The Impact of Asymmetric Regulation on Product Bundling

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3 June 2015

Regulation on Product Bundling

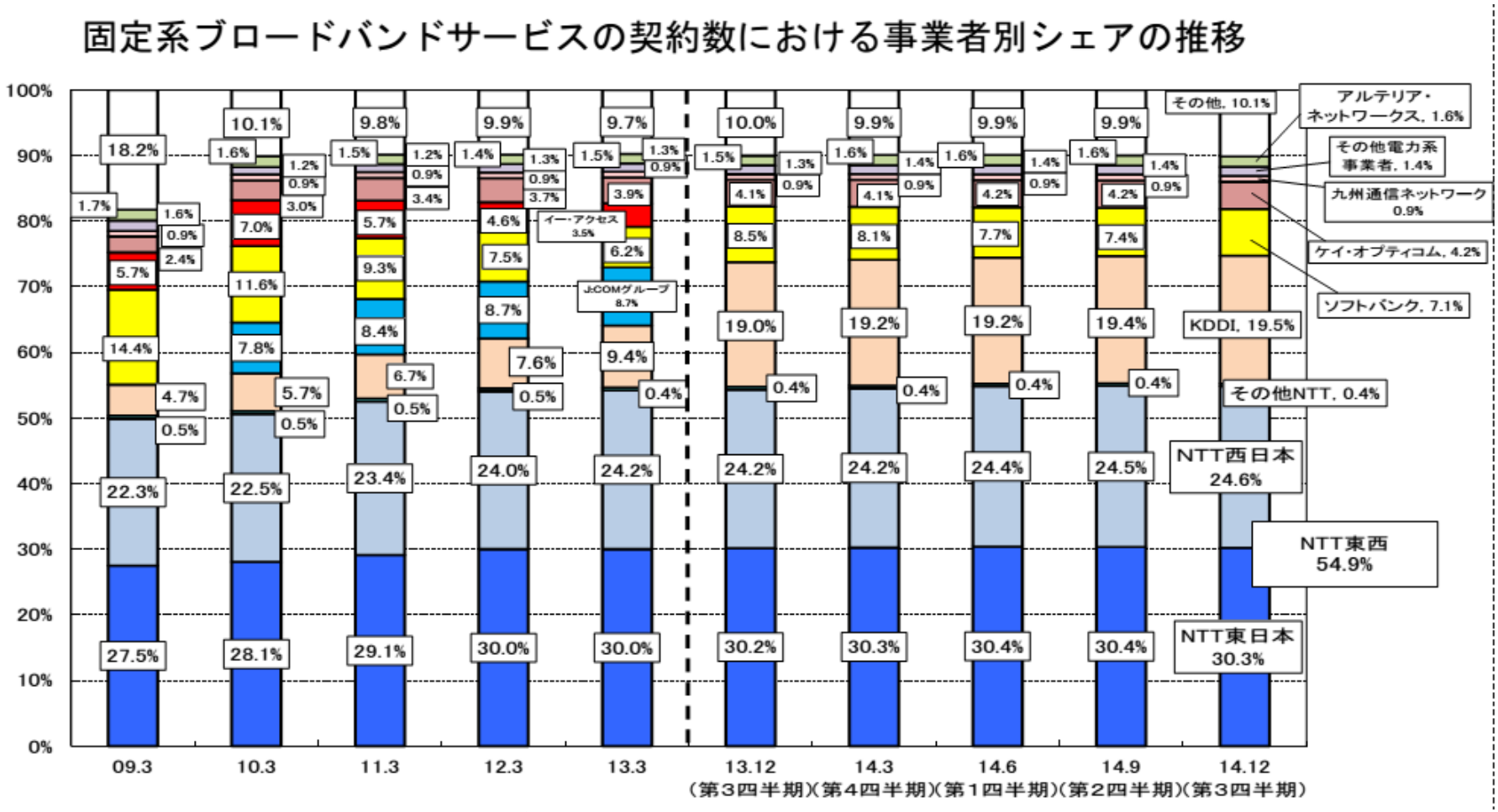
- How do regulation on Product Bundling affect welfare?
  - Two main motivations for product bundling
    - Price discrimination
    - Entry deterrence
- Economists know two-key features
  - The level of market dominance
  - Correlation of willingness to pay for goods bundled
- This paper
  - Comparing subgame perfect Nash equilibriums (SPNE) with/without regulation on product bundling by incumbent
  - Challenge:
    - Flexible substitute/complement between goods bundled
    - Correlating willingness to pay for goods bundled
    - Multiple equilibrium for multiproduct firms' Bertrand-Nash equilibrium and choice of bundle pricing

Asymmetric regulation on Product Bundling in Japanese telecommunications market

- Regulation on product bundling
  - Japanese asymmetric regulation on product bundling is unique.
    - Due to public concern about leveraging the monopoly power in the local phone market, Incumbent(NTT) has been prohibited to bundle fixed communications and mobile communications till Feb, 2015
    - There are no regulation in EU and US on product bundling of fixed broadband and mobile communications. However, EU requests significant market power operators to make other firms possible to replicate their services.

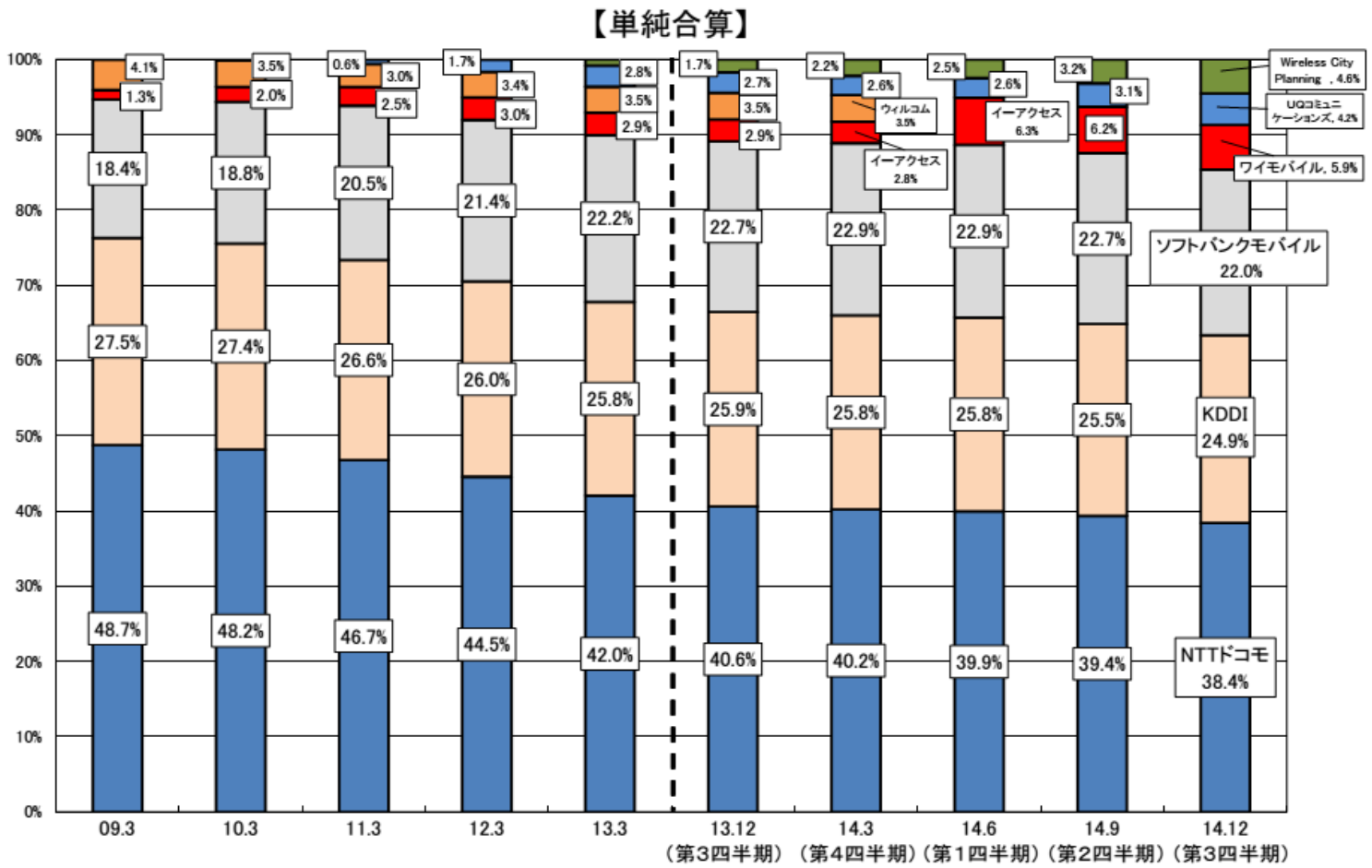
- Sequence of introduction of product bundling
  - In 2012, KDDI(2nd largest operator) introduced bundle discount for FTTH and smartphone. ($12/month for every smartphone)
  - After KDDI's introduction of bundle discount, SoftBank introduced similar bundle discount.
  - In 2014, NTT's mobile operator announced to start bundle discount using wholesale services of NTT's fixed operator's FTTH.

Progress of Market share in Japan



出所：電気通信サービスの契約数及びシェアに関する四半期データの公表（平成26年度第3四半期（12月末））

Progress of Market share in Japan



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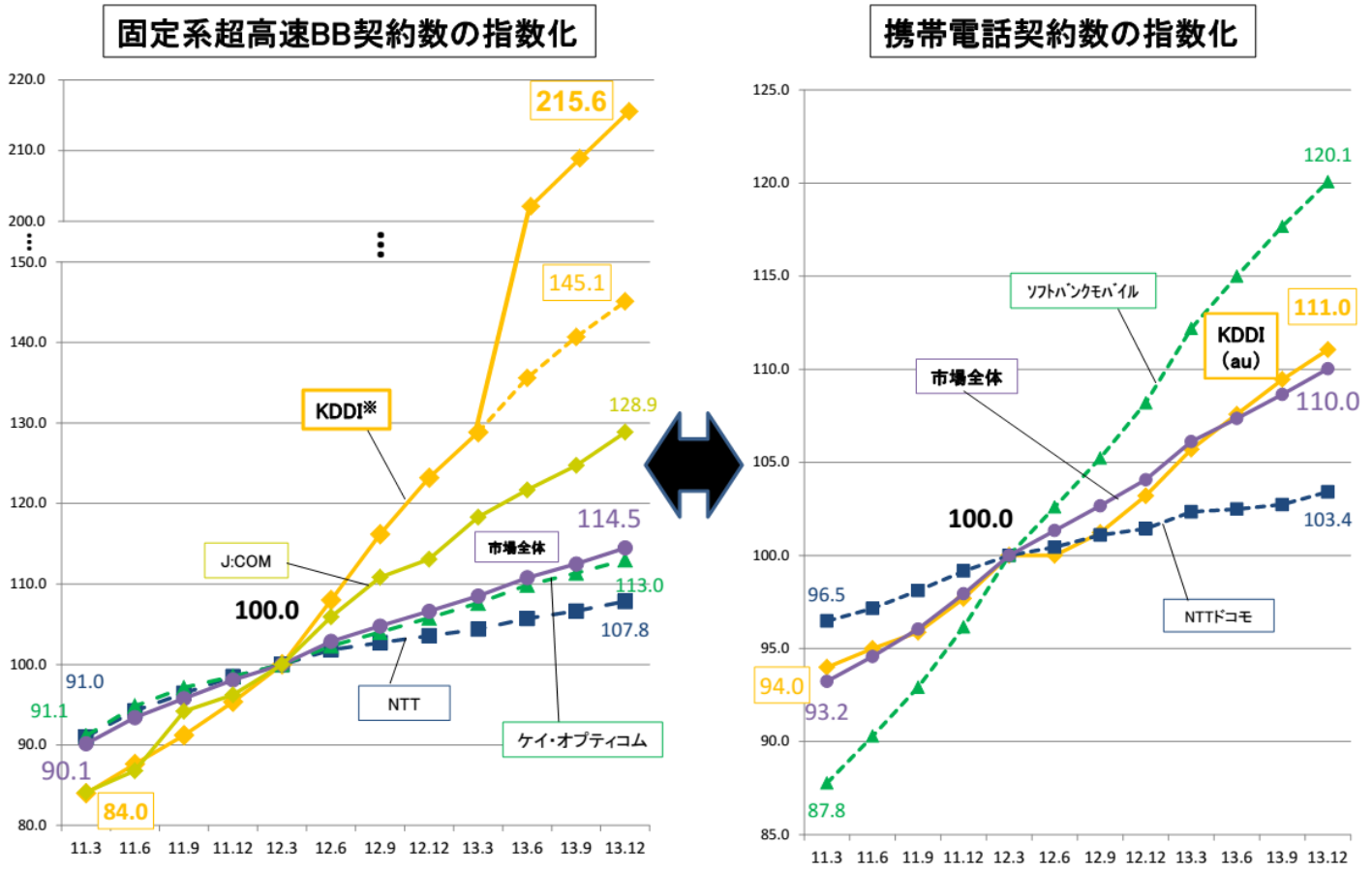
Progress of Market share in Japan

【図表Ⅰ－28　固定系超高速ブロードバンド及び携帯電話契約数の指数化】



※　破線部はＪ：COM の契約数を考慮しなかった場合。
（注）上表の指数は、各社ごとに２０１２年３月期との契約数の比較を行ったもの。
（２０１２年３月期における各社の契約数が異なることに注意を要する。）

出所：総務省資料

Underlying model

- Setup
  - Firms provide two goods (fixed broadband and mobile communications)
- Stage 1: Firms choose whether to bundle or not to bundle.
  $b_j = 1$ if firm j choose to bundle
  - Here we say bundle as mixed bundling.
  - $B = (b_{NTT}, b_{KDDI}, b_{SoftBank})$ represent a choice in the first stages.
- Stage 2: Firms choose strategic variable (price or quantity)
  - Firm j's Profit function

$$\Pi_j = p_j^B s_{jj} + p_j^F \sum_{k \neq j} s_{jk} + p_j^M \sum_{k \neq j} s_{kj}$$

where
p_j^B, p_j^F, p_j^M prices of firm j's bundle, fixed broadband, and mobile communications respectively
If $b_j = 0 \rightarrow p_j^B = p_j^F + p_j^M$
s_{jk} share of alternative that contain firm j's fixed broadband and firm k's mobile communications

Theorists' Checklist

- 1. Demand for goods bundled (Stigler, 1963)
  - Correlation ↑ ⇒ Demand for goods bundled ↓
- 2. Demand substitutes or compliments (Lewbel, 1985)
  - Complementarities ↑ ⇒ optimal price for bundle goods ↑
- 3. Bundling as product differentiation (Chen, 1997)
  - Firms can increases profits to choose asymmetric choice on product bundling
- 4. Pure bundling as entry barrier (Choi and Stefanadis, 2006)
  - Incumbent monopolist use pure bundling to prevents specialist entry by pure-bundling

Literature 1

- The effect of bundling on price and welfare
  - Substitutes
    - Crawford (2008), and Crawford and Yurukoglu (2012): the cable television channels (B to B to C)
    - Shiller and Waldfogel (2011): music download (B to C)
    - Ho et al. (2012): movie (B to B)
    - Kuroda (2014): Public broadcasting channels (B to C)
  - Flexible
    - Gentzkow (2007): bundle of paper and online news by flexible complementarities or substitutabilities frameworks (B to C)
    - Luo (2012): bundle internet and phone services (B to C)
- This paper
  - Estimates demand for competing goods bundled.
  - Allowing incumbent to bundle products increases consumer surplus through expanding market demand

Literature 2

- Substitutes or complements?
  - Vogelsang (2010) provides comprehensive review on this literature on phone.
  - Verboven (2014) found fixed broadband technologies generate strong complementarities between fixed and mobile access.

- This paper
  - NTT(incumbant) ’s fixed and mobile is complements
  - Competitors’ are ambiguous

Literature 3

- Firm's incentives to bundle
  - Fox and Lazzati (2015) provides the identification strategy by using potential games.
  - Macieira et al (2014) investigated the firms' incentives to provide Triple-Play (Phone, Internet, and TV) under oligopoly market

- This paper
  - Tractable number of firms and goods enable us to finds multiple equilibriums.
  - Compare the equilibrium choice of product bundling with/without regulation. We find bundling is dominant strategy for incumbent.
  - The incentive to use pure bundling instead of mixed bundling as a tool for leverage does not work in this market.

Industry detail

- Competition began in 1985
  - National monopolist NTT grope is privatized.
  - Allowing entry to the communications market make many firms enter into the long distance call market.

- In 2000's
  - Because of low access charge for line sharing($1.2), many ADSL providers enter into the fixed broadband market.
  - ADSL operators has consolidated over decades.
  - Because of using beauty contest for spectrum allocation, entry into the mobile market is limited. However, mobile operators has began to consolidate from 2010.
  -

- The market are dominated three national group firms
  - There are many regional CATV operator, regional FTTH operator(mainly electricity monopolist's) and some DSL provider in fixed market.
  - MVNO began to expand their share in the last years, but share is still small.(6% in the end of 2013.)

Industry detail

- NTT
  - Established in early 20's by government as national monopolist for telephone
  - Privatized in 1985
  - It is regulated by the telecommunications business law as dominant player and by the NTT law that make Government held 1/3 share.
    - Mandatory open access for their fixed facilities and mobile facilities by the telecommunication's act
  - There are two regional fixed services operators and one national mobile operator in NTT grope
  - Fixed services
    - Phone: PSTN, ISDN, VOIP(NGN)
    - Broadband: ADSL, FTTH
  - Mobile services
    - W-CDMA, FD-LTE

Industry detail

- KDDI
  - Three firms (KDD + DDI + IDO) merged into KDDI in 2000.
    - KDD: Divided from NTT in 1953 as the monopolist for international call. Privatized in 1953 (KDDI law is abolished 1998)
    - DDI: Fixed and mobile operator that is established in 1984 as new entrant for telecommunication market.
    - IDO: Mobile operator established in 1987. It is partially financed by Toyota and two regional electricity monopoly firms in the Tokyo and Chubu areas in 1987.
  - It is regulated by telecommunications business law as significant player in mobile market.
  - There is one national fixed and mobile services operator, many local CATV operator, one national mobile internet(WiMAX) operator in KDDI grope
    - It acquired FTTH facilities from Electricity monopoly firms in Tokyo and Chubu areas in the mid 2000's.
    - It acquired 2nd largest CATV operator in 2010 and merged largest one in 2013.
  - Fixed services
    - Phone: PSTN, ISDN, CATV, VOIP
    - Broadband: CATV, FTTH(partially using NTT's facility)
  - Mobile services
    - cdma2000, FD-LTE, WiMAX, WiMax2+(TD-LTE)

Industry detail

- SoftBank
  - Established in 1981 by Msayoshi Son(One of most successful entrepreneur in Japan)
  - It is regulated by telecommunication act as significant player in mobile market.
  - There is two national fixed operators and two national mobile operators in SoftBank grope
    - It enter fixed broadband market in 2003 as ADSL operator
    - It acquired
      - national fixed operator in 2004
      - national mobile operator from Vodafone in 2006
      - national mobile operator that provides PHS(Japanese local 2G technology) and AXGP(TD-LTE) in 2010
      - national mobile operator that provides W-CDMA and LTE in 2011
  - Fixed services
    - Phone: PSTN, ISDN, CATV(joint with regional CATV operators)
    - Broadband: ADSL, FTTH(using NTT's facility)
  - Mobile services
    - PHS, W-CDMA, FD-LTE, AXGP(TD-LTE)

Our data

- Combine three surveys conducted by the Japan Ministry of Internal Affairs (MIC) and Communications.
  - Two online surveys
    - Conducted by the MIC in February, 2014
    - 2,010 individual who use fixed broadband.
  - 500 individual who use mobile communications but not not use fixed broadband.
  - Choice of services, rate plan, expenditure, characteristics of respondents
  - One mail survey
    - Online surveys does not contain individuals who does not use internet or mobile communications, we draw characteristics of them from the Communications Usage Trend Survey 2012.
    - This survey was sent by post to 40,592 households in proportion to region and city size. The MIC obtained 20,418 valid responses in February, 2013.
    - The survey provides use or not use various communications services. But no data on a rate plan or firms.
    - Age, sex and use of communication services of all member's in respondents household are available.
    - We randomly draw 1,230 respondents characteristics who do not use internet or mobile phone from this survey.
- We obtain 3,740 individual observations that include
  - 2,000 broadband users, 2,298 mobile phone users and 1,239 non-users
  - communication services usage and characteristics (age and sex)

Our data

Alternative	(Fixed, Mobile)	Number of Observations	Expenditure(thousand yen)	S.D of expenditure	Difference of expenditure from sum of sepalate alternatives	Age	Rate of Men
1	(NTT, NTT)	408	8.761	4.808	−0.3	46.7	63.5%
2	(NTT, KDDI)	181	9.112	5.603	−0.1	46.9	70.2%
3	(NTT, SoftBank)	215	8.520	3.839	−0.7	46.7	65.1%
4	(NTT, None)	100	4.443	3.206		51.0	70.0%
5	(KDDI, NTT)	105	9.780	6.426	−0.6	47.3	67.6%
6	(KDDI, KDDI)	244	9.016	4.420	−1.5	47.3	68.0%
7	(KDDI, SoftBank)	87	9.738	4.244	−0.8	49.6	67.8%
8	(KDDI, None)	38	5.758	2.797		49.9	73.7%
9	(SoftBank, NTT)	83	6.579	3.234	−1.2	45.7	63.9%
10	(SoftBank, KDDI)	51	5.985	3.029	−1.9	48.0	60.8%
11	(SoftBank, SoftBank)	92	7.807	3.698	−0.2	48.0	66.3%
12	(SoftBank, None)	26	3.137	1.462		47.3	73.1%
13	(Other, NTT)	171	8.176	3.626	−0.2	47.3	68.4%
14	(Other, KDDI)	74	8.018	4.330	−0.4	47.1	73.0%
15	(Other, SoftBank)	96	8.429	3.867	−0.1	47.4	64.6%
16	(Other, None)	39	3.679	1.286		49.8	69.2%
17	(None, NTT)	116	4.668	3.244		39.8	65.5%
18	(None, KDDI)	209	4.720	2.465		41.6	67.0%
19	(None, SoftBank)	166	4.821	2.638		43.2	66.9%
20	(None, None)	1239	0.000	0.000		62.6	39.7%
Total	(ALL, ALL)	3740	5.004	5.092		51.7	57.8%

Empirical Model

- Goals
  - Estimate demand for combinations of fixed broadband and mobile communications

    with
    - Flexible complementarities/substitutabilities between goods
    - Correlations between willingness to pay for goods

- Set up
  - There are 20 alternatives that combine four fixed broadbands and three mobile communications [(4+1)x(3+1) = 20 alternatives]
  - Consumer choose an alternative that gives highest utility
  - Expenditure for alternative j depends consumer characteristics x_i and unobserved demand shock e_{ij}

Empirical Model

- Consumer i's utility
  - Utility of fixed broadband f $\delta_{if}(=\delta_f(x_i)+e_i^{\delta_f}, e_i^{\delta_f} \sim N(0,\sigma_{\delta_f}))$
  - Utility of mobile communications $\delta_{im}(=\delta_m(x_i)+e_i^{\delta_m}, e_i^{\delta_m} \sim N(0,\sigma_{\delta_m}))$
  - Difference between the base utility of bundle and the sum of the utility of separate goods $\Gamma_{ij}(=\Gamma_j(x_i)+e_i^{\Gamma_j}, e_i^{\Gamma_j} \sim N(0,\sigma_{\Gamma_j}))$

    $\Gamma_{ij}=0$ if consumer choose alternative j that include two firms
  - Expenditure for alternative j y_{ij} (discuss next slide)
  - Unobserved demand shock ε_{ij} (discuss next slide)
  - The utility that consumer i obtains from alternatives J

$$U_{ij}=\Gamma_{ij}+\delta_{if}+\delta_{im}-\alpha y_{ij}+\varepsilon_{ij}$$

  - ε_{ij} could be correlated with y_{ij} because of unobserved attributes, such as quality of networks

Empirical Model

- Control function approach
  - Following Petrin and Train (2010), we use a control function approach to manage endogeneity of prices.
  - Consumer i's expenditure for alternative j is
    $$y_{ij} = h(x_i, z_j, \gamma_j) + u_{ij}$$
    - Individual i's characteristics x_i(age, sex)
    - Expenditure for alternative j in other region z_j (hausman type IV)
  - u_{ij} is unobserved factor that independent of x_i and z_j
    - Regress y_{ij}on x_i, z_j , we get estimates of unobserved factor $\hat{u}_{ij}$
    - Appling the simplest approximation, replace ε_{ij} in utility function by $\varepsilon_{ij} = \lambda\hat{u}_{ij} + \tilde{\varepsilon}_{ij}$, where $\tilde{\varepsilon}_{ij}$ is independent of y_{ij} ,λ is a parameter of control function.
    - Because $y_{ik}(k \neq j)$ is not observed, we use $\hat{y}_{ik}(k \neq j)$ for consumer i's expenditure for alternative k.

Empirical Model

- The choice probability of consumer i for alternative j

$$P_{ij} = \int \Pr(U_{ij} > U_{ik} \forall j \neq k \mid u_{ij}) d\tilde{\varepsilon}_i$$

  - Assuming element of $\tilde{\varepsilon}_i = (\tilde{\varepsilon}_{i1}, \tilde{\varepsilon}_{i2}, ..., \tilde{\varepsilon}_{i20})$ is i.i.d extreme value

$$P_{ij} = \int \frac{\exp(\Gamma_{ij} + \delta_{if} + \delta_{im} - \alpha y_{ij})}{1 + \sum_j \Gamma_{ij} + \delta_{if} + \delta_{im} - \alpha y_{ij}} f(\Gamma_{ij}, \delta_{if}, \delta_{im}) d\Gamma_{ij} d\delta_{if} d\delta_{im}$$

  where $f(\Gamma_{ij}, \delta_{if}, \delta_{im})$ is the joint normal distribution $N(\theta_i, \Sigma)$

  - We use 300 halton draws to simulate the integration on $f(\Gamma_{ij}, \delta_{if}, \delta_{im})$

- Standard errors of parameters are estimated by 100 bootstrap samples.

Estimation Results

	MNL	Mixed Logit with Correlation
Number of Observations	3740	3740
Number of Parameters	12	87
Log-likelihood at convergence	-9847.212	-8364.92478
McFadden R	0.1211	0.2534
Adjusted McFdden R	0.1200	0.2525

		Estimates	Std. Err	Estimates	Std. Err	Standard deviations of Parameters	
δ_{if}	NTT	-0.6458***	0.0135	23.4373**	10.5133	8.33565	10.08179
	KDDI	-1.4725***	0.0314	-11.8075	14.4678	68.3508***	9.95051
	SoftBank	-1.9923***	0.1472	16.9470	15.5345	31.5431***	10.69081
	Other	-1.2115***	0.0498	7.1900	9.6989	38.7961***	9.64624
δ_{im}	NTT	-0.4996***	0.0114	44.4027***	8.8849	54.6814***	9.76583
	KDDI	-0.5292***	0.0262	52.6545***	9.0467	66.9291***	8.65307
	SoftBank	-0.4408***	0.0171	43.5472***	7.3491	30.8452***	9.19806
Γ_{ij}	NTT	1.3046***	0.0596	-23.6629*	13.3886	58.9305***	13.80601
	KDDI	1.6238***	0.0595	13.4539	17.5637	113.766***	14.90701
	SoftBank	0.9674***	0.1966	-18.6142	56.7806	57.9294**	23.31524
α		-0.0861***	0.0096	-4.8782***	0.1274		
λ		0.0692***	0.0337	4.8699***	0.2331		

* = significant at the 10% level; **= significant at the 5% level; and *** = significant at the 1% level.

Estimation Results

Heterogeneity in mean	Estimates		Std. Err
F_NTT:MEN	5.74225	***	4.56806
F_NTT:AGE	-0.17325	***	0.13613
F_KDDI:MEN	23.7439	***	5.55953
F_KDDI:AGE	-0.67742	***	0.16592
F_SoftBank:MEN	8.31732	***	8.07581
F_SoftBank:AGE	-0.65016	***	0.17759
F_Other:MEN	12.005	***	4.68928
F_Other:AGE	-0.46931	***	0.12995
M_NTT:MEN	18.7554	***	4.44687
M_NTT:AGE	-1.07937	***	0.12647
M_KDDI:MEN	21.0067	***	4.66952
M_KDDI:AGE	-1.32676	***	0.10806
M_SoftBank:MEN	11.4813	***	5.37711
M_SoftBank:AGE	-0.69634	***	0.12865
G_NTT:MEN	-19.7044	***	6.90178
G_NTT:AGE	1.22122	***	0.19335
G_KDDI:MEN	-27.6592	***	8.91984
G_KDDI:AGE	1.24255	***	0.25639
G_SoftBank:MEN	-3.8691		30.258
G_SoftBank:AGE	0.63154	***	0.38101

Diagonal values in L	Estimates	Std. Err
F_NTT	8.33565***	10.08179
F_KDDI	47.8893***	7.65345
F_SoftBank	18.101***	6.46876
F_Other	2.87926***	5.07933
M_NTT	34.9646***	3.09738
M_KDDI	15.1648***	3.15095
M_SoftBank	5.53291***	3.44143
G_NTT	0.31751	5.77064
G_KDDI	2.69004**	4.28186
G_SoftBank	7.62182***	5.73858

Below diagonal values in L	Estimates	Std. Err
F_KDDI:F_NTT	-48.7693***	20.21019
F_SoftBank:F_NTT	-25.3664***	19.45004
F_SoftBank:F_KDDI	4.88561***	12.84069
F_Other:F_NTT	-26.9797***	18.6313
F_Other:F_KDDI	-8.53267***	10.47373
F_Other:F_SoftBank	-26.3844***	7.94435
M_NTT:F_NTT	-24.5978***	17.51806
M_NTT:F_KDDI	-18.3316***	11.49322
M_NTT:F_SoftBank	-20.5153***	7.69766
M_NTT:F_O	20.1385***	5.1681
M_KDDI:F_NTT	-40.4559***	15.82109
M_KDDI:F_KDDI	-39.5953***	7.42712
M_KDDI:F_SoftBank	7.15252***	5.10983
M_KDDI:F_O	16.7322***	5.05244
M_KDDI:M_NTT	26.7197***	4.44207
M_SoftBank:F_NTT	-26.015***	18.48413
M_SoftBank:F_KDDI	3.7148***	6.92281

Below diagonal values in L (Cont)	Estimates	Std. Err
M_SoftBank:F_SoftBank	-4.65691***	4.97396
M_SoftBank:F_Other	7.38255***	5.38671
M_SoftBank:M_NTT	11.2228***	4.64012
M_SoftBank:M_KDDI	-5.30049***	4.67839
G_NTT:F_NTT	33.0007***	22.87179
G_NTT:F_KDDI	18.028***	8.90459
G_NTT:F_SoftBank	20.9387***	7.82122
G_NTT:F_Other	-20.0071***	7.28348
G_NTT:M_NTT	-34.9202***	6.78465
G_NTT:M_KDDI	-0.71724	5.89373
G_NTT:M_SoftBank	0.01373	5.82192
G_KDDI:F_NTT	80.7863***	18.965
G_KDDI:F_KDDI	69.3307***	13.00605
G_KDDI:F_SoftBank	-28.9076***	7.57112
G_KDDI:F_Other	-6.31277***	8.0233
G_KDDI:M_NTT	-14.5067***	6.12852
G_KDDI:M_KDDI	-11.6417***	7.11316
G_KDDI:M_SoftBank	19.4888***	6.14321
G_KDDI:G_SoftBank	1.05309	6.96882
G_SoftBank:F_NTT	39.0389***	20.32353
G_SoftBank:F_KDDI	-26.3897***	12.86748
G_SoftBank:F_SoftBank	20.6728***	11.68895
G_SoftBank:F_Other	0.7424	6.97248
G_SoftBank:M_NTT	7.42359***	14.50694
G_SoftBank:M_KDDI	23.1022***	11.7851
G_SoftBank:M_SoftBank	-0.12518	10.20528
G_SoftBank:G_NTT	-7.60502***	9.6609
G_SoftBank:G_KDDI	1.63899	7.50894

* = significant at the 10% level; **= significant at the 5% level; and *** = significant at the 1% level.

Estimation Results

Expected

Choice	NTT	KDDI	SB	Others	SUM
NTT	32.82%	7.09%	8.33%	0.94%	49.19%
KDDI	3.09%	6.49%	2.31%	0.85%	12.74%
SB	1.52%	0.41%	2.43%	0.68%	5.04%
Others	5.24%	2.63%	3.07%	0.00%	10.94%
None	3.15%	3.56%	1.99%	13.39%	22.09%
SUM	45.82%	20.18%	18.13%	15.87%	100.00%

Ratio (Expected / Observed)

Choice	NTT	KDDI	SB	Others	SUM
NTT	152%	100%	100%	58%	127%
KDDI	100%	100%	100%	100%	100%
SB	100%	100%	99%	98%	99%
Others	100%	100%	99%	955%	100%
None	100%	100%	100%	56%	68%
SUM	133%	100%	100%	59%	100%

Observed

Choice	NTT	KDDI	SB	Others	SUM
NTT	21.54%	7.09%	8.36%	1.63%	38.62%
KDDI	3.09%	6.51%	2.31%	0.85%	12.76%
SB	1.52%	0.41%	2.45%	0.69%	5.07%
Others	5.24%	2.63%	3.09%	0.00%	10.96%
None	3.15%	3.56%	2.00%	23.89%	32.59%
SUM	34.54%	20.20%	18.20%	27.07%	100.00%

Correlation between parameters

Correlation		δ_f				δ_m			Γ		
		NTT	KDDI	SB	Other	NTT	KDDI	SB	NTT	KDDI	SB
δ_f	NTT	1	-0.71351	-0.80418	-0.69542	-0.44984	-0.60446	-0.8434	0.55999	0.71011	0.6739
	KDDI	-0.71351	1	0.68232	0.3421	0.08608	0.01679	0.68616	-0.18522	-0.07969	-0.80002
	SoftBank	-0.80418	0.68232	1	0.13492	0.09453	0.45579	0.61027	-0.19906	-0.62248	-0.40772
	Other	-0.69542	0.3421	0.13492	1	0.66904	0.49635	0.68047	-0.72355	-0.45917	-0.6102
δ_m	NTT	-0.44984	0.08608	0.09453	0.66904	1	0.77749	0.71646	-0.9917	-0.53037	-0.19765
	KDDI	-0.60446	0.01679	0.45579	0.49635	0.77749	1	0.58857	-0.8057	-0.90488	0.04502
	SoftBank	-0.8434	0.68616	0.61027	0.68047	0.71646	0.58857	1	-0.78383	-0.49851	-0.69634
Γ	NTT	0.55999	-0.18522	-0.19906	-0.72355	-0.9917	-0.8057	-0.78383	1	0.58954	0.27897
	KDDI	0.71011	-0.07969	-0.62248	-0.45917	-0.53037	-0.90488	-0.49851	0.58954	1	0.05147
	SoftBank	0.6739	-0.80002	-0.40772	-0.6102	-0.19765	0.04502	-0.69634	0.27897	0.05147	1

Price elasticities

		Fixed					Mobile			
1% Price Change		NTT	KDDI	SoftBank	Other	None	NTT	KDDI	SoftBank	None
Fixed Broadband	NTT	-6.931	0.002	0.456	0.045	2.328	-3.624	-0.001	0.001	2.010
	KDDI	0.001	-0.056	0.101	0.000	0.000	0.000	-0.002	-0.002	0.002
	SoftBank	0.089	0.035	-0.808	0.037	0.057	0.011	0.001	0.000	-0.006
	Other	0.014	0.000	0.066	-0.256	0.036	0.007	-0.001	-0.008	0.000
Mobile communications	NTT	-4.155	-0.016	0.104	0.008	1.425	-3.816	0.011	0.001	2.110
	KDDI	-0.602	0.000	0.111	-0.029	0.199	0.011	-0.017	0.001	0.002
	SoftBank	-0.729	0.000	0.000	-0.014	0.255	0.001	0.001	-0.018	0.007
Bundle	NTT	-1.514	0.000	0.000	1.144	0.472	0.000	0.000	0.000	0.000
	KDDI	0.000	-0.514	0.808	0.170	0.000	0.143	-0.201	0.046	0.000
	SoftBank	0.000	0.041	-0.271	0.127	0.000	0.004	0.011	-0.037	0.009

- NTT's fixed and mobile are substitutes. But, competitor's its are ambiguous.
- Bundle is substitutes for it's components.

Counterfactual Analysis

- Firm j's profit is

$$\Pi_j = p_j^B s_{jj} + p_j^F \sum_{k \neq j} s_{jk} + p_j^M \sum_{k \neq j} s_{kj}$$

- The first-order condition for a Bertrand-Nash equilibrium in the second stage is $\frac{\partial \Pi_j}{\partial p_j^B} = 0, \frac{\partial \Pi_j}{\partial p_j^F} = 0, \frac{\partial \Pi_j}{\partial p_j^M} = 0$ equals to

$$s_{jj} + (p_j^B - mc_j^F - mc_j^M)\frac{\partial s_{jj}}{\partial p_j^B} + (p_j^F - mc_j^F)\frac{\partial}{\partial p_j^B}\left(\sum_{m \neq j} s_{jm}\right) + (p_j^M - mc_j^M)\frac{\partial}{\partial p_j^B}\left(\sum_{f \neq j} s_{fj}\right) = 0$$

$$\sum_m s_{jm} + (p_j^B - mc_j^F - mc_j^M)\frac{\partial s_{jj}}{\partial p_j^F} + (p_j^F - mc_j^F)\frac{\partial}{\partial p_j^F}\left(\sum_{m \neq j} s_{jm}\right) + (p_j^M - mc_j^M)\frac{\partial}{\partial p_j^F}\left(\sum_{f \neq j} s_{fj}\right) = 0$$

$$\sum_f s_{fj} + (p_j^B - mc_j^F - mc_j^M)\frac{\partial s_{jj}}{\partial p_j^M} + (p_j^F - mc_j^F)\frac{\partial}{\partial p_j^M}\left(\sum_{m \neq j} s_{jm}\right) + (p_j^M - mc_j^M)\frac{\partial}{\partial p_j^M}\left(\sum_{f \neq j} s_{fj}\right) = 0$$

- When firm j chooses not to bundle, the first constraint on p_j^B does not bind.

Counterfactual Analysis

- Marginal costs
  - Because of possibility of multiple equilibrium, recovering marginal costs from equilibrium does not work for this model.
  - We use access charge as the marginal cost for goods.
    - Fixed broadband: Use weighted average of access charges for FTTH(¥3108) and ADSL(¥1371). We assume the technology share of firms are fixed.
    - Mobile communications: Use termination charge of mobile phone call and access charge for mobile data. We assume minutes of usage is 73min and use 4.2GB data per month.

		Monthly cost per customer (thousand yen)
Fixed Broadband	NTT	3.006
	KDDI	3.108
	SoftBank	1.631
	Other	2.983
Mobile communications	NTT	1.432
	KDDI	2.708
	SoftBank	3.257

Counterfactual Analysis

- Methods
  - We calculate individual parameters over sample by a Bayesian Procedure that proposed by Train (2009).
  - Using a parameters on sample, we calculate left hand side of binding first-order conditions in every second stages. We set the stopping point as the sum of square of the left-hand side is less than 10^{-5}
  - Using the Generalized Reduced Gradient method to find above mentioned point.

- Choice of equilibrium
  - Unfortunately(?), we found multiple Bertrand-Nash equilibrium in some second stages.
  - We pick an equilibrium that gives highest social surplus.
    - Assuming the fact that agents are able to coordinate each other justify this assumption.
  - Choice of bundling at first stage could have multiple equilibrium, too. However, it is unique in our case.

Counterfactual Analysis

	B	(1,1,1)	(0,1,1)	(1,1,0)	(0,1,0)	(1,0,1)	(0,0,1)	(1,0,0)	(0,0,0)
Prices of Fixed Broadband	NTT	4.166	3.866	4.428	3.886	4.176	3.898	4.143	3.808
	KDDI	8.704	10.04	18.67	10.50	4.697	5.331	3.782	3.151
	SoftBank	2.759	2.789	2.345	2.716	2.829	2.947	3.003	2.933
	Other	4.888	4.894	3.638	4.777	5.205	4.738	5.242	5.241
Prices of Mobile communications	NTT	7.146	4.223	19.93	4.201	8.411	4.178	9.411	4.276
	KDDI	6.789	6.768	12.11	10.68	6.571	5.880	7.734	8.475
	SoftBank	5.981	6.045	15.99	5.994	5.988	6.094	5.702	6.050
Prices of Bundle	NTT	8.041		8.028		8.025		8.022	
	KDDI	10.51	10.52	9.67	10.61				
	SoftBank	2.588	2.467			3.674	2.727		
Firms' Profits	NTT	**5.142**	4.978	**5.209**	5.160	**5.409**	5.094	**5.681**	5.257
	KDDI	**1.863**	**1.917**	**3.432**	**2.473**	1.766	1.701	1.850	1.777
	SoftBank	**1.097**	1.033	0.156	**1.144**	1.138	1.027	**1.205**	**1.135**
	Other	0.496	0.458	0.248	0.423	0.457	0.397	0.446	0.350
Sum of Profits		8.598	8.386	9.045	9.200	8.770	8.220	9.182	8.519
Consumer Surplus		5.111	5.408	2.993	4.695	5.091	5.748	4.748	5.423
Social Surplus		13.71	13.79	12.04	13.89	13.86	13.97	13.93	13.94

Counterfactual Analysis

- The effect of asymmetric regulation on product bundling
  - B=(0,1,0) is SPNE with regulation
    - Producer, Consumer, Social surplus is (¥9,200, ¥4,695, ¥13,890) per person
  - B=(1,1,1) is SPNE without regulation
    - Producer, Consumer, Social surplus is (¥8,598, ¥5,111, ¥13,710) per person
  - Comparing SPNE with/without regulation
    - Producer, Consumer, Social surplus increases (¥-602, ¥416, ¥-186) per person
    - Two sources of welfare loss
      - The fact that NTT and SoftBank increases fixed broadband prices to avoid cannibalization between bundle and fixed broadband.
      - Firm provides bundle goods to consumers who has lower willingness to pay for components than marginal costs.
  - Bundle of NTT's products increases NTT's profit and decreases competitors profit. However, competitors still earn higher profit than regional fixed operators.

Counterfactual Analysis

B(1,1,1)

		Mobile communication				
		NTT	KDDI	SoftBank	None	Sum
Fixed Broadband	NTT	47.62%	6.98%	7.63%	0.26%	62.48%
	KDDI	1.51%	5.98%	1.81%	0.73%	10.04%
	SoftBank	2.17%	0.99%	7.24%	0.82%	11.22%
	Other	4.58%	2.94%	2.63%	0.00%	10.14%
	None	1.46%	2.07%	1.30%	1.29%	6.12%
	Sum	57.33%	18.96%	20.61%	3.10%	100.00%

B(0,1,0)

		Mobile communication				
		NTT	KDDI	SoftBank	None	Sum
Fixed Broadband	NTT	47.03%	8.49%	8.73%	0.70%	64.94%
	KDDI	4.43%	5.89%	2.01%	0.94%	13.27%
	SoftBank	2.93%	0.22%	2.27%	0.92%	6.34%
	Other	5.38%	0.11%	2.43%	0.00%	7.92%
	None	3.36%	1.78%	0.77%	1.61%	7.53%
	Sum	63.14%	16.50%	16.21%	4.16%	100.00%

Counterfactual Analysis

- Does the incumbent have an incentive to use pure bundling instead of mixed bundling as a tool for leverage?
  - We calculate Bertrand-Nash equilibriums in second stages that NTT choose pure-bundling.

- Results
  - NTT's profit increases by using pure bundling when others do not bundle (3.392 to 3.877)
  - However, competitor's profit increases by using mixed bundling when NTT choose pure-bundling.
  - Therefore, (PB, 0, 0) is not SPNE. Unique SPNE is (1,1,1)

Counterfactual Analysis

	B	(PB,1,1)	(PB,1,0)	(PB,0,1)	(PB,0,0)
Prices of Fixed Broadband	NTT				
	KDDI	3.816	3.989	3.756	3.774
	SoftBank	2.450	2.497	2.795	2.158
	Other	4.991	5.002	5.264	4.864
Prices of Mobile communications	NTT				
	KDDI	7.066	7.074	6.885	6.898
	SoftBank	5.492	5.486	5.479	5.468
Prices of Bundle	NTT	8.015	8.015	8.003	8.014
	KDDI	10.384	10.375		
	SoftBank	8.084		7.907	
Firms' Profits	NTT	3.877	3.874	3.903	3.877
	KDDI	**2.138**	**2.151**	2.094	2.092
	SoftBank	**1.492**	1.487	**1.496**	1.483
	Other	0.520	0.528	0.541	0.516
Sum of Profits		8.027	8.040	8.034	7.967
Consumer Surplus		4.608	4.600	4.598	4.657
Social Surplus		12.63	12.64	12.63	12.62

Conclusion

- Asymmetric regulation have an effect on the market equilibrium.
  - Because product bundling intensifies price competition, firms prices significantly decreases.
- Strategy
  - Bundling is dominant strategy for NTT and KDDI.
  - SoftBank choose bundling only if all competitor choose bundling.
- Comparing equilibriums with/without asymmetric regulation
  - Diffusion rate of fixed broadband increases from 92.5% to 93.9%
  - Diffusion rate of fixed broadband increases from 95.8% to 96.9%
  - Average expenditure who use fixed broadband or mobile communications decreases from ¥9,399 to ¥8,710
  - Competitors are still able to earn profit without asymmetric regulation.

Policy discussion

- Banning bundling?
  - Consumer surplus and social surplus of B=(0,0,0) is higher than equilibrium choice B=(1,1,1).
  - Because of
    - NTT and KDDI increases its fixed broadband price to avoid cannibalization in B=(1,1,1) and strategic complementarities enable regional fixed operators to increases its prices.
    - Product bundling have an product differentiation effect. In case of B=(0,0,0), they can't differentiate their products through bundling.
  - Making regional operator to entry into mobile market as MVNO enable us to draw the competition intensify effects of product bundling.