

Substitution between Fixed-line and Mobile Access: the Role of Complementarities

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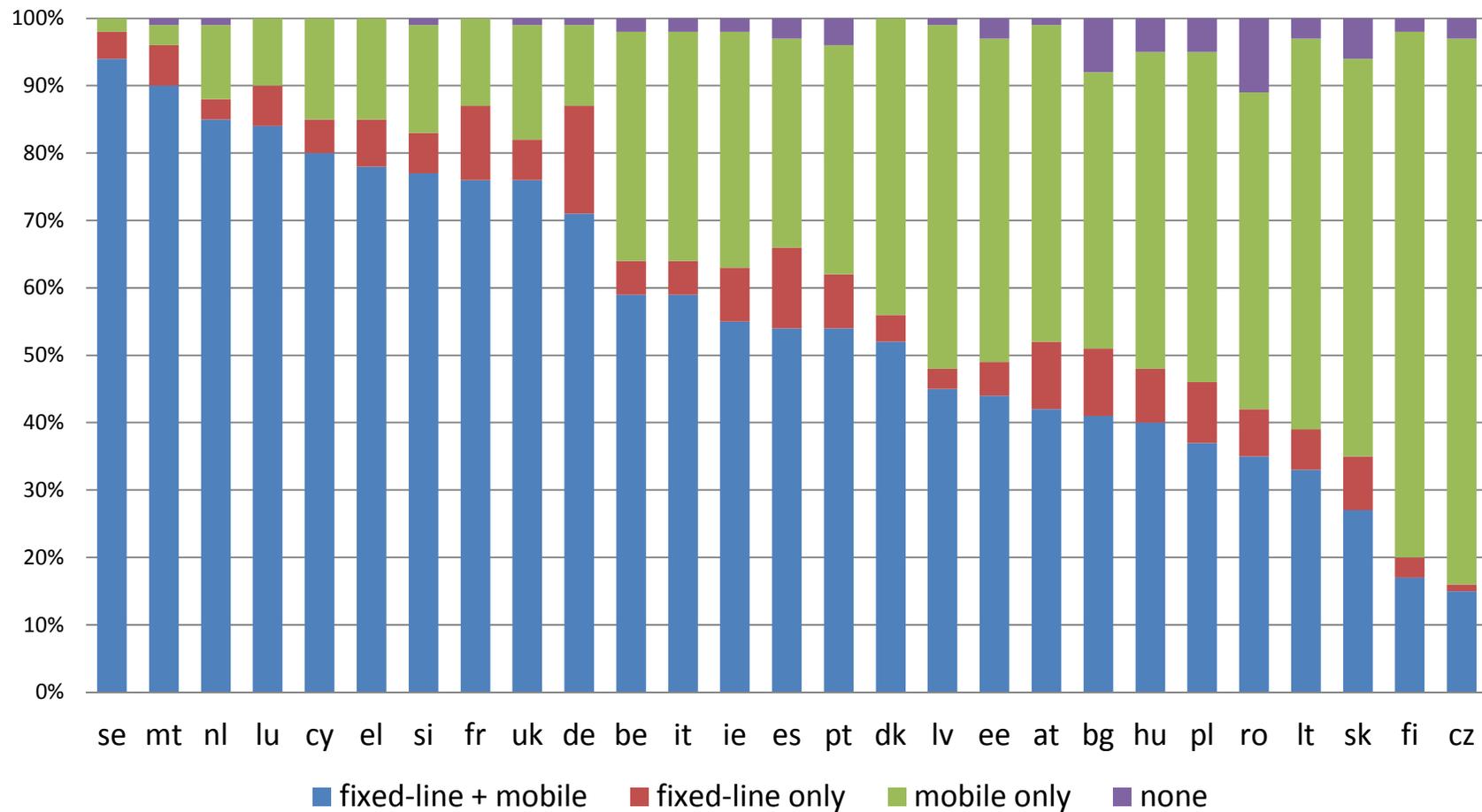
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Motivation

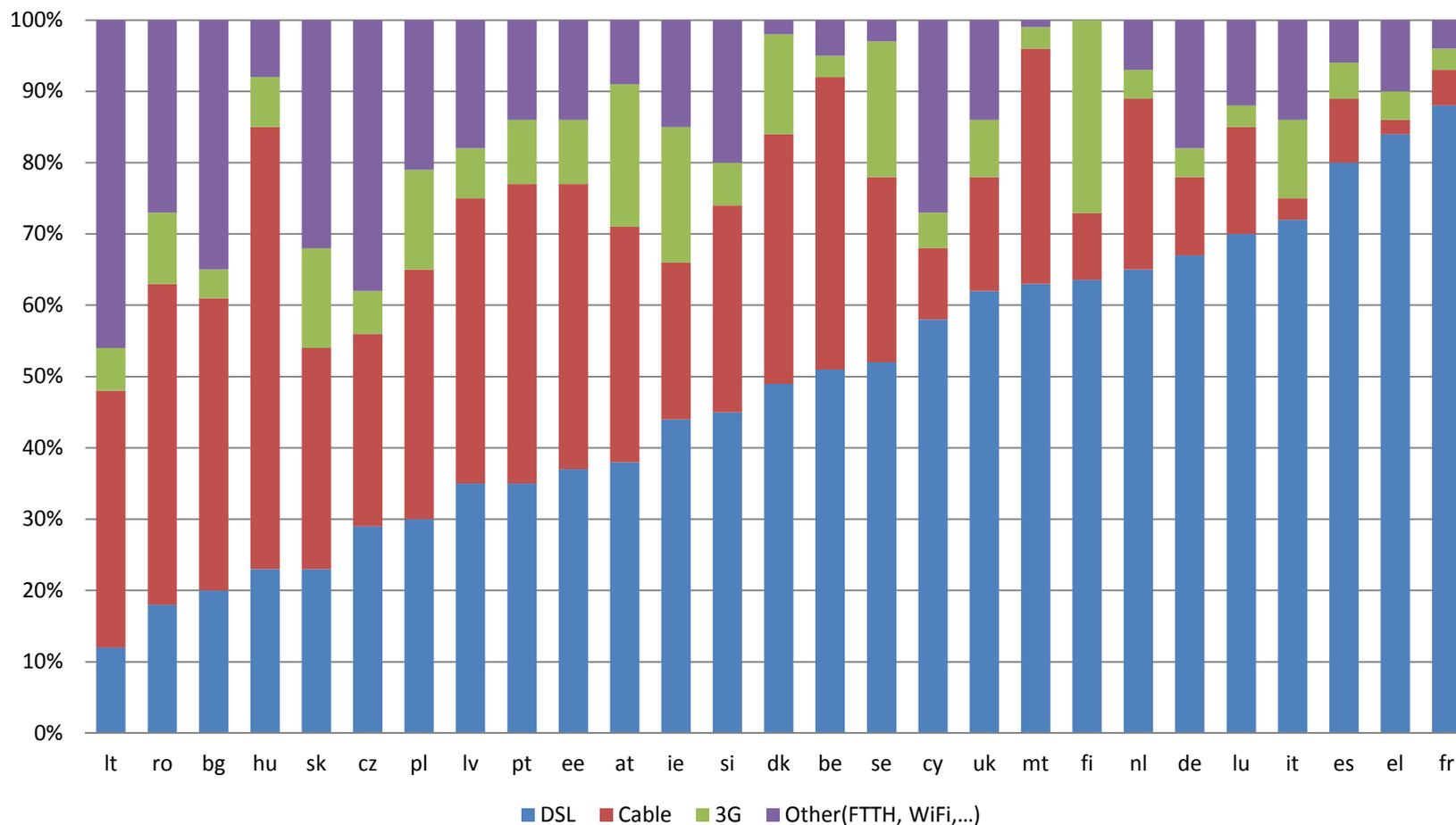
- Since the 1990s, the number of communications options increased: fixed-line, mobile, Internet.
- Ongoing fixed-to-mobile substitution (FMS):
 - Declining role of fixed-line in favour of mobile voice services
 - But this trend has slowed down with the growth of Internet (via dial-up and DSL) and the introduction of bundled offers
 - However, this may change again in the future with increasing usage of alternative broadband technologies to DSL access
- These developments must be taken into account by regulators and market players.

Access to voice services in the EU in 2011 by households



Source: Eurobarometer, 2011

Different broadband technologies used by households with Internet in the EU in 2011



Source: Eurobarometer, 2011

Motivating questions

- What is the extent and determinants of fixed to mobile substitution (F2M)?
- How did possible complementarities slow down F2M?
 - What is the impact of bundling on FMS?
 - How does the adoption of different broadband technologies influence FMS?
 - Do the fixed-line incumbents influence FMS?

Relevant literature

- Most studies on fixed-line and mobile voice find substitution
 - Aggregate country-level data: Gruber and Verboven (2001) for the EU, Ward and Zheng (2012) for China, etc.
 - Individual-level data: Rodini et al. (2003) for U.S., Ward and Woroch (2010) for U.S., Garcia-Marinoso and Suarez (2013) for Spain.
- Studies on fixed and mobile broadband access also find substitution
 - Individual-level data: Cardona et al. (2009) for Austria, Srinuan et al. (2012) for Sweden, Grzybowski et al (2013) for Slovakia.
- Two recent studies explicitly model the substitution or complementarity between fixed and mobile voice using Gentzkow's (2007) framework:
 - Liu et al. (2010): panel survey data of U.S. households to model broadband services
 - Macher et al. (2012): survey data of U.S. households to model fixed-line and mobile connections → substitutes

No studies combine voice and broadband adoption, and allow for differences across countries → adapt model of Gentzkow (2007).

Data sources

- We use five Special Eurobarometer surveys conducted:
 - In 27 EU countries
 - In approximately 12 months intervals between Dec 2005 and Dec 2012, with the exception of 2008
 - Among total of 160,363 households
- Data on incumbents' prices of mobile and fixed-line telecom services from "Telecoms Price Developments" produced annually for the EC by Teligen for years 2005-2011:
 - Prices are approximated by "composite baskets" calculated for different consumer profiles assuming certain number of calls per annum.
 - The number and distribution of calls are kept constant over time.
 - Mobile prices are for representative prepaid and post-paid tariffs of incumbent and main competitor
 - Fixed-line prices are for a representative tariff of incumbent only

Remark: no information used on broadband prices.

- The remaining data on GDP per capita in NUTS regions is collected from Eurostat.

Econometric model: base specification

- **Base model specification:** models the households' decisions whether to use fixed-line services ($j=F$) and/or mobile telephone services ($j=M$):

→ Choice set includes 4 bundles of these services:

$$r \in \{0, F, M, F+M\}$$

where $r=0$ is no telephone at all

- Households in the surveys with access to fixed-line and mobile:

		Fixed-line		
		No	Yes	Total
Mobile	No	5775	19,567	25,342
	Yes	46,471	88,550	135,021
	Total	52,246	108,117	160,363

Econometric model: base + incumbent

- **Base model + incumbent:** the base model is extended to distinguish between the type of operator providing the voice service: incumbent or competitor.
- The index j now refers to voice service and operator type: incumbent fixed-line ($j=F_1$), competitor fixed-line ($j=F_2$), incumbent mobile ($j=M_1$), competitor mobile ($j=M_2$).

→ Choice set includes 9 bundles:

$$r \in \{0, F_1, F_2, M_1, M_2, F_1+M_1, F_1+M_2, F_2+M_1, F_2+M_2\}.$$

- Information on the name of operator used by the household is only available for 2005 and 2006 → the analysis is limited to these two years.

Mobile/fixed-line	No fixed-line	Incumbent	Competitor	Total
No mobile	3,297	8,459	835	12,591
Incumbent	4,091	10,227	1,423	15,741
Competitor	8,993	12,995	3,086	25,074
Total	16,381	31,681	5,344	53,406

Econometric model: extended specification

- **Extended model specification:** models the households' simultaneous decision to adopt telephone services and internet

Up to 24 choices: $r \in \{0, F, M, F+M\}$ times 6 internet choices $k \in \{0,1,2,3,4,5\}$

where: $k=0$ is no internet, $k=1$ is dial-up; $k=2$ is DSL; $k=3$ is cable modem; $k=4$ mobile broadband; $k=5$ other broadband (usually fibre or WiFi)

- There are only few households with Internet access but no voice access (none) → restrict the choice set to the remaining 19 alternatives.

Simultaneous use of voice and broadband technologies

	DSL	Dial-up	Cable modem	Mobile	Other	None	Total
Mobile only	6,210	1,155	7,183	3,019	3,008	26,710	47,285
Fixed-line only	1,325	774	497	50	129	16,861	19,636
Mobile+ Fixed-line	33,470	12,253	11,447	2,259	2,656	29,133	91,218
None	79	26	88	15	29	5,544	5,781
Total	41,084	14,208	19,215	5,343	5,822	78,248	163,920

- There are few households multihoming broadband access which are dropped from the analysis (3,557 observations out of which 1,717 multihome with mobile).

Choice sets: geographic availability

- Fixed voice services may not always be available in rural areas, especially in the CEE countries.
 - We also estimated the models on a sub-sample of households living in large towns and cities where fixed-line connection should be in general available.
- Certain types of broadband internet technologies may not be available in certain geographic areas or even in whole countries.
 - In the extended model, we restrict the choice sets to those broadband technologies that are available in the region where the household lives.
- If there is a single household which chooses a particular broadband technology in a given area → we assume that it is available to all households in this area, and otherwise not available at all (the choice set is still potentially too broad).

Econometric model: utility from a voice connection

- Household i 's stand-alone utility from a connection to voice service j is:

$$\bar{u}_{ij} = \beta_j x_i + \alpha p_{ij}$$

where

- p_{ij} is the fixed subscription charge + usage cost of a representative consumer → varies by country, year, and type of contract (pre-paid versus post-paid)
- x_i is a vector of household characteristics:
 - demographics (such as sex, age, education, household size);
 - employment status (such as student, retired or employment sector);
 - regional and time information (country, regional GDP per capita, time effects).

Econometric model: base specification

- A household i has two possible choices of voice services: $j \in \{F, M\}$, with utility for a bundle of voice services $r \in \{0, F, M, F+M\}$:

$$u_{ir} = \varepsilon_{ir} \quad \text{if } r = 0$$

$$u_{ir} = \sum_{j \in r} \bar{u}_{ij} + \Gamma_{ir} + \varepsilon_{ir} \quad \text{if } r \neq 0$$

- The term Γ_{ir} is the difference between the household's total utility for a bundle r and the sum of the stand-alone utilities.
 - For the singleton bundles, $r=\{F, M\}$, we set $\Gamma_{ir}=0$.
 - For the real bundle $r=F+M$, the services are:
 - complements if $\Gamma_{ir} > 0$
 - independent if $\Gamma_{ir} = 0$
 - substitutes if $\Gamma_{ir} < 0$ \rightarrow may be expected
- The substitution/complementarity parameter is specified as: $\Gamma_{ir} = \gamma x_i$
 - Households may be heterogeneous in their valuation of the substitutability according to the same household characteristics (demographics, employment status and regional and time information).

Econometric model: extended specification

- Household's valuation of voice services $j \in \{F, M\}$ may depend on the use of specific internet technology k , which reflects substitution or complementarity between a particular voice service and internet technology: $\Delta_{ij,k}$

$$\begin{aligned}\bar{u}_{ir,k} &= \varepsilon_{ir,k} && \text{if } r = 0, k = 0 \\ \bar{u}_{ir,k} &= \sum_{j \in r} \bar{u}_{ij} + \Gamma_{ir} + \Delta_{ij,k} + \varepsilon_{ir,k} && \text{if } r \neq 0\end{aligned}$$

- We specify household's valuation of adding internet technology to voice services as: $\Delta_{ij,k} = \delta_{j,k} + x_i \delta_k$.
 - $\delta_{j,k}$ captures the valuations for combining the voice service $j \in \{F, M\}$ with the various internet technologies k (homogeneous across households):
 - Is it more likely to keep voice fixed-line when using DSL? Less likely when using mobile broadband?
 - $x_i \delta_k$ captures household heterogeneity for the valuation of having any internet connection $k > 0$ assuming that $\delta_k = \delta_1$ is the same for all internet connections.

Choice probabilities and estimation

- In the more general extended model given that the $\varepsilon_{ir,k}$ are type I extreme value distributed, random utility maximization results in the following logit choice probabilities:

$$s_{ir,k} = \frac{\exp(V_{ir,k})}{1 + \sum_k \sum_r \exp(V_{jr,k})}$$

- where $V_{ir,k} \equiv u_{ir,k} - \varepsilon_{ir,k}$ is the deterministic component of household i 's utility for voice bundle r and internet technology k .
- Define $y_{ir,k}=1$ if household i selects voice bundle r and internet technology k . The maximum likelihood estimator is the value of the parameter vector that maximizes

$$LL(\theta) = \sum_{i=1}^N \sum_{r,k} y_{ir,k} \log s_{ir,k}(\theta)$$

Empirical results: base specification

	Base model			Base model + incumbent		
	Mobile	Fixed-line	Mobile+Fixed γ	Mobile	Fixed-line	Mobile+Fixed γ
Price	-0.038*** (0.001)	-0.038*** (0.001)		-0.042*** (0.001)	-0.042*** (0.001)	
Intercept	-0.643*** (0.103)	2.910*** (0.104)	-0.654*** (0.114)	-1.426*** (0.148)	0.719*** (0.141)	-0.225 (0.166)
CEE dummy	0.164*** (0.027)	-0.620*** (0.034)	-0.411*** (0.038)	-0.168** (0.078)	-1.091*** (0.078)	0.236*** (0.088)
GDP per capita	1.303*** (0.027)	1.104*** (0.029)	-0.710*** (0.031)	0.954*** (0.051)	0.408*** (0.050)	-0.134** (0.057)
Bundle Mobile+Fixed			2.144*** (0.048)			1.437*** (0.072)
Incumbent effect				-0.516*** (0.017)	1.334*** (0.016)	0.397*** (0.021)
Year dummy: 2007	0.051 (0.047)	-0.408*** (0.047)	0.075 (0.051)	0.104** (0.043)	-0.274*** (0.043)	-0.005 (0.048)
Year dummy: 2008	0.215*** (0.048)	-0.590*** (0.049)	0.160*** (0.053)			
Year dummy: 2009	1.041*** (0.054)	-0.168*** (0.055)	-0.373*** (0.058)			
Year dummy: 2011	1.252*** (0.056)	-0.350*** (0.058)	-0.234*** (0.062)			
Year dummy: 2012	1.274*** (0.055)	-0.380*** (0.058)	-0.282*** (0.061)			
Observations	640,948			405,902		
Number of households	160,363			53,199		

- Base model: choices of voice connections. The regression includes household characteristics.
- Base model + incumbent: choices of voice connections from incumbent vs. competitor. The regression includes household characteristics.

Empirical results: base specification

- Price: negative and highly significant effect on utility in both specifications.
- Regional characteristics:
 - Households in richer regions are more likely to have mobile and fixed-line.
 - Households from the CEE countries are more likely to have mobile, but less likely to have fixed-line (after controlling for regional income and other household characteristics).
- Substitution or complementarity between fixed and mobile
 - Households on average view fixed-line and mobile voice as substitutes.
 - Stronger substitution in the CEE countries and in countries with a high regional income per capita → the latter may be due to the lower quality of the fixed network than in the WE countries.
 - Bundling fixed-line and mobile results in contractual complementarities → reduces substitution.
 - There is substantial consumer heterogeneity in the extent of substitution.
 - The degree of substitution changes over time (weaker in years 2006-2008).

Empirical results: base + incumbent

- Households have a considerably higher valuation for a fixed-line connection at the incumbent fixed-line operator.
 - The incumbent operator is the dominant provider of fixed-line services.
- Households tend to have a lower valuation for a mobile connection that is offered by the incumbent.
 - Most EU countries promoted competition in the mobile telephony market through the policy of granting licenses to non-incumbent operators.
- Two sources of **complementarity** between fixed-line and mobile:
 - Contractual from having a single contract for fixed and mobile from the same operator (as before)
 - Incumbent effect → it is more likely to get both mobile and fixed-line from the incumbent (fixed-line operators can leverage their dominant position in the fixed telephony market into the mobile telephony market).

Empirical results: extended specification

	Mobile	Fixed-line	Mobile+Fixed γ	Broadband	Broadband+Mobile	Broadband+Fixed
Price	-0.039*** (0.001)	-0.039*** (0.001)				
Intercept	-0.695*** (0.104)	3.069*** (0.105)	-0.437*** (0.115)			
CEE dummy	0.137*** (0.028)	-0.637*** (0.034)	-0.403*** (0.039)			
GDP per capita	1.205*** (0.027)	0.961*** (0.030)	-0.809*** (0.032)	0.823*** (0.010)		
Dial-up connection				-7.946*** (0.078)	1.025*** (0.041)	2.471*** (0.035)
DSL connection				-6.709*** (0.068)	1.509*** (0.032)	1.789*** (0.019)
Cable connection				-6.450*** (0.078)	1.412*** (0.049)	0.552*** (0.020)
Mobile broadband				-7.835*** (0.196)	1.786*** (0.186)	-0.833*** (0.040)
Other broadband				-7.681*** (0.129)	1.343*** (0.113)	0.042 (0.035)
Bundle Mobile + Fixed			1.645*** (0.059)		0.543*** (0.102)	3.564*** (0.051)
Observations	2,982,316					
Households	160,363					

Empirical results: extended specification

- Mobile voice:
 - All five broadband technologies are complementary
 - Complementarity is strongest for the mobile broadband technology.
- Fixed-line:
 - DSL and dial-up show a strong complementarity.
 - Cable and other broadband show only very weak or no complementarity, whereas mobile broadband is a strong substitute.
- As in the base model, a contract that bundles fixed and mobile voice generates complementarities (in the form of price discounts or convenience).
- There is even stronger complementarity from contracts that bundle fixed voice with broadband internet (dialup or DSL).
- Significant interactions of household characteristics with Internet access dummy → heterogeneity in Internet adoption.

Counterfactuals and conclusions

- Significant **substitution** from fixed to mobile telephony
 - 2007: mobile telephony reduced fixed-line penetration by **6%** points to 67%
 - 2012: mobile telephony reduced fixed-line penetration by **14%** points to 63%
- The degree of substitution differs across countries with stronger substitution in:
 - regions with a high income per capita
 - in the CEE countries
- The decline in fixed-line slowed down because of various **complementarities**:
 - Fixed-line and mobile bundles raised fixed-line penetration by **1.3%** points in 2012.
 - Internet raised fixed-line penetration by **9.9%** points (mainly due to DSL) in 2012.
 - Incumbency advantages raised both fixed-line and mobile penetration by **1.8%** and **1%** points in 2007, and raised the incumbent's share in fixed-line and mobile by 2.5% and 4.8% points in 2007.
- The fixed-line incumbents were able to maintain higher fixed-line penetration and leverage their position to mobile voice services and broadband.