.5843, and some interesting results.

Coefficients of monthly payment and per Mbits/s price show that the relations between the cap and each of the 2 parts of the charges have the same proportion but opposite direction. This means that charging higher monthly payments tends to set about 1.6GB higher when every USDPPP of the monthly payment increases, in case of charging higher Mbit/s price, and vice versa (if set about 1.6GB lower, every USDPPP increases). The variable MIN shows that the cap increases about 25MB of when it takes one minute more.

Tables 4-1 and 4-2 show the estimation using logit and probit model. As assumptions and settings shown in section 4, we describe the cap when the agency defines the amount of the cap, and examine its validity statistically. As shown in the previous section, we set one of the thresholds at the level of the standard deviation. Ordinary estimation in logit model sets zero as the threshold of DC in normalization. This methodology is referred to in section 2 above.

All variables observable in the model except uplink speed are statistically significant as this model is following statistical procedures. In the logit model, we obtain better significance and different characteristics than we expect intuitively.

Table 3: Estimation of the Simple OLS Model

Source	SS	df	MS		
Model	7.6094e+11	5	1.5219e+11	Number of obs =	168
Residual	5.1430e+11	162	3.1747e+09	F(5, 162) =	47.94
				Prob > F =	0.0000
				R-squared =	0.5967
				Adj R-squared =	0.5843
Total	1.2752e+12	167	7.6362e+09	Root MSE =	56345

BitcapMB	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Downkbits	1.214278	.2261913	5.37	0.000	.7676147	1.660942
Upkbits	-.0736806	.4102286	-0.18	0.858	-.8837654	.7364043
Minutestore~p	25.07939	2.809708	8.93	0.000	19.53101	30.62776
USDpricemon~P	1607.965	221.7996	7.25	0.000	1169.973	2045.956
PMbitsUSDPPP	-1607.329	407.8008	-3.94	0.000	-2412.62	-802.0388
_cons	-44601.59	11405.24	-3.91	0.000	-67123.7	-22079.47

Table 4-1: Estimation of the Logit Model under the Cap at Standard Deviation Level

Logistic regression		
	Number of obs =	168
	LR chi2(5) =	155.02
	Prob > chi2 =	0.0000
Log likelihood = -26.432545	Pseudo R2 =	0.7457

dum_cap	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Downkbits	.0000362	.0000162	2.24	0.025	4.47e-06	.000068
Upkbits	.0000386	.0000245	1.57	0.115	-9.44e-06	.0000867
Minutestore~p	.0096622	.0021671	4.46	0.000	.0054148	.0139097
USDpricemon~P	.0973612	.0268512	3.63	0.000	.0447338	.1499887
PMbitsUSDPPP	-1.092491	.2791981	-3.91	0.000	-1.639709	-.5452728
_cons	-9.572502	2.148389	-4.46	0.000	-13.78327	-5.361738

Note: 14 failures and 10 successes completely determined.

```
Average marginal effects                          Number of obs    =        168
Model VCE    : OIM

Expression   : Pr(dum_cap), predict()
dy/dx w.r.t. : Downkbits Upkbits Minutestoreachbitcap USDpricemonthlyPPP
               PMbitsUSDPPP
```

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
Downkbits	1.74e-06	6.95e-07	2.51	0.012	3.83e-07	3.11e-06
Upkbits	1.86e-06	1.13e-06	1.65	0.099	-3.50e-07	4.07e-06
Minutestore~p	.0004649	.0000465	9.99	0.000	.0003737	.0005562
USDpricemon~P	.0046848	.0009168	5.11	0.000	.002888	.0064817
PMbitsUSDPPP	-.0525686	.0085161	-6.17	0.000	-.0692599	-.0358773

Table 4-2: Estimation of the Probit Model under the Cap at STD Dev. Level

```
Probit regression                                 Number of obs    =        168
                                                  LR chi2(5)       =     156.02
                                                  Prob > chi2      =     0.0000
Log likelihood = -25.934349                       Pseudo R2        =     0.7505
```

dum_cap	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Downkbits	.0000221	9.18e-06	2.40	0.016	4.06e-06	.0000401
Upkbits	.0000257	.0000132	1.95	0.051	-1.31e-07	.0000515
Minutestore~p	.0055607	.001169	4.76	0.000	.0032695	.0078518
USDpricemon~P	.0572013	.0151497	3.78	0.000	.0275085	.0868941
PMbitsUSDPPP	-.6222723	.1414881	-4.40	0.000	-.8995839	-.3449607
_cons	-5.661604	1.202083	-4.71	0.000	-8.017644	-3.305565

Note: 27 failures and 14 successes completely determined.

```
Average marginal effects                          Number of obs    =        168
Model VCE    : OIM

Expression   : Pr(dum_cap), predict()
dy/dx w.r.t. : Downkbits Upkbits Minutestoreachbitcap USDpricemonthlyPPP
               PMbitsUSDPPP
```

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
Downkbits	1.84e-06	6.70e-07	2.74	0.006	5.23e-07	3.15e-06
Upkbits	2.13e-06	9.97e-07	2.14	0.032	1.81e-07	4.09e-06
Minutestore~p	.0004626	.0000457	10.12	0.000	.000373	.0005523
USDpricemon~P	.004759	.0008864	5.37	0.000	.0030216	.0064963
PMbitsUSDPPP	-.0517712	.0070007	-7.40	0.000	-.0654923	-.0380502

Taking a recent trend in the mobile data market into consideration, some mobile operators implement a 5GB cap to limit explosive demand for data use, and avoid congestion of their network. Recent lively demand for mobile data use is not a phenomenon that arose suddenly. Operators have emerged to bundle their services in the name of fixed and mobile convergence. This business strategy benefits both operators and customers, but operators underestimate the demand for data use. Customers take the bundled service as a seamless service and expect seamless access without limits on the place of access. Lower charges on each service caused by bundling seems to give an excuse for lower quality of each service. It seems this bundling trend makes this article relevant even for data on fixed line services.

As shown in the tables, the marginal effect of the PBIT shows that this variable fee causes about 2.5% or 5.2% decline of the probability of setting the cap at each level. The estimation at 5GB level shown in table 5-1 and 5-2 suggests that setting the cap at 5GB would be statistically more significant than the case of the cap at standard deviation level, and be justified even under fixed line data. This implies that the cap of 5GB in mobile market seems to be calculated, justified, and set by the operators. The irrationality of this implication is that most operators set the same amount of the cap even though the capacity, density, and quality of their networks are different. A 5GB cap could be justified as long as their services are offered by bundling, and the PBIT would have the same level and conditions as those of fixed line services.

Table 5-1: Estimation of the Logit Model under the Cap at 5GB Level

Logistic regression	Number of obs = 168
	LR chi2(5) = 135.39
	Prob > chi2 = 0.0000
Log likelihood = -6.3673264	Pseudo R2 = 0.9140

dum_cap5GB	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Downkbits	-.0000502	.0001047	-0.48	0.632	-.0002555	.0001551
Upkbits	.0003572	.0003443	1.04	0.300	-.0003177	.0010321
Minutestore~p	.0831697	.0427457	1.95	0.052	-.0006104	.1669498
USDpricemon~P	.4408606	.2465946	1.79	0.074	-.0424559	.9241772
PMbitsUSDPPP	-2.133419	1.072962	-1.99	0.047	-4.236386	-.0304527
_cons	-14.20924	7.553591	-1.88	0.060	-29.014	.5955288

Note: 5 failures and 110 successes completely determined.

```
Average marginal effects                          Number of obs   =        168
Model VCE    : OIM

Expression   : Pr(dum_cap5GB), predict()
dy/dx w.r.t. : Downkbits Upkbits Minutestoreachbitcap USDpricemonthlyPPP
               PMbitsUSDPPP
```

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
Downkbits	-5.78e-07	1.18e-06	-0.49	0.624	-2.89e-06	1.74e-06
Upkbits	4.12e-06	3.64e-06	1.13	0.258	-3.02e-06	.0000112
Minutestore~p	.0009583	.0003112	3.08	0.002	.0003484	.0015682
USDpricemon~P	.0050798	.0020004	2.54	0.011	.0011592	.0090004
PMbitsUSDPPP	-.0245821	.0075576	-3.25	0.001	-.0393948	-.0097694

Table 5-2: Estimation of the Probit Model under the Cap at 5GB Level

```
Probit regression                                 Number of obs   =        168
                                                  LR chi2(5)      =     135.63
                                                  Prob > chi2     =     0.0000
Log likelihood = -6.2495927                       Pseudo R2       =     0.9156
```

dum_cap5GB	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Downkbits	-.0000285	.0000577	-0.49	0.621	-.0001417	.0000846
Upkbits	.0001967	.0001972	1.00	0.319	-.0001898	.0005832
Minutestore~p	.0476209	.0241081	1.98	0.048	.0003699	.0948718
USDpricemon~P	.2439697	.1343844	1.82	0.069	-.0194189	.5073583
PMbitsUSDPPP	-1.222599	.6043495	-2.02	0.043	-2.407102	-.0380956
_cons	-7.902153	4.138259	-1.91	0.056	-16.01299	.2086854

Note: 11 failures and 121 successes completely determined.

```
Average marginal effects                          Number of obs   =        168
Model VCE    : OIM

Expression   : Pr(dum_cap5GB), predict()
dy/dx w.r.t. : Downkbits Upkbits Minutestoreachbitcap USDpricemonthlyPPP
               PMbitsUSDPPP
```

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
Downkbits	-5.72e-07	1.14e-06	-0.50	0.614	-2.80e-06	1.65e-06
Upkbits	3.94e-06	3.70e-06	1.07	0.287	-3.31e-06	.0000112
Minutestore~p	.0009546	.0003252	2.94	0.003	.0003172	.001592
USDpricemon~P	.0048906	.0020712	2.36	0.018	.0008312	.00895
PMbitsUSDPPP	-.0245082	.0079078	-3.10	0.002	-.0400072	-.0090092

6. CONCLUSION

This article considers a case where a regulatory agency takes a qualitative incentive into consideration for competition. By way of oversight, a regulatory agency could use logit and probit model which could set a threshold of Bit/Data cap at the standard deviation level and 5GB level derived from sample basic statistics.

Unlike earlier studies, we apply logit and probit models to the telecommunications market, and modify its setting of a stochastic process to a 5GB threshold set by statistical result, standard deviation, and practical market observation. To do this, we organize empirical data available worldwide and consider qualitative factors. This article substitutes the cap-setting process taking qualitative factors into consideration for the neoclassical price setting process in a view of quantitative adjustment. With this view, we use empirical methodology to justify thresholds actually set by operators. The result and estimation of this article would contribute not only to capturing relationships in the market with the cap we actually face, but would also give the regulatory agency a regulatory instrument to benchmark. The contribution also shows that this analysis gives some reasons for operators to rationalize thresholds they actually set.

Through our estimation, threshold settings of monthly and per Mbit/s are more likely to be set by the capacity that could be accessed without congestion or other concerns on quality of service, as one of the factors “minutes to the limit” represents a certain usability of the service. Estimation of section 5 suggests that the Price-per-Mbit/s could be an effective indicator of bit/data cap, because this variable is statistically significant.

In this analysis, we tried to implement an interaction term, but we could not get statistically significant results in our logit and probit model. We should point out that the empirical data on the cap used are for fixed line services, so the result and estimation could be difficult to explain the mobile market. However applying our contributions to the mobile market, we found some rationality in the threshold settings of the market. In other words, the cap could be justified as long as services are offered by bundling; we could think the mobile market is similar to a state of fixed line service. Considering trends in the mobile market, we need to collect detailed data worldwide on mobile data usage. Future analysis should build a more persuasive model as a regulatory instrument. Further analysis needs to consider more detail on market circumstances in a single country.

We should also make deeper observation on the existence of slackness in the threshold, i.e. when operators offer a lower level of threshold than the optimal level at a given price as we discussed here. Furthermore, not only implementing a concept of differentiation in empirical analysis, but use of empirical data of the mobile market is necessary for deeper understanding of telecommunications industry.

Appendix

Country	Company	Plan	Downkbits	Upkbits	BitcapMB	Minutestoreachbitcap	USDpricemonthlyPPP	PMbitsUSDPPP	dum_cap	dum_cap5GB	
Australia	Bigpond/Telstra	BigPond Elite 2GB	30720	1000	2000	8.8888889	32.68979	1.63449	0	0	
Australia	Bigpond/Telstra	BigPond Elite 2GB	20480	1000	2000	13.333333	32.68979	1.08966	0	0	
Australia	Bigpond/Telstra	BigPond Turbo 2GB	8192	256	2000	33.333333	26.14529	3.268161	0	0	
Australia	Bigpond/Telstra	BigPond Turbo 2GB	1536	128	2000	177.77778	26.14529	17.43019	0	0	
Australia	Internode	Home-512-Starter	512	128	5000	1333.3333	26.14529	52.29058	0	0	
Australia	Internode	Home-NakedExtreme-10	24576	1000	10000	55.555556	32.68979	1.362075	0	1	
Australia	Internode	Home-UltraBundle-10	20480	820	10000	66.666667	39.20157	1.960079	0	1	
Australia	Internode	Home-NakedUltra-10	20480	820	10000	66.666667	32.68979	1.63449	0	1	
Australia	Internode	Home-FibreHigh-15	102400	2000	15000	20	52.3233	0.523233	0	1	
Australia	Internode	Home-FibreMid-15	51200	8000	15000	40	39.23429	0.784686	0	1	
Australia	Internode	Home-FibreEntry-15 (standard plan)	25600	4000	15000	80	32.68979	1.307592	0	1	
Australia	Internode	Home-Fast-25	24576	1000	25000	138.88889	65.37958	2.724149	0	1	
Australia	Internode	Home-Standard-25	1536	256	25000	2222.2222	52.29058	34.86038	0	1	
Australia	Internode	Home-FibreHigh-30	102400		30000	40	58.8678	0.588678	0	1	
Australia	Internode	Home-FibreMid-30	51200	1000	30000	80	45.7788	0.915576	0	1	
Australia	Internode	Home-FibreEntry-30	25600	2000	30000	160	39.23429	1.569372	0	1	
Australia	Internode	Home-Extreme-30	24576	8000	30000	166.66667	45.74607	1.906086	0	1	
Australia	Optus	30GB Broadband + Home Phone	20480	4000	30000	200	45.74607	2.287304	0	1	
Australia	Bigpond/Telstra	BigPond Turbo 50GB	30720	1000	50000	222.22222	52.3233	1.74411	0	1	
Australia	Internode	Easy Broadband	24576	1000	50000	277.77778	52.29058	2.178774	0	1	
Australia	Internode	Home-Fast-50	24576	1000	50000	277.77778	85.01309	3.542212	0	1	
Australia	Bigpond/Telstra	BigPond Turbo 50GB	20480	1000	50000	333.33333	85.01309	3.542212	0	1	
Australia	Internode	Home-Standard-50	1536	256	50000	4444.4444	58.83508	39.22339	0	1	
Australia	Internode	Home-FibreHigh-60	102400	2000	60000	80	65.4123	0.654123	0	1	
Australia	Internode	Home-FibreMid-60	51200	8000	60000	160	52.3233	1.046466	0	1	
Australia	Internode	Home-FibreEntry-60	25600	4000	60000	320	45.7788	1.831152	0	1	
Australia	Internode	Home-NakedExtreme-60	24576	1000	60000	333.33333	45.7788	1.90745	0	1	
Australia	Internode	Home-UltraBundle-60	20480	820	60000	400	52.29058	2.614529	0	1	
Australia	Internode	Home-NakedUltra-60	20480	820	60000	400	45.7788	2.28894	0	1	
Australia	Internode	Home-FibreHigh-100	102400	1000	100000	133.33333	78.50131	0.785013	1	1	
Australia	Internode	Home-FibreMid-100	51200	2000	100000	266.66667	65.4123	1.308246	1	1	
Australia	Internode	Home-FibreEntry-100	25600	8000	100000	533.33333	58.8678	2.354712	1	1	
Australia	Internode	Home-NakedExtreme-100	24576	4000	100000	555.55556	58.8678	2.452825	1	1	
Australia	Internode	Home-Fast-100	24576	1000	100000	555.55556	111.1911	4.632963	1	1	
Australia	Internode	Home-UltraBundle-60	20480	820	100000	666.66667	65.37958	3.268979	1	1	
Australia	Internode	Home-NakedUltra-100	20480	256	100000	666.66667	58.8678	2.94339	1	1	
Australia	Internode	Home-Standard-100	1536	820	100000	8888.8889	85.01309	56.67539	1	1	
Australia	Optus	Naked (Standalone) Broadband 14 GB	20480		120000	800	39.26047	1.963024	1	1	
Australia	Optus	Naked (Standalone) Broadband 30 GB	20480		150000	1000	45.80497	2.290249	1	1	
Australia	Optus	Naked (Standalone) Broadband 60 GB	20480		170000	1133.3333	52.34948	2.617474	1	1	
Australia	Internode	Home-Fibrehigh-200	102400	1000	200000	266.66667	104.6793	1.046793	1	1	
Australia	Internode	Home-FibreMid-200	51200	1000	200000	533.33333	87.00916	1.740183	1	1	
Australia	Bigpond/Telstra	BigPond Elite 200GB	30720	2000	200000	888.88889	65.4123	3.270615	1	1	
Australia	Internode	Home-FibreEntry-200	25600	8000	200000	1066.6667	85.04581	3.401833	1	1	
Australia	Bigpond/Telstra	BigPond Elite 200GB	20480	4000	200000	1333.3333	65.4123	3.270615	1	1	
Australia	Internode	Home-NakedExtreme-240	24576	1000	240000	1333.3333	71.95681	2.9982	1	1	
Belgium	Base	home internet 1	1024	256	1000	133.33333	27.68549	27.68549	0	0	
Belgium	Telenet	BasicNet	4096	400	15000	500	20.93023	5.232558	0	1	
Belgium	Belgacom	Internet Start	3072	2115.6	15000	666.66667	35.09136	11.69712	0	1	
Belgium	Telenet	ComfortNet	15360	1000	50000	444.44444	33.93134	2.262089	0	1	
Belgium	Belgacom	Internet Comfort	12288	1500	50000	555.55556	31.95367	2.662806	0	1	
Belgium	Telenet	ExpressNet	30720	1250	80000	355.55556	47.51938	1.583979	0	1	
Belgium	Belgacom	Internet Favorite	25600	3500	100000	533.33333	41.07143	1.642857	1	1	
Canada	Bell Canada	Essential Plus	2048	800	2000	133.33333	30.70952	15.35476	0	0	
Canada	Rogers	Ultra-lite	512	256	2000	533.33333	28.49365	56.98731	0	0	
Canada	Shaw	High-speed lite	1024	256	13000	1733.3333	28.46705	28.46705	0	1	
Canada	Rogers	Lite	3072	256	15000	666.66667	35.84923	11.94974	0	1	
Canada	Bell Canada	Performance	6144	1000	25000	555.55556	39.90399	6.650665	0	1	
Canada	Bell Canada	Fibe12	12288	1000	50000	555.55556	46.79984	3.899986	0	1	
Canada	Bell Canada	Fibe12 + option 7Mbps upload	12288	7000	50000	555.55556	51.39707	4.283089	0	1	
Canada	Rogers	Express	10240	512	60000	800	45.96314	4.596314	0	1	
Canada	Bell Canada	Fibe25	25600	1000	75000	400	55.9943	3.499644	0	1	
Canada	Bell Canada	Fibe16	16384	7000	75000	625	60.59154	3.786971	0	1	
Canada	Bell Canada	Fibe16 + option 7Mbps upload	16384	7000	75000	625	64.26933	2.570773	0	1	
Canada	Shaw	High-speed	7680	512	75000	1333.3333	39.7502	5.300027	0	1	
Canada	Rogers	Extreme	15360	1000	80000	711.11111	61.59374	4.106249	0	1	
Canada	Rogers	Extreme Plus	25600	1000	125000	666.66667	70.7882	2.831528	1	1	
Canada	Shaw	High-Speed Extreme	15360	1000	125000	1111.1111	48.8633	3.257554	1	1	
Canada	Rogers	Ultimate	51200	2000	175000	466.66667	98.3716	1.967432	1	1	
Canada	Shaw	Warp	51200	3000	250000	666.66667	97.51017	1.950203	1	1	
Canada	Shaw	Nitro	102400	5000	500000	666.66667	145.8096	1.458096	1	1	
Hungary	T-Home	Kezdo (DSL Kezdo)	5120	2500	1000	26.666667	28.43697	5.687393	0	0	
Hungary	T-Home	Kezdo (Kabelnet Kezdo)	5120	21838	1000	26.666667	28.43697	5.687393	0	0	
Hungary	T-Home	Kezdo (Optinet Kezdo)	5120	2918.703	1000	26.666667	28.43697	5.687393	0	0	
Hungary	T-Home	Maximum (Kabelnet Maximum)	81920	500	350000	583.33333	72.49864	0.906233	1	1	
Hungary	T-Home	Super (Kabelnet Super)	51200	5000	350000	933.33333	66.24876	1.324975	1	1	
Hungary	T-Home	Extra (Kabelnet Extra)	25600	5000	350000	1866.6667			1	1	
Hungary	T-Home	Csaladi (Kabelnet Csaladi)	15360	400	350000	3111.1111			1	1	*
Hungary	T-Home	Alap (Kabelnet Alap)	5120	400	350000	9333.3333	34.99934	6.999869	1	1	*
Iceland	Siminn	Grunnaskrift	12288	12000	1000	11.111111	26.19063	2.182553	0	0	*
Iceland	Vodafone	Huggulega 1GB	12288	12000	1000	11.111111	26.19063	2.182553	0	0	*
Iceland	TAL	DSL 1GB	12288	12000	1000	11.111111	26.19063	2.182553	0	0	*
Iceland	Vodafone	Huggulega netid - meiri hradi	51200		10000	26.666667			0	1	*
Iceland	TAL	FTTH 10GB net	51200		10000	26.666667			0	1	*
Iceland	Siminn	Leid 1	12288	12000	10000	111.11111	21.51373	0.430275	0	1	*
Iceland	Vodafone	Huggulega 10GB	12288	12000	10000	111.11111	21.51373	0.430275	0	1	*
Iceland	TAL	DSL 10GB	12288	12000	10000	111.11111	21.51373	0.430275	0	1	*
Iceland	TAL	DSL 20GB	12288	12000	20000	222.22222	37.703	3.141916	0	1	*
Iceland	Vodafone	Flotta netid - meiri hradi	51200	50000	30000	80	28.70896	0.574179	0	1	*
Iceland	TAL	FTTH 30GB net	51200	50000	30000	80	28.70896	0.574179	0	1	*
Iceland	Vodafone	Flotta netid	12288	50000	30000	333.33333	43.45918	3.621598	0	1	*

Iceland	TAL	FTTH 60GB net	51200	820	60000	160	33.0261	0.660522	0	1	*
Iceland	Siminn	Leid 2	12288	12000	60000	666.6667	58.0511	4.837592	0	1	*
Iceland	TAL	DSL 60GB	12288	12000	60000	666.6667	44.89822	3.741519	0	1	*
Iceland	Vodafone	Ofurnetid – meiri hradi	51200	50000	70000	186.6667	57.13011	1.142602	0	1	*
Iceland	Vodafone	Ofurnetid 70GB	12288	50000	70000	777.7778	50.65441	4.221201	0	1	*
Iceland	TAL	FTTH 80GB net	51200	50000	80000	213.3333	40.22133	0.804427	0	1	*
Iceland	TAL	DSL 80GB	12288	12000	80000	888.8889	52.09345	4.341121	0	1	*
Iceland	Vodafone	Enn meira nidurhal	51200	50000	120000	320	59.28868	4.940723	1	1	*
Iceland	TAL	FTTH 120GB net	51200	50000	120000	320	59.28868	4.940723	1	1	*
Iceland	Siminn	Leid 3	16384	1024	120000	1000	66.68537	4.167836	1	1	*
Iceland	Vodafone	Enn meira nidurhal	12288	12000	120000	1333.333	59.28868	4.940723	1	1	*
Iceland	TAL	DSL 120GB	12288	12000	120000	1333.333	59.28868	4.940723	1	1	*
Ireland	Eircom	Up to 1Mb home broadband	1024	1000	10000	1333.333	39.7446	39.7446	0	1	
Ireland	Irish Broadband	Imagine up to 1Mb	1024	1000	10000	1333.333	43.32269	43.32269	0	1	
Ireland	Irish Broadband	Imagine up to 3Mb	3072	3000	20000	888.8889	49.56778	16.52259	0	1	
Ireland	Irish Broadband	Imagine up to 7Mb	7782.4	7600	30000	526.3158	59.39096	7.8146	0	1	
Ireland	Eircom	Up to 3Mb home broadband	3072	3000	30000	1333.333	48.23428	16.07809	0	1	
Ireland	Eircom	Up to 7Mb home broadband	7168	7000	50000	952.381	57.15373	8.164819	0	1	
Ireland	Eircom	Up to 24Mb home broadband	24576	24000	75000	416.6667	65.91601	2.746501	0	1	
Ireland	UPC Ireland	30Mb Broadband Ultra	30720	15000	120000	533.3333	39.04715	2.603143	1	1	
Ireland	UPC Ireland	15Mb Broadband Express	15360	30000	120000	1066.667	48.87033	1.629011	1	1	
Ireland	UPC Ireland	8Mb Broadband Value	8192	8000	120000	2000	32.17092	4.021365	1	1	
Luxembourg	EPT	LuxDSL Junior	5120	512	2000	53.33333	53.4606	10.69212	0	0	
Luxembourg	Numericable	Internet 3 Mega	3072	256	3000	133.3333	33.3682	11.12273	0	0	
Luxembourg	EPT	LuxDSL Run	10240	640	15000	200	72.28905	7.228905	0	1	
New Zealand	Telecom	Go	24576		3000	16.66667	55.62613	2.317756	0	0	
New Zealand	Vodafone	Easy Pack	24576	1000	5000	27.77778	42.34725	1.764469	0	0	
New Zealand	Telecom	Explorer	24576		10000	55.55556	61.67574	2.569823	0	1	
New Zealand	Vodafone	Ideal Pack	24576	1000	10000	55.55556	48.39685	2.016536	0	1	
New Zealand	Vodafone	Ideal Naked	24576	1000	10000	55.55556	48.39685	2.016536	0	1	
New Zealand	Telecom	Adventure	24576		20000	111.1111	67.72535	2.82189	0	1	
New Zealand	TelstraClear	LightSpeed 20G	15360	1000	20000	177.7778	33.84755	2.256503	0	1	
New Zealand	Vodafone	Ultimate Pack	24576	1000	30000	166.6667	67.72535	2.82189	0	1	
New Zealand	Vodafone	Ultimate Nacked	24576	1000	30000	166.6667	51.42166	2.142569	0	1	
New Zealand	Telecom	Pro	24576	1000	40000	222.2222	79.82456	3.326023	0	1	
New Zealand	TelstraClear	LightSpeed 40G	15360		40000	355.5556	33.84755	2.256503	0	1	
New Zealand	TelstraClear	LightSpeed 60G	15360	2000	60000	533.3333	58.04598	3.869732	0	1	
New Zealand	TelstraClear	LightSpeed 90G	15360	2000	90000	800	84.66425	5.644283	1	1	
New Zealand	TelstraClear	WarpSpeed 120G	25600	2000	120000	640	127.0115	5.08046	1	1	
Portugal	Zon	Zon Net SD Net	5120	256	10000	266.6667	42.12079	8.424157	0	1	
Portugal	Clix	Pack ADSL Net Outras Zonas + Telefone	1024	128	12000	1600	56.61517	56.61517	0	1	
Portugal	Clix	Pack ADSL Net Outras Zonas + Telefone	8124	512	50000	840.3086	71.9382	9.067543	0	1	
Portugal	Clix	Pack Fibra Net + Telefone	30720	1024	60000	266.6667	26.90602	1.121084	0	1	
Portugal	Clix	Pack ADSL Net + Telefone Sem assinatura	24576	3000	60000	333.3333	40.36575	1.345525	0	1	
Portugal	Clix	Pack ADSL Net Outras Zonas + Telefone	24576	1024	100000	555.5556	98.0618	4.085908	1	1	
Portugal	Clix	Pack Fibra Net + Telefone	102400	10000	200000	266.6667	53.82549	0	1	1	
Portugal	Clix	Pack Fibra Net + Telefone	102400	10000	200000	266.6667	67.28523	0	1	1	
Slovak Republic	T-Com	Optik 1	10240	512	2000	26.66667	14.5	1.45	0	0	
Slovak Republic	T-Com	Turbo 2 Mini	2048	256	2000	133.3333	14.5	1.45	0	0	
Slovak Republic	T-Com	Turbo 2 Mini Solo + (faster upload)	2048	256	2000	133.3333	19.33871	9.669355	0	0	
Slovak Republic	T-Com	Turbo 2 Mini	2048	512	2000	133.3333	14.5	7.25	0	0	
Slovak Republic	T-Com	Turbo 2 Mini + (faster upload)	2048	512	2000	133.3333	14.5	7.25	0	0	
Slovak Republic	T-Com	Optik 2	20480	1000	120000	800	25.3871	1.269355	1	1	
Slovak Republic	T-Com	Turbo 3 Solo	3584	256	120000	4571.429	37.48387	10.70968	1	1	
Slovak Republic	T-Com	Turbo 3 Solo + (faster upload)	3584	512	120000	4571.429	37.48387	10.70968	1	1	
Slovak Republic	T-Com	Turbo 3	3584	256	120000	4571.429	35.06452	10.01843	1	1	
Slovak Republic	T-Com	Turbo 3 + (faster upload)	3584	512	120000	4571.429	35.06452	10.01843	1	1	
Slovak Republic	T-Com	Turbo 2 Solo	2048	256	120000	8000	27.80645	13.90323	1	1	
Slovak Republic	T-Com	Turbo 2 Solo + (faster upload)	2048	512	120000	8000	27.80645	13.90323	1	1	
Slovak Republic	T-Com	Turbo 2	2048	256	120000	8000	25.3871	12.69355	1	1	
Slovak Republic	T-Com	Turbo 2 + (faster upload)	2048	512	120000	8000	25.3871	12.69355	1	1	
Slovak Republic	T-Com	Optik 4	81920	2000	240000	400	45.95161	0.574395	1	1	
Slovak Republic	T-Com	Optik 3	40960	4000	240000	800	36.27419	0.906855	1	1	
Slovak Republic	T-Com	Turbo 4 Solo	12288	512	240000	2666.667	48.37097	4.030914	1	1	
Slovak Republic	T-Com	Turbo 4	12288	512	240000	2666.667	45.95161	3.829301	1	1	
Spain	Telefonica	Movistar kit ADSL Mini	1024	320	2000	266.6667	51.23923	51.23923	0	0	
Spain	Telefonica	Movistar kit ADSL 1 Mb	1024	256	20000	2666.667	66.36744	66.36744	0	1	
Turkey	Turksat/Uydunet	10 Mbps'e kadar limitli	10240		1000	13.33333	20.33133	2.033133	0	0	
Turkey	Turksat/Uydunet	5 Mbps'e kadar limitli	5120		1000	26.66667	0	0	0	0	
Turkey	Turksat/Uydunet	1 Mbps'e kadar limitli	1024		1000	133.3333	14.30723	14.30723	0	0	
Turkey	Superonline	1 Mbps'e kadar limitli	10240	1000	4000	53.33333	20.64445	2.064445	0	0	
Turkey	Superonline	8 Mbps' e kadar 4GB	8192	1000	4000	66.66667	38.27466	4.784333	0	0	
Turkey	Turk Telekom / TTNet	NET4	8192	1000	4000	66.66667	21.83735	2.729669	0	0	
Turkey	Turk Telekom / TTNet	NET4 (Plus)*	8192	1000	4000	66.66667	23.34337	2.917922	0	0	
Turkey	Superonline	8 Mbps' e kadar 6GB	8192	1000	6000	100	38.27466	4.784333	0	1	
Turkey	Turk Telekom / TTNet	NET6	8192	1000	6000	100	29.36747	3.670934	0	1	
Turkey	Superonline	NET6	20480	5000	8000	53.33333	27.54706	1.377353	0	1	
Turkey	Superonline	NET6	50480	5000	12000	32.45642	41.35228	0.838842	0	1	
Turkey	Superonline	8 Mbps Limitsiz	8192	250	15000	250	84.77316	10.59664	0	1	
Turkey	Superonline	8 Mbps' e kadar Limitsiz	8192	512	15000	250	44.86352	5.60794	0	1	
Turkey	Turk Telekom / TTNet	8 Mbps' e kadar Limitsiz	8192	1000	15000	250	36.89759	4.612199	0	1	
Turkey	Superonline	4 Mbps Limitsiz	4096	1000	15000	500	72.83509	18.20877	0	1	
Turkey	Superonline	2 Mbps Limitsiz	2048	1000	15000	1000	58.76318	29.38159	0	1	
Turkey	Superonline	1 Mbps Limitsiz	1024	1000	15000	2000	44.69785	44.69785	0	1	
Turkey	Superonline	1 Mbps Limitsiz	102400	5000	16000	21.33333	62.06012	0.620601	0	1	
Turkey	Superonline	1 Mbps Limitsiz	10240	1000	50000	666.6667	34.44967	3.444967	0	1	
Turkey	Superonline	1 Mbps Limitsiz	20480	5000	100000	666.6667	48.2549	2.412745	1	1	
Turkey	Superonline	1 Mbps Limitsiz	50480	5000	250000	676.1754	68.96273	1.398927	1	1	
Turkey	Superonline	1 Mbps Limitsiz	102400	5000	500000	666.6667	137.9888	1.379888	1	1	
United Kingdom	BT	Option 1	20480		10000	66.66667	38.14371	1.907186	0	1	
United Kingdom	BT	BT Infinity Option 1	40960	2000	40000	133.3333	44.13174	1.103293	0	1	
United Kingdom	BT	Option 2	20480		40000	266.6667	45.62874	2.281437	0	1	
United Kingdom	Sky	Sky Broadband Unlimited with Sky Talk	20480	1300	40000	266.6667	31.43713	1.571856	0	1	
United Kingdom	Sky	Sky Broadband Unlimited without Sky Talk	20480	1300	40000	266.6667	22.45509	1.122755	0	1	

* information are added from telecom operators' websites
Source: OECD Communications Outlook 2011, OECD Broadband Statistics Sep., 2010, and Telecom Operators' Websites

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