Income, affordable and threshold effects on FMS in the developed and developing economies

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ABSTRACT

This paper studies the effects on fixed to mobile substitution (FMS) that has evolved into an essential industry trend. Based on data from 1997 through 2005, three kinds of effects, income, affordable and threshold, are derived from various FMS patterns in developed and developing economies. The income effect is the prerequisite for the two other effects. For the G7 and new industry economies (NIE) (Taiwan, Singapore, H.K and S. Korea), the 5% income effect threshold is crossed and the mobile penetration rate climbs up rapidly. However, for Association of Southeast Asian Nations (ASEAN) and Brazil, Russia, India and China (BRIC),[1] most of these developing economies have experienced only the income effect. When mobile average revenue per user (ARPU) comes close to or drops lower than fixed line ARPU, the mobile penetration rate begins to increase and the affordable effect appears. As the mobile penetration rate begins to grow, it does not at first affect fixed line growth. The threshold effect happens only when the mobile penetration rate crosses a critical mass threshold; then the growth of fixed line penetration will decline or stop. Once mobile substitution occurs, the traditional paradigm of fixed line as the universal service obligation (USO) is no longer valid and the rules must be changed.

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1. Introduction

This article studies the consistent effects of fixed to mobile substitution (FMS) to discover the differences in FMS patterns among countries at different levels of economic development and to attempt to derive some basic rules for the evolution of the industry and markets. FMS occurs in two ways: one is from the shift of traffic from fixed line to mobile; the other is from the growth of mobile subscriptions. These are called traffic substitution and penetration substitution, respectively. Once penetration substitution occurs, the traditional paradigm of fixed line as the universal service obligation (USO) is no longer valid, and the role of mobile communication must be redefined. In this study the rate of fixed penetration is based on households, which reveals a better description than that based on population. It compares global

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[1] ASEAN was established on 8 August 1967 in Bangkok by the five original member Countries, namely, Indonesia, Malaysia, Philippines, Singapore and Thailand. Thereafter, Brunei Darussalam, Vietnam, Lao PDR, Myanmar and Cambodia continued to join. BRIC or BRICs are terms for four brick countries used to refer to the combination of Brazil, Russia, India and China.
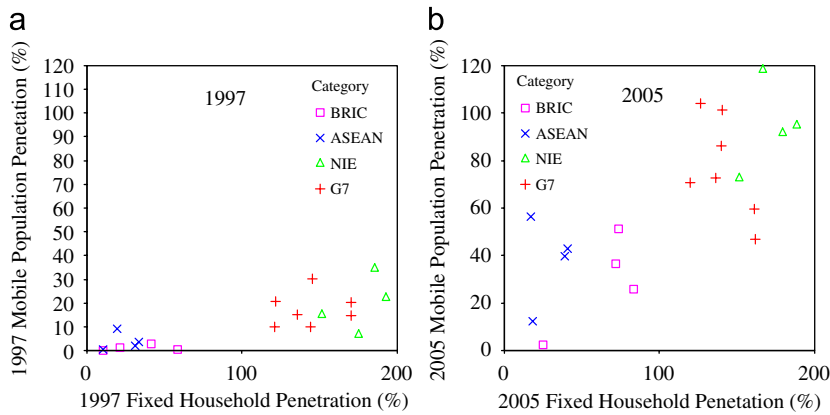
Fig. 1. (a) 1997 penetration distribution, (b) 2005 penetration distribution.

relative fixed penetration through 9 years and distinguishes the three continuous effects of penetration substitution on FMS patterns. The results show that 'income effect' occurs mainly in Association of Southeast Asian Nations (ASEAN) and Brazil, Russia, India and China (BRIC) that have fixed line household penetration lower than 100%, and 'affordable effect' and 'threshold effect' occur as a consequence of the income effect.

The objects under study in this article are the four groups of regions/countries, namely, G7 and new industry economies (NIE) representing the developed economies, and ASEAN and BRIC representing the developing economies. Because of its relative lower per capita income Russia has been removed from G8 and reclassified with the BRIC group. Thailand, Malaysia, the Philippines and Indonesia have been selected as examples from among the 10 ASEAN countries, while Singapore has been placed in the NIE group because of its similarities to that group in economic development. The spread of fixed and mobile penetration in the four groups reveals significant differences among them during the period 1997–2005. The growth and decline of fixed household penetration and mobile population penetration among the four groups is shown in Fig. 1a and b where the horizontal axis, based on households, represents fixed penetration, and the vertical axis, based on population, represents mobile penetration. The trends are clear; mobile penetration universally increased.

The following studies have examined from diverse viewpoints how mobile penetration, having spread widely over a short period, has affected fixed line service. Gruber, (2001) studied the effect of competition and innovation on the diffusion of mobile communication in the countries of Middle and Eastern Europe. Rodini, Ward, and Woroch, (2003) investigated fixed line and mobile substitution. He did a market research of American households covering the years 2000–2001 and used cross-price elasticity to prove that mobile and second fixed lines substitute for each other. He indicates that the degree to which mobile substitutes for fixed line has significant implications for the policy of fixed line unbundling, the policy of fixed line and mobile vertical separation and USO. Gary, Grant, and Brain, (2004), basing his study on data from 56 countries worldwide during the period 1995–2000, uses a dynamic demand model to verify the significant substitution effect of mobile phones substituting for fixed telephony, and he proposes that the reduction of fixed service prices can slow the growth of mobile networks. Banerjee and Ros (2004) indicate that, according to International Telecommunication Union (ITU) data, the number of global mobile subscribers (1.15 billion) surpassed the number of fixed subscribers (1.13 billion) in 2002. Using cluster analysis he divided 61 countries into four clusters to show that the expanded model for technology substitution and economic substitution demonstrates that regional connections and economic development will influence the substitution of mobile for fixed telephony. Watanabe, Konda, Ouchi, and Wei, (2004) indicate that successive innovation and diffusion of technology will bring about complementarities and substitution between the new technology and the existing technology, and they also propose that the trend from fixed line to mobile phone to mobile internet is the industry macro-evolutionary trend of the telecommunication ecosystem through competition and cooperation. Hodge (2005) examined the difference in tariff structures between fixed line and mobile in South Africa, and found that the balance between fixed monthly and usage fees makes mobile both more affordable and cheaper than fixed line for the bottom 50–60% of households that spend relatively little on communication. Vagliasindi, Guney, and Taubman, (2006) explored the competition between traditional fixed line and mobile services across Eastern Europe and the former Soviet Union. Mao, Tsai, and Chen, (2007) studied the issue of FMS patterns of traffic substitution and penetration substitution. They indicate that during 1997–2004, for those countries such as G7 and NIE with fixed line penetration higher than 100%, the FMS is mostly traffic substitution; and for those countries with fixed-line penetration lower than 100% such as ASEAN and BRIC, the FMS is mostly penetration substitution. They also found income effect FMS differences for the developing countries; when disposable income is very limited then telecom penetration will be low. Overall, G7 in 1999 and NIE in 2000 crossed the 5% income effect threshold, and mobile penetration increased rapidly. As for ASEAN and BRIC, the developing economies, except for fixed lines in Russia (1997–2003), all experienced the income effect, but not the affordable and threshold effects, and therefore have little higher telecom penetration.

This paper adds the 1-year data of 2005 to follow the research of Mao et al. (2007) to further explore the income effect, and to see more clearly the consistent impact of affordable effect and threshold effect. Four groups of countries, G7, NIE, ASEAN and BRIC, have been chosen for studying the implications of the growth and decline of the following indicators which are penetration, revenue, average revenue per user (ARPU) of the fixed line and mobile services and per capita income, and further to analyze the relationship between per capita income and these indicators. The structure of this paper is as follows. Section 2 defines the data and hypotheses, and three hypotheses are proposed. Section 3 tests the income effect and further analyses the related data during 1997–2004. Section 4 verifies the two hypotheses of affordable effect and threshold effect. Section 5 presents the conclusions.

2. Data, measures and hypotheses

2.1. Data

The study period for this paper covers the years 1997–2005. The related data have been retrieved from telecom regulators as published on their websites (Appendix A), from the telcos' annual reports and from ITU Telecommunication Indicators 2006, which was published in January 15, 2007 by ITU. The penetration and subscriber data for fixed and mobile cover the years 1997–2005, while the complete revenue and ARPU data for the four groups of countries are at present available only for the period 1997–2004. The per capita GDP from 1997 to 2005 are found in Appendix B. The related data for fixed line and mobile subscribers are in Appendices C and D.

2.2. Measures

To study FMS it is necessary to measure the penetration level of fixed line and mobile services. This study adopts total population, or per capita use, as a basis for measuring the mobile penetration in each country, and the penetration of mobile services into the total population is here called mobile penetration. To measure fixed line penetration households are used as the basis for measuring, and the percentage, or penetration rate, of fixed line service reflects how many fixed lines a household have. This is called fixed line penetration. The number may be higher than the actual number of fixed lines in each household because the fixed lines include a small percentage of business customers.

The fixed line and mobile penetration trends for the USA and the Philippines are illustrated in Fig. 2a and b. Their similarities are the fast rise of mobile penetration. On the other hand, fixed line penetration growth in both countries appears to stagnate and even decline. The main difference between them, however, the level at which fixed line penetration does an accelerated change appear. In the USA it is at more than 150%, almost one and a half lines per household, and it shows some decline beginning in 2001. While in the Philippines fixed line penetration is only at 45.2%, and even at this low level of penetration shows some decline beginning in 2000. For details see Fig. 2a and b.

Based on the evolution of mobile penetration substituting fixed line penetration, it is foreseeable that the greater 100% level of fixed line penetration achieved in the developed countries cannot be reached by the developing countries. Mao et al. (2007) indicate that mobile penetration allows most families to no longer have to depend on fixed lines for communication, and therefore traditional telephone use stays at the current low penetration level or even experiences further decline. That is, they no longer apply for new lines, or they cancel their fixed line service. Because mobile penetration grows rapidly, fixed line penetration does not change to a higher level. Therefore, in this study it is pertinent to explore the relevant relationships between income level, telecom expenditure and telecom penetration, and how these relationships influence the growth and decline of fixed line and mobile penetration.
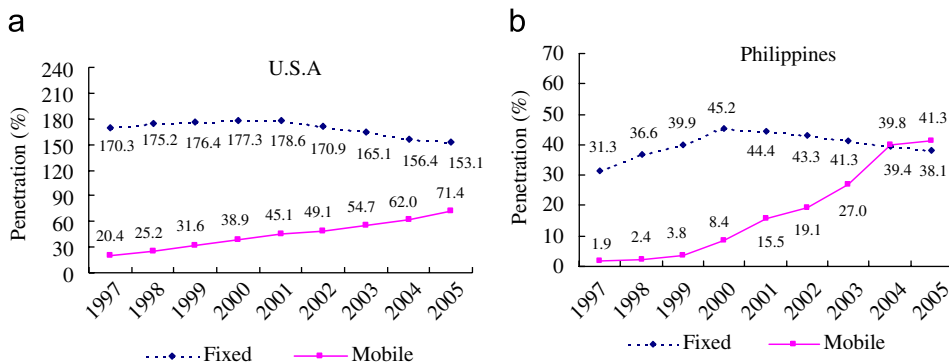

Fig. 2. (a) USA fixed line and mobile penetration growth trend (%). (b) The Philippines fixed line and mobile penetration growth trend (%).

2.3. Hypotheses to be verified

In order to establish a basis for cross-country comparison and analysis, this study further converts the absolute value of each country's fixed line and mobile revenue into ARPU. Fixed line ARPU is calculated by dividing the total annual revenue by total number of fixed lines, and mobile ARPU is calculated by dividing the total annual revenue by total number of mobile users. Because the four groups of countries or regions studied in this paper have great inter-group differences as well as intra-group differences in the level of economic development, the following hypotheses, which are subject to testing, are proposed.

Hypothesis 1. There exists an 'income effect' in telecom penetration, i.e., When the ratio of fixed line and mobile expenditure (combined or separate) to annual personal income (abbreviated as the A/I ratio) is high, then fixed line or mobile penetration is not easily increased.

The function of communication satisfies a basic need in people's daily life, but if the cost of this basic need takes a higher percentage of the users' disposable income so as to reduce the satisfaction of other basic needs such as food, clothing or housing, then this telecommunication need will not necessarily have a high priority among users. Therefore, when the ratio of the expense of fixed line or mobile communication to annual income (this can be measured by ARPU) is too high, then neither fixed line nor mobile penetration can increase easily.

In addition, mobile service when first available was priced relatively much higher compared to fixed line service, especially for those countries with lower per capita income, and this unavoidably became an obstacle to the growth of telecommunication penetration. A reasonable assumption is that for mobile communication to have penetration substitution the cost of mobile communication must be lower than fixed line service. Unless mobile service becomes more affordable it is difficult to anticipate the obvious effect of penetration substitution. Therefore, Hypothesis 2 is proposed and will be tested.

Hypothesis 2. There exists an 'affordable effect' in those countries that have an 'income effect', i.e., only when mobile ARPU is close to or lower than fixed line ARPU will mobile penetration grow rapidly and exhibit the penetration substitution effect.

According to the above Hypothesis 2, a further inference may be made: even if the affordable effect of mobile communication is beginning to appear but penetration of mobile communication itself has not reached a certain threshold, then fixed line penetration still has growth opportunities. But when mobile penetration crosses a certain threshold value then the growth of fixed line penetration will decline or even stop. Therefore, Hypothesis 3 is proposed and will be tested.

Hypothesis 3. For countries that display the affordable effect there is an additional threshold effect, i.e., when mobile penetration reaches a certain critical mass its substitution effect will cause the growth of fixed line penetration to decline or stop.

3. Income effect

The relative data from the four groups of countries will be used to analyze and verify the above three hypotheses. Because the revenue data for fixed line and mobile services are only available through the end of 2004, therefore, the ARPU to per capita GDP is calculated for the same period. During the above case analysis of ASEAN and BRIC it was mentioned that there are income, affordable and threshold effects that must be studied in order to fully explain the FMS substitution relationship of penetration and traffic volume. The explanation and illustration of these effects and their influence on FMS are given below.

3.1. Definition of income effect

In economics the concept of disposable income means that for each household the portion of their disposable income that they spend on food, housing, clothing and transportation, the basic needs will normally be adjusted according to the urgency of need and the actual cost. When income level is low and disposable income is limited and there is difficulty in meeting even the basic needs of food, housing, etc., then for the relatively higher cost and lower urgency of telecommunication, the demand for it will be delayed or given up. In other words, when communication expense occupies a high proportion of disposable income then only higher income people will use this modern communication tool. In this circumstance telecommunication penetration will be difficult to expand. Only when the ratio of communication expense to disposable income is lower than a certain threshold will telecommunication service be widely used. This paper uses fixed line and mobile expenditure (excluding data) as a measurement of each individual's annual fixed line or mobile expenditure (ARPU), then finds the ratio of this to annual per capita income (an individual's GDP) as the A/I ratio (%) and uses these indicators to analyze the relationship among income level, telecom expenditure and telecom penetration. The effect that only when the A/I ratio (%) is lower than a certain level will telecom penetration start to increase considerably is called the 'income effect'.

3.2. Income effect in the developed economies

In G7 and NIE countries each household already had more than one fixed line before 1997; therefore, fixed line for these two groups of countries there was no such thing as an income effect, and mobile markets began to be developed after 1997. For example in G7, the A/I ratio (combined fixed line and mobile expenditure per user to per capita income) dropped from 5.8% in 1997 to 4.6% in 1999 and 3.6% in 2004. For NIE this ratio dropped from 8.6% in 1997 to 4.8% in 2000 and to 4.0% in 2004. Overall, in both G7 and NIE countries, beginning in 1999 and 2000, respectively, the A/I ratio dropped below 5%. Mobile penetration turned around and increased considerably. By 2004 the average mobile penetration in both groups of countries reached 77.3% for G7 and 96.9% for NIE, respectively. Based on these data it can therefore be deduced that for G7 and NIE 5% is the upper threshold for the income effect. In other words, when the A/I ratio is lower than 5% mobile service penetration will rapidly develop significant growth. For details see Tables 1 and 2.

Table 1
G7 penetration vs. A/I ratio (ARPU/per capita income, %)

G7	Service	ARPU/GDP/year	1997	1998	1999	2000	2001	2002	2003	2004	2005
France	Fixed	Penetration (%)	143.8	144.0	141.4	140.5	138.7	138.5	136.7	135.0	133.8
		ARPU/GDP (%)	2.1	1.9	1.9	1.8	1.7	1.6	1.6	1.4	–
	Mobile	Penetration (%)	10.0	19.2	35.5	48.9	58.4	61.6	66.5	73.7	79.5
		ARPU/GDP (%)	2.6	1.6	1.1	1.1	1.1	1.2	1.2	1.2	–
		Total ARPU/ GDP	4.7	3.5	3.0	2.9	2.8	2.8	2.8	2.6	–
UK	Fixed	Penetration (%)	135.7	137.4	141.3	144.6	146.1	140.9	138.7	135.2	126.7
		ARPU/GDP (%)	2.9	2.6	2.5	2.2	2.0	1.9	2.0	1.9	–
	Mobile	Penetration (%)	15.0	25.1	45.7	72.7	77.2	83.6	90.8	102.2	109.8
		ARPU/GDP (%)	2.7	1.8	1.3	0.9	1.0	1.1	1.2	1.4	–
		Total ARPU/GDP	5.6	4.4	3.8	3.1	3.0	3.0	3.2	3.3	–
Germany	Fixed	Penetration (%)	120.7	124.0	127.6	131.7	136.4	138.9	139.3	139.5	139.8
		ARPU/GDP (%)	2.2	2.1	1.9	1.7	1.6	1.6	1.7	1.7	–
	Mobile	Penetration (%)	10.	17.0	28.5	58.6	68.1	71.6	78.5	86.4	95.8
		ARPU/GDP (%)	4.7	2.9	2.3	1.8	1.6	1.6	1.5	1.2	–
		Total ARPU/ GDP	6.9	5.0	4.2	3.5	3.2	3.2	3.2	2.9	–
Canada	Fixed	Penetration (%)	170.2	173.6	178.1	182.6	177.6	171.5	169.4	166.1	166.3
		ARPU/GDP (%)	2.2	2.3	2.1	2.1	2.0	2.0	1.7	1.7	–
	Mobile	Penetration (%)	14.7	18.3	22.7	28.4	34.3	38.0	42.3	46.7	52.5
		ARPU/GDP (%)	2.6	2.7	2.2	2.0	1.8	1.9	1.9	1.9	–
		Total ARPU/GDP	4.8	5.0	4.3	4.1	3.8	3.9	3.6	3.6	–
Italy	Fixed	Penetration (%)	121.3	122.6	125.1	128.9	127.3	126.2	122.0	119.0	109.9
		ARPU/GDP (%)	3.3	3.9	3.6	3.1	3.0	2.7	2.6	2.3	–
	Mobile	Penetration (%)	20.5	35.7	52.4	74.2	88.8	91.6	96.6	98.6	103.3
		ARPU/GDP (%)	2.8	2.1	1.5	1.3	1.3	1.3	1.3	1.2	–
		Total ARPU/GDP	6.1	6.0	5.1	4.4	4.3	4.0	3.9	3.5	–
USA	Fixed	Penetration (%)	170.3	175.2	176.4	177.3	178.6	170.9	165.1	156.4	153.1
		ARPU/GDP (%)	3.8	3.7	3.6	3.5	3.3	3.1	2.9	2.8	–
	Mobile	Penetration (%)	20.4	25.2	31.6	38.9	45.1	49.1	54.7	62.0	71.4
		ARPU/GDP (%)	2.0	1.7	1.7	1.6	1.6	1.6	1.5	1.4	–
		Total ARPU/ GDP	5.8	5.4	5.3	5.1	4.9	4.7	4.4	4.4	–
Japan	Fixed	Penetration (%)	145.3	147.2	151.9	131.7	127.7	126.3	125.8	123.7	121.9
		ARPU/GDP (%)	3.1	3.0	3.0	2.6	2.5	2.3	2.0	1.6	–
	Mobile	Penetration (%)	30.3	37.4	44.9	50.3	57.2	62.1	66.9	71.6	75.3
		ARPU/GDP (%)	3.9	3.6	3.6	3.5	3.4	3.4	3.1	3.0	–
		Total ARPU/GDP	7.0	6.6	6.6	6.1	5.9	5.7	5.1	4.6	–
Average	Fixed	Penetration (%)	143.9	146.3	148.8	148.2	147.5	144.7	142.4	139.3	135.9
		ARPU/GDP (%)	2.8	2.8	2.7	2.4	2.3	2.2	2.1	1.9	–
	Mobile	Penetration (%)	17.3	25.4	37.3	53.1	61.3	65.4	70.9	77.3	83.9
		ARPU/GDP (%)	3.0	2.3	2.0	1.7	1.7	1.7	1.7	1.6	–
		Total ARPU/ GDP	5.8	5.1	4.6	4.2	4.0	3.9	3.7	3.6	–

Source: statistics data from ITU published in January 2007.

Table 2
NIE penetration vs. A/I ratio (ARPU/per capita income, %)

NIE	Service	ARPU/GDP/year	1997	1998	1999	2000	2001	2002	2003	2004	2005
Taiwan	Fixed	Penetration (%)	175.1	180.5	184.4	189.2	189.0	189.2	189.5	188.7	186.5
		ARPU/GDP (%)	3.1	3.1	2.4	2.3	2.1	1.6	1.5	1.4	–
	Mobile	Penetration (%)	6.9	21.6	52.2	80.2	96.6	106.1	111.0	100.3	97.4
		ARPU/GDP (%)	6.8	5.6	2.3	2.0	1.9	1.8	1.8	2.0	–
		Total ARPU/ GDP	9.9	8.7	4.7	4.3	4.0	3.4	3.3	3.4	–
Singapore	Fixed	Penetration (%)	192.6	196.5	198.0	200.8	198.0	193.2	186.0	180.8	175.8
		ARPU/GDP (%)	4.1	3.8	3.4	2.3	2.3	2.3	2.2	3.0	–
	Mobile	Penetration (%)	22.4	27.9	40.9	68.4	72.4	79.6	85.5	95.5	100.8
		ARPU/GDP (%)	3.5	3.4	2.2	1.4	1.6	1.7	1.6	1.3	–
		Total ARPU/ GDP	7.6	7.2	5.6	3.7	3.9	4.0	3.8	4.3	–
H.K.	Fixed	Penetration (%)	185.7	188.0	190.5	191.6	189.1	178.0	171.3	166.1	166.9
		ARPU/GDP (%)	3.2	3.8	3.4	2.3	2.3	2.3	2.2	2.3	–
	Mobile	Penetration (%)	34.4	48.5	64.4	78.0	84.4	91.2	105.6	118.8	123.5
		ARPU/GDP (%)	4.4	3.0	2.4	2.3	1.6	1.8	1.2	1.0	–
		Total ARPU/ GDP	7.6	6.8	5.8	4.6	3.9	4.1	3.4	3.3	–
S. Korea	Fixed	Penetration (%)	151.4	146.0	146.2	153.2	155.7	156.6	152.7	151.7	150.5
		ARPU/GDP (%)	2.5	2.4	3.6	3.1	2.8	2.4	2.2	1.8	–
	Mobile	Penetration (%)	15.2	30.9	50.3	57.0	61.4	67.9	70.1	72.9	79.4
		ARPU/GDP (%)	6.6	4.4	3.4	3.5	3.6	3.3	3.2	3.0	–
		Total ARPU/ GDP	9.1	6.8	7.0	6.6	6.4	5.7	5.4	4.8	–
Average	Fixed	Penetration (%)	176.2	177.8	179.8	183.7	182.9	179.2	174.9	171.8	169.9
		ARPU/GDP (%)	3.2	3.3	3.2	2.5	2.4	2.2	2.0	2.1	–
	Mobile	Penetration (%)	19.7	32.2	52.0	70.9	78.7	86.2	93.0	96.9	100.3
		ARPU/GDP (%)	5.3	4.1	2.6	2.3	2.2	2.2	2.0	1.8	–
		Total ARPU/ GDP	8.6	7.4	5.8	4.8	4.6	4.3	4.0	4.0	–

Source: statistics data from ITU published in January 2007 (ITU World Telecommunication Indicator, 2006).

3.2.1. Income effect in G7

In terms of the G7 countries, France in 1997 was the first to cross that income effect threshold point, and then mobile penetration began to take off. This was followed by the UK in 1998, Germany and Canada in 1999, Italy in 2000, the USA in 2001, and, finally, Japan in 2004. In 2004 the total A/I ratio of Japan was 4.6% which was lower than the upper threshold (5%), and mobile penetration increased to 75.3%. One special thing worth noting is that Japan's mobile A/I ratio at the level of 3.0% was higher than all other G7 countries in 2004; the mobile penetration rate in Japan was lower than the other G7 countries except for the USA and Canada. For details see Table 1.

3.2.2. Income effect in NIE

For the NIE countries, Taiwan in 1999 was the first to cross that threshold point for the income effect and then had the highest mobile penetration in the world during the period of 2000–2003.[2] The income effect threshold was crossed by Singapore and Hong Kong in 2000, and by S. Korea in 2004. In 2003 the total A/I ratio for S. Korea was 5.4%, still slightly higher than the upper threshold (5%). Hence, S. Korea had the lowest mobile penetration of the NIE countries even though the total A/I ratio had decreased to 4.8% in 2004. One special thing worth noting about Hong Kong is that the mobile A/I ratio is very low at the level of 1.0 so that Hong Kong had the worldwide highest mobile penetration of 118.8% in 2004 and 123.5% in 2005. For details see Table 2.

3.3. Income effect in the developing economies

The aforementioned criteria adopted for G7 and NIE are used to examine the relationship of income level, telecom expenditure and telecom penetrations among the ASEAN and BRIC countries. In 1997 for ASEAN and BRIC only a few households had fixed line services, and mobile communication was even more limited. This situation caused users to make a choice between the two rather than subscribe to both. Therefore, either fixed line ARPU or mobile ARPU can be applied for comparison with per capita income as the reference point for the growth of penetration. Thus the A/I ratio for these countries is either fixed line expenditure to per capita income or mobile expenditure to per capita income. Then this ratio is

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[2] Taiwan's mobile penetration rate has declined since 2004 because mobile operators were required to cancel invalid pre-subscribed accounts by the regulator-DGT (NCC, National Communications Committee).

Table 3
ASEAN penetration vs. A/I ratio (ARPU/per capita income, %)

ASEAN	Service	ARPU/GDP/year	1997	1998	1999	2000	2001	2002	2003	2004	2005
Malaysia	Fixed	Penetration (%)	97.5	99.6	93.4	94.2	93.7	87.6	83.9	80.0	78.2
		ARPU/GDP (%)	10.7	10.9	9.5	8.9	9.6	9.4	12.3	13.4	–
	Mobile	Penetration (%)	9.2	9.7	12.0	21.8	30.8	36.9	43.9	57.1	74.1
		ARPU/GDP (%)	13.6	13.9	12.0	8.3	7.8	7.0	5.5	5.0	–
		Total ARPU/GDP	24.3	24.8	21.5	17.2	17.4	16.4	17.8	18.4	–
Thailand	Fixed	Penetration (%)	33.5	35.0	33.4	35.7	38.5	41.3	39.6	37.0	37.2
		ARPU/GDP (%)	16.4	16.1	18.6	17.4	15.9	12.5	11.3	8.7	–
	Mobile	Penetration (%)	3.4	3.7	3.8	4.9	12.1	25.7	36.2	42.8	45.0
		ARPU/GDP (%)	17.4	17.2	16.8	17.0	10.0	6.4	6.1	4.8	–
		Total ARPU/GDP	33.8	33.3	35.4	34.4	25.9	18.9	17.4	13.5	–
Philippines	Fixed	Penetration (%)	31.3	36.6	39.9	45.2	44.4	43.3	41.3	39.4	38.1
		ARPU/GDP (%)	23.4	21.6	17.2	13.6	12.6	11.3	11.2	10.0	–
	Mobile	Penetration (%)	1.9	2.4	3.9	8.5	15.6	19.4	27.8	39.8	41.3
		ARPU/GDP (%)	26.0	23.4	16.6	11.3	9.8	9.0	8.1	6.0	–
		Total ARPU/GDP	49.4	45.0	33.8	24.9	22.4	20.3	19.3	16.0	–
Indonesia	Fixed	Penetration (%)	10.3	11.3	11.9	12.8	13.6	14.4	15.6	18.1	22.8
		ARPU/GDP (%)	39.5	27.5	25.9	23.6	21.0	17.0	15.1	13.6	–
	Mobile	Penetration (%)	0.5	0.5	1.1	1.7	2.9	5.0	7.5	13.5	21.1
		ARPU/GDP (%)	30.1	44.2	35.0	30.1	17.3	14.2	12.8	7.8	–
		Total ARPU/GDP	69.6	71.7	60.9	53.7	38.3	31.2	27.9	21.4	–
Average	Fixed	Penetration (%)	43.2	45.6	44.7	47.0	47.5	46.6	45.1	43.6	44.1
		ARPU/GDP (%)	22.5	19.0	17.8	15.9	14.8	12.6	12.5	11.4	–
	Mobile	Penetration (%)	3.8	4.1	5.2	9.2	15.4	21.8	28.9	38.3	45.4
		ARPU/GDP (%)	21.8	24.7	20.1	16.7	11.2	9.2	8.1	5.9	–
		Total ARPU/GDP	44.3	43.7	37.9	32.6	26.0	21.7	20.6	17.3	–

Source: statistics data from ITU published in January 2007 (ITU World Telecommunication Indicator, 2006).

used to find the starting point of the penetration growth, followed by a discussion of the upper threshold of income effect. These data show that during 1997–2005, except for Russia's fixed line service, and for mobile service in Malaysia, Thailand, Russia and Brazil, other ASEAN and BRIC countries' A/I ratios are higher than 5%. This study also concludes that for ASEAN and BRIC countries one can use the 5% A/I ratio as an indicator of income effect. For details see Tables 3 and 4.

3.3.1. Income effect in ASEAN

During the period 1997–2005 the fixed line penetration rate for Malaysia, Thailand and the Philippines stagnated and even declined; only Indonesia was still growing. The year 2000 is the point for significant decline in the mobile A/I ratio for Malaysia and the Philippines, and then the year 2001 for Thailand and Indonesia. After these years the mobile penetration rate grew considerably. One thing worth noting about Thailand is that the mobile A/I ratio of 4.8% in 2004 had dropped below the upper threshold. The income effect for ASEAN countries is further analyzed below in Table 3:

- *Malaysia*: The fixed line A/I ratio declined from 9.5% in 1999 to 8.9% in 2000, at the same time fixed line penetration grew from 93.4% to 94.2%. Without crossing the income effect threshold, fixed penetration growth already showed a tendency toward stagnation. In 2003 and 2004 the fixed line A/I ratio was even higher than in 1997, and the fixed line penetration rate declined to 80.0% in 2004 and 78.2% in 2005. This conforms to Hypothesis 1. The mobile A/I ratio dropped from 12% in 1999 to 8.3% in 2000 at which time the turn toward mobile growth appeared, and the penetration rate increased from 12% to 21.8%. In 2003 the mobile A/I ratio was 5.5%, which is close to the upper threshold, and the penetration rate grew to 43.9%. In 2004 the mobile A/I ratio was 5.0%, which is equal to the upper threshold, and in 2005 the mobile penetration rate grew considerably from 57.1% to 74.1%. This is the highest penetration rate among ASEAN countries, and it conforms to Hypothesis 1.
- *Thailand*: The fixed line A/I ratio dropped from 15.9% in 2001 to 12.5% in 2002. At the same time fixed line penetration grew from 38.5% to its peak of 41.3%. This conforms to Hypothesis 1. The mobile A/I ratio dropped from 17% in 2000 to 10% in 2001, at which time the growth of mobile penetration appeared to reach a point of acceleration when penetration increased from 4.9% to 12.1%. In 2004 the mobile A/I ratio decreased to 4.8%, which is lower than the upper threshold, and in 2005 the mobile penetration rate grew from 42.8% to 45%. This conforms to Hypothesis 1.
- *Philippines*: The fixed line A/I ratio dropped from 17.2% in 1999 to 13.6% in 2000, and at the same time the fixed line penetration increased from 39.9% to its peak of 45.2%. When the mobile A/I ratio dropped from 11.3% in 2000 to 9.8% in

Table 4
BRIC penetration vs. A/I ratio (ARPU/per capita income, %)

BRIC	Service	ARPU/GDP/year	1997	1998	1999	2000	2001	2002	2003	2004	2005
Russia	Fixed	Penetration (%)	58.6	60.8	60.7	61.7	63.5	68.3	71.3	75.2	78.9
		ARPU/GDP (%)	1.9	3.1	4.8	3.6	3.6	4.2	4.3	3.9	–
	Mobile	Penetration (%)	0.3	0.5	0.9	2.4	5.5	12.4	25.2	51.2	86.9
		ARPU/GDP (%)	13.7	32.7	49.8	23.8	11.6	7.1	6.9	4.0	–
		Total ARPU/GDP	15.6	35.8	54.6	27.4	15.2	11.3	11.2	7.9	–
Brazil	Fixed	Penetration (%)	41.5	46.9	58.3	68.7	82.2	81.6	78.6	76.4	73.7
		ARPU/GDP (%)	12.7	13.3	12.6	11.3	10.7	11.5	10.0	9.8	–
	Mobile	Penetration (%)	2.8	4.4	9.0	13.6	16.7	19.0	26.2	35.7	46.2
		ARPU/GDP (%)	13.2	17.0	12.3	9.2	7.7	6.8	5.3	4.2	–
		Total ARPU/GDP	25.9	30.3	24.9	20.5	18.4	18.3	15.3	14.0	–
China	Fixed	Penetration (%)	21.1	26.1	32.0	41.6	50.8	61.7	72.7	84.1	89.4
		ARPU/GDP (%)	26.8	26.7	22.2	14.6	12.1	10.9	9.0	7.3	–
	Mobile	Penetration (%)	1.1	1.9	3.4	6.7	11.3	16.1	20.9	25.6	29.9
		ARPU/GDP (%)	59.0	40.3	27.1	21.4	14.3	12.5	8.9	7.2	–
		Total ARPU/GDP	85.8	67.0	49.3	36.0	26.4	23.4	17.9	14.5	–
India	Fixed	Penetration (%)	10.2	12.1	14.5	17.3	19.7	20.5	21.3	22.5	24.1
		ARPU/GDP (%)	64.9	55.6	42.6	36.8	31.6	29.2	28.5	28.1	–
	Mobile	Penetration (%)	0.1	0.1	0.1	0.2	0.3	0.6	1.2	4.4	8.2
		ARPU/GDP (%)		98.3	92.8	63.3	43.9	22.3	19.0	11.8	–
		Total ARPU/GDP	64.9	153.9	135.4	100.1	75.5	51.5	47.5	39.9	–
Average	Fixed	Penetration (%)	32.8	36.5	41.4	47.3	54.0	58.0	61.0	64.6	66.5
		ARPU/GDP (%)	26.6	24.7	20.6	16.6	14.5	14.0	13.0	12.3	–
	Mobile	Penetration (%)	1.1	1.7	3.4	5.7	8.5	12.0	18.4	29.2	42.8
		ARPU/GDP (%)	21.5	47.1	45.5	29.4	19.4	12.2	10.0	6.8	–
		Total ARPU/GDP	48.1	71.8	66.1	46.0	33.9	26.1	23.0	19.1	–

Source: statistics data from ITU published in January 2007 (ITU World Telecommunication Indicator, 2006).

2001, the growth of mobile penetration accelerated and increased from 8.5% to 15.6%. Since 2003 the mobile A/I ratios have been relatively lower than that of fixed line, and therefore mobile penetration increased significantly from 27.8% to 39.8% in 2004 and to 41.3% in 2005. This conforms to Hypothesis 1.

- *Indonesia*: The fixed line A/I ratio was 39.5% in 1997 and fixed line penetration only at 10.3%. The fixed line A/I ratio dropped to 27.5% in 1998 and fixed line penetration grew slightly to 11.3%. In 2004 the fixed line A/I ratio dropped to 13.6%, down from 15.1% in 2003, at which time the growth of fixed line turned upward, and the fixed line penetration rate grew from 15.6% to 18.1%. The mobile A/I ratio dropped from 30.1% in 2000 to 17.3% in 2001, and mobile penetration increased from 1.7% to 2.9% in 2001. The mobile A/I ratio significantly decreased from 12.8% in 2003 to 7.8% in 2004, and then the mobile penetration rate grew considerably from 13.5% to 21.1% in 2005. This conforms to Hypothesis 1.

3.3.2. Income effect in BRIC

Between 1997 and 2005 all BRIC countries, except for fixed line in Russia (1997–2004), and mobile in Russia (2004) and Brazil (2004), had fixed or mobile A/I ratios that were above the upper threshold. Each country's income effect for BRIC is analyzed as Table 4:

- *Russia*: Russia's fixed line service is the only one in the BRIC countries to have no income effect. During the period 1997–2004 the fixed line A/I ratio was lower than 5%, and fixed line penetration grew from 58.6% in 1997 to 78.9% in 2005. The mobile A/I ratio dropped from 23.8% in 2000 to 11.4% in 2001, at which time mobile growth appeared and mobile penetration grew from 2.4% to 5.5%. Since the mobile A/I ratio was still too high, mobile penetration was correspondingly low during 1997–2001. The mobile A/I ratio declined from 6.9% in 2003 to 4.0% in 2004, which is lower than the upper threshold, and the mobile penetration rate grew considerably from 51.2% in 2004 to 86.9% in 2005.[3] This conforms to Hypothesis 1.

- *Brazil*: The fixed line A/I ratio dropped from 12.6% in 1999 to 11.3% in 2001. During the same period fixed line penetration grew from 58.3% to 68.7%. From 2001 to 2002 instead of declining, the fixed line A/I ratio increased, and fixed line penetration started to decline from 82.2% in 2001 to 81.6% in 2002. The mobile A/I ratio declined from 12.3% in

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[3] Russian mobile operators attracted more than 51.4 million new subscribers in 2005, 88% (or 45.4 million) of which live outside Moscow.

1999 to 9.2% in 2000, at which time mobile penetration increased from 9.0% to 13.6%. In 2004 the mobile A/I ratio was 4.2%, which is lower than the upper threshold, and then the mobile penetration rate grew considerably to 35.7% in 2004 and 46.2% in 2005. This conforms to Hypothesis 1.

- *China*: The fixed line A/I ratio dropped from 22.2% in 1999 to 14.6% in 2000. The growth of fixed line service shows that it reached a turning point, and the fixed line penetration rate grew from 32% to 41.6%. The mobile A/I ratio dropped from 21.4% in 2000 to 14.3% in 2001, at which time mobile growth reached a turning point, and its penetration rate grew from 6.7% to 11.3%, still at a low level. The mobile A/I ratio was lower as of 2004, and mobile penetration grew significantly from 25.6% in 2004 to 29.9% in 2005. This conforms to Hypothesis 1.
- *India*: The fixed line A/I ratio was as high as 55.6% in 1998, and fixed line penetration rate was only 12.1%. In 1999 the A/I ratio dropped to 42.6% and penetration grew a little to 14.5%. The mobile A/I ratio dropped from 43.9% in 2001 to 22.3% in 2002, and mobile penetration increased from 0.3% to 0.6%. Because of the income effect it is difficult to grow either fixed line or mobile penetration. This conforms to Hypothesis 1.

In summary, in 1997 mobile business was still in its initial stages globally, and mobile penetration in G7 and NIE, excluding Hong Kong at 34.4% and Japan at 30.3%, was low, ranging between 6.6% (S. Korea) and 22% (Singapore). In 2005 each household in ASEAN and BRIC countries still had less than one fixed line, with the average in ASEAN being 44.1% and in BRIC 66.5%, and mobile penetration was still low, averaging 45.4% in ASEAN and 42.8% in BRIC. In other words, ASEAN people are slightly more dependent on mobile communication than BRIC, and BRIC people are more dependent on fixed line connections than ASEAN. Over time, because of market competition, a decline in services rates, and gradual increases in per capita income, the A/I ratios will gradually fall to less that 5%, and ASEAN and BRIC countries will cross the income effect threshold in the future.

4. Affordable effect vs. threshold effect

The income effect is a prerequisite for the affordable effect and a threshold effect. During the period 1997–2005, G7 and NIE countries crossed the income effect threshold, and both fixed line and mobile penetration were at a high level in 2005. Except for fixed line penetration in Russia, and mobile penetration in Thailand, Russia and Brazil in 2004, ASEAN and BRIC countries have all experienced the phenomenon of income effect. The definitions of affordable effect and threshold effect are given below.

4.1. Definitions of affordable and threshold effects

4.1.1. Affordable effect
This effect reveals at what time mobile service becomes more attractive to users than fixed line service, thus causing mobile penetration to grow rapidly, faster than fixed line. This study estimates that only when mobile ARPU is close to or lower than fixed line ARPU will mobile become affordable relative to fixed line, and its penetration will begin to grow considerably.

4.1.2. Threshold effect
When mobile penetration begins to grow because of the affordable effect this growth will not necessarily stop the growth of fixed line penetration. There will still be room for fixed line service to grow. It is only after mobile penetration reaches a certain critical mass that fixed line growth will stagnate. In other words, FMS penetration substitution does not immediately appear when mobile communication first enters the market but happens only when mobile penetration reaches a certain threshold level. When mobile penetration substitution reaches that threshold level fixed line penetration will stagnate or even decline.

The affordable effect enables mobile penetration to grow faster than fixed line penetration. But even if the cost of mobile service (ARPU) is lower than that of fixed line, if this cost cannot overcome the income effect threshold then mobile penetration growth still cannot take off. Nevertheless, even if the affordable effect is in play and the threshold of income effect has been crossed, if mobile penetration growth has not reached a critical mass, fixed line penetration growth may continue to grow even if at a slower pace. But once mobile penetration reaches a critical mass threshold, the strong growth of mobile will inhibit the growth of fixed line service, and at this point the threshold effect begins.

4.2. Affordable and threshold effects in ASEAN

Within the ASEAN countries there are differences in the affordable effect and the threshold effect. The mutual influence of these two effects for each country and the point for accelerated penetration (Fig. 9a–h) are studied below:

(1) *Thailand*: In 1999 fixed line ARPU increased and fixed line penetration declined slightly from 35% in 1998 to 33.4% in 1999. This shows that when ARPU increases penetration decreases.
  - In 2000 mobile ARPU dropped below fixed line ARPU. Mobile penetration growth started to accelerate from 4.9% in 2000 to 12.1% in 2001. The affordable effect took hold, and the differences between mobile and fixed line ARPU have

been widening since 2001. In 2003 mobile ARPU was about one-half of that of fixed line. In 2004 mobile penetration reached 42.8% surpassing the fixed line penetration of 37.0%. This conforms to Hypothesis 2.

- In 2002 the mobile penetration rate grew from 12.1% in 2001 to 25.7%. During the same period fixed line penetration grew from 38.5% to 41.3%, but the fixed line growth rate is less than that of mobile.
- When the mobile penetration rate reached the critical mass threshold of 25.7% in 2002, fixed line penetration declined from 41.3% in 2002 to 37.1% in 2003. This can be explained by the rapid growth of mobile penetration as fixed line service lost its appeal, but also by some fixed line users canceling their services. Fixed line penetration therefore started to drop below 40% beginning in 2003 (37.1% in 2003, 37.0% in 2004 and 37.2% in 2005). This is the threshold effect and conforms to Hypothesis 3. See Fig. 3a and b.

(2) *The Philippines*
- Mobile ARPU dropped below fixed line ARPU in 1999. The growth of mobile penetration started to accelerate from 3.8% in 1999 to 8.4% in 2000. The affordable effect is thus shown. This conforms to Hypothesis 2. Meanwhile fixed line penetration grew from 39.9% in 1999 to 45.2% in 2000, but at a slower pace than that of the growth of mobile penetration.
- When mobile penetration reached the critical mass threshold of 8.4% in 2000, fixed line penetration began to decline from 45.2% in 2000 to 44.4% in 2001. The threshold effect began to work. Fixed line penetration further declined to 38.1% in 2005. This conforms to Hypothesis 3.
- In 2003 when mobile ARPU was about 73% of fixed line ARPU mobile penetration began to grow rapidly and surpassed fixed line penetration in 2004. In 2005 mobile penetration reached 41.3% and surpassed the fixed penetration of 38.1%. The FMS pattern in the Philippines can be said to be the combined action of the affordable effect and the threshold effect. For details see Fig. 3c and d.

(3) *Malaysia*
- Mobile ARPU dropped below fixed line ARPU in 2000, and the growth of mobile penetration accelerated from 21.8% in 2000 to 30.8% in 2001. This is the affordable effect appears, and conforms to Hypothesis 2.
- When mobile penetration rapidly increased to the critical mass threshold of 9.7% in 1999, fixed line penetration started to decline from the stagnating level of 99.6% in 1998 to 94.4% in 1999. During 1999–2001 mobile penetration grew from 12.0% to 30.8%, while fixed line penetration stagnated at the level of 93.4% in 1999 to 93.7% in 2001. In 2001 when mobile penetration grew from 30.8% to 36.9% in 2002, the threshold effect came into play and caused fixed line business to significantly decline. This conforms to Hypothesis 3.
- The differences between fixed line and mobile ARPU continued to widen after mobile ARPU dropped below fixed line in 2000. Furthermore, fixed line ARPU increased in 2003, in which year mobile ARPU was only about 44.7% of fixed line ARPU. The affordable effect is again shown. Mobile penetration grew from 43.9% in 2003 to 57.1% in 2004 and 74.1% in 2005, while fixed line penetration dropped to 78.2% in 2005. This conforms to Hypothesis 3. For details see Fig. 3e and f.

(4) *Indonesia*
- Because of the income effect both fixed line and mobile penetration are low. Since 2001 mobile ARPU dropped lower than fixed line ARPU, and the growth of mobile penetration started to accelerate in 2001 rising from 2.9% to 5.0% in 2002 showing that the affordable effect has appeared. This conforms to Hypothesis 2.
- In 2003 mobile ARPU was about 84% of fixed line ARPU. Mobile penetration grew from 7.5% in 2003 and 13.5% in 2004 to 21.1% in 2005, and during the same time the growth of fixed penetration was from 15.6% in 2003 and 18.1% in 2004 to 22.8% in 2005. During the years 2003–2005, although mobile penetration growth did not reach the critical mass threshold level to stop the growth of fixed line penetration, the growth rate of mobile penetration exceeded the fixed line growth rate. If this trend continues, the income effect and the affordable effect will come into play and then the threshold effect will occur in the near future, and this will conform to Hypothesis 3. See Fig. 3g and h.

4.3. Affordable and threshold effects in BRIC

For BRIC countries, there are also differences in the affordable effect and the threshold effect within the group. The mutual influence of the two effects is studied below:

(1) *Brazil*
- In 1999 when mobile ARPU dropped below fixed line ARPU, with the additional influence of the income effect (the mobile A/I ratio declined from 12.3% in 1999 to 9.2% in 2000) the growth of mobile penetration increased in 1999 rising from 9% to 13.6% in 2000 indicating an affordable effect. This conforms to Hypothesis 2.
- When mobile penetration grew from 13.6% in 2000 to 16.7% in 2001, at the same time fixed line penetration grew from 68.7% to 82.2%. Fixed line penetration still grew rapidly and at a faster rate than mobile penetration. In 2001 when mobile penetration reached the 16.7% critical mass threshold, fixed line penetration dropped from 82.2% in 2001 to 81.6% in 2002 and further declined to 73.7% in 2005. The threshold effect was at work. This conforms to Hypothesis 3. See Fig. 4a and b.
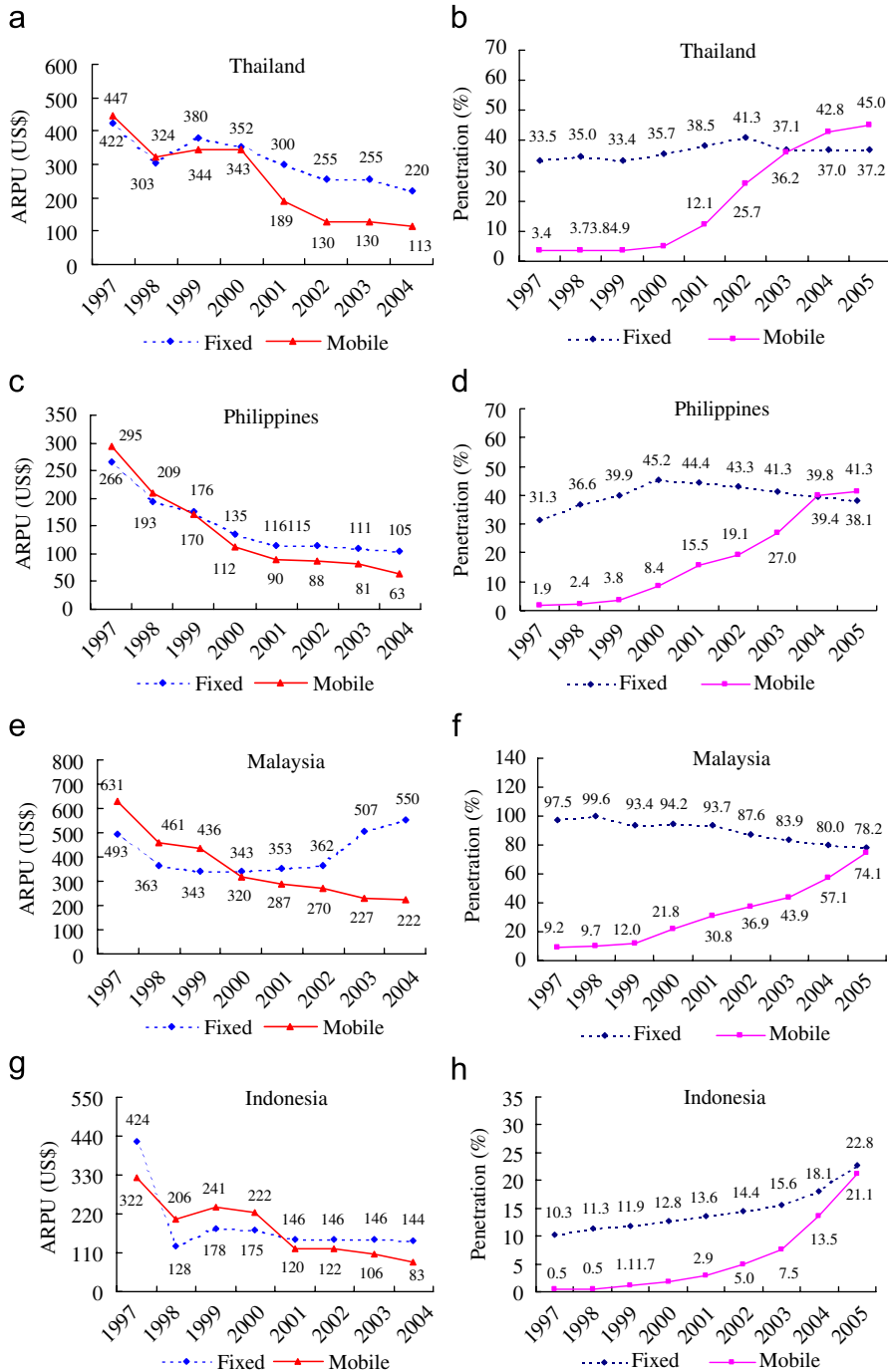
Fig. 3. (a) Thailand fixed line and mobile ARPU. (b) Thailand fixed line and mobile penetration. (c) The Philippines fixed line and mobile ARPU. (d) The Philippines fixed line and mobile penetration. (e) Malaysia fixed line and mobile ARPU. (f) Malaysia fixed line and mobile penetration. (g) Indonesia fixed line and mobile ARPU. (h) Indonesia fixed line and mobile penetration.

(2) *Russia*

- In 1997 when Russia began its mobile service, the penetration rate was very low at 0.3%. Because mobile ARPU has been considerably higher than fixed line ARPU therefore the FMS threshold is high. As of 2003 mobile ARPU had dropped below fixed ARPU, and the growth of mobile penetration accelerated from 25.2% to 51.2% in 2004. This is the affordable effect and conforms to Hypothesis 2.
- The fixed line A/I ratio for Russia has been the lowest among the BRIC countries thus requiring that mobile ARPU decrease further to stop the growth of fixed line penetration. Under the influence of the affordable effect the rise in
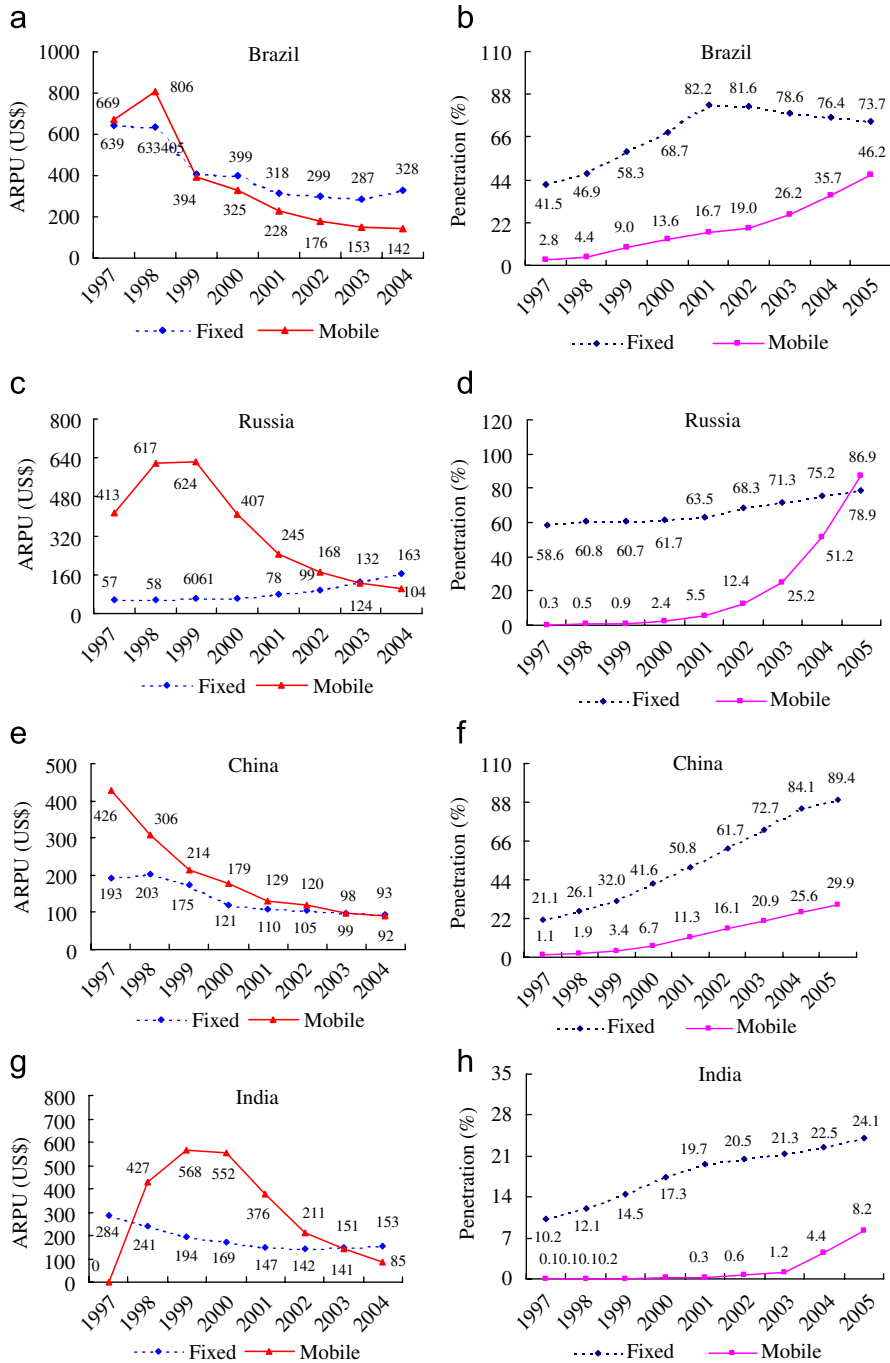
Fig. 4. (a) Brazil fixed line and mobile ARPU. (b) Brazil fixed line and mobile penetration. (c) Russia fixed line and mobile ARPU. (d) Russia fixed line and mobile penetration. (e) China fixed line and mobile ARPU. (f) China fixed line and mobile penetration. (g) India fixed line and mobile ARPU. (h) India fixed line and mobile penetration.

mobile penetration was very steep, reaching 86.9% in 2005, surpassing fixed line penetration. Nevertheless, from 2001 to 2004 when mobile penetration was growing rapidly fixed line penetration still showed a slight growth, but that slight growth slowed further from 75.2% in 2004 to 78.9% in 2005. It is foreseeable that the trend will continue and then the threshold effect is likely to happen, and that will conform to Hypothesis 3. See Fig. 4c and d.

(3) *China*
- In 1997 mobile ARPU was much higher than fixed line ARPU, and mobile penetration was only at 1.1%. Since 2001, with the deceasing mobile ARPU coming close to the level of fixed line ARPU, the growth of mobile penetration

accelerated from 11.3% to 16.1% in 2002. The affordable effect had begun to show. This conforms to Hypothesis 2. Because fixed line ARPU was lower than mobile ARPU during the study period, when mobile ARPU got close to fixed line ARPU beginning in 2003 and the mobile penetration rate showed rapid growth, the fixed line penetration rate also continued to grow.

- As of 2004 the threshold effect had not appeared. China is the only BRIC country in which fixed line penetration continues to grow rapidly and mobile penetration has not caught up. The rapid growth of fixed line penetration is related to China's actively developing broadband xDSL accessibility. For the year 2003–2004 the growth rate of mobile penetration was 24%, which exceeded that of fixed line penetration at 14%. Over time, with the aid of the affordable effect, the threshold effect may then take hold in China. This will conform to Hypothesis 3. See Fig. 4e and f.

(4) *India*

- Mobile ARPU had been much higher than fixed line ARPU and therefore there was no significant growth in mobile penetration until 2003. The mobile ARPU was lower than the fixed ARPU in 2004, and then the growth of mobile penetration accelerated, rising from 4.4% in 2004 to 8.2% in 2005. This conforms to Hypothesis 2.
- In 2003 when mobile penetration began to show growth, fixed line penetration grew only slightly from 21.3% in 2003 to 22.5% in 2004 and 24.1% in 2005. Although the threshold effect has not yet happened fixed line growth began to slow. It is still too early, however, to know whether there will be a threshold effect. If mobile penetration accelerates and grows faster than fixed line, then the threshold effect will take place and it will conform to Hypothesis 3. See Fig. 4g and h.

The prerequisite for the threshold effect is that the affordable effect must first happen, and to have an affordable effect there must also be an income effect. The eight countries of ASEAN and BRIC in the study of penetration substitution all exhibit the phenomenon of the affordable effect. Because the introduction of mobile service does not necessarily stop the growth of fixed line service, fixed line penetration still has room to grow. This explains FMS development in Indonesia, Russia, China and India. It is foreseeable that the threshold effect is likely to occur because fixed line growth slowed from 2004 to 2005. When mobile penetration growth reaches a critical mass threshold then fixed line penetration growth will stagnate or even decline. The Philippines, Thailand, Malaysia and Brazil all show this threshold effect. The critical mass value of the mobile penetration threshold effect for these four countries is between 8.4% (the Philippines) and 25.7% (Thailand).

5. Conclusion

FMS patterns in developed and developing economies exhibit significant differences. This article has shown that the income effect is a prerequisite for both an affordable effect and the threshold effect. That is, when disposable income is very limited then telecom penetration will be low. Overall, G7 in 1999 and NIE in 2000 crossed the 5% income effect threshold, and mobile penetration increased rapidly. But for ASEAN and BRIC countries, except for fixed lines in Russia, and mobile in Malaysia, Thailand, Russia and Brazil, all others still had not crossed the 5% income effect threshold in 2004. Therefore, any growth in telecom penetration is difficult to attain. This conforms to Hypothesis 1. When mobile ARPU comes close to or drops lower than fixed line ARPU mobile penetration begins to increase considerably and the affordable effect will appear. This conforms to Hypothesis 2. As mobile penetration begins to grow rapidly, it will not necessarily cause the fixed line growth to stagnate. It is only when the mobile penetration rate crosses a certain critical mass threshold level that the FMS substitution effect will cause fixed line penetration growth to decline or even stop and this phenomenon of the threshold effect conforms to Hypothesis 3.

In addition, this study discovered when observing the four groups of countries that there is a tendency in FMS patterns such that the differences between G7 and NIE countries is slight, and that the basic trends for ASEAN and BRIC countries are essentially the same. Although the FMS differences at inception are large, with a continuing decline in mobile ARPU and increases in per capita income, the relevant FMS effects begin to take hold so that in the long run the matured economic markets will follow the same track. This seems to represent an attractor in a macro system that guides the development of the overall situation and a control factor of this attractor is the three effects (income, affordable and threshold) of penetration substitution. It has been shown from the above description that mobile service in Malaysia, Thailand, Russia and Brazil had crossed the obstacle of the income effect as at 2004. It is foreseeable that this trend will continue with the threshold effect occurring for mobile in Russia in the near future. If telecom businesses take the evolution of the industry into consideration in their strategic planning, they should have excellent opportunities for capturing markets.

Nevertheless, the diminishing price differences between mobile and fixed line services will accelerate the mobile replacement of fixed line service. In G7 and NIE countries the FMS pattern is the substitution of second fixed lines by mobile, unlike ASEAN and BRIC countries in which first fixed lines are being substituted by mobile. Fixed-only operators facing 'traffic substitution' may lose some traffic income but may still keep the income from the basic monthly rental. Nevertheless, the fixed-only operators facing penetration substitution will lose both the basic monthly fixed line rental and traffic income to mobile businesses. However, for ASEAN and BRIC countries, which mainly exhibit penetration substitution on FMS, the traditional paradigm of using the fixed line network as the foundation of a national telecom policy has

changed. The three effects-incomes, affordable and threshold-in association with the penetration substitution effect, illustrate the basic mechanics of mobile substitution of fixed lines.

Appendix A. Referred regulators websites

See Table A1.

Table A1
Referred regulators websites

Country	Regulator websites
Brazil	www.anatel.gov.br
Canada	www.ic.gc.ca
China	www.mii.gov.cn
Finland	www.mintc.fi
France	www.anfr.fr
Germany	www.regtp.de
H.K	www.ofta.gov.hk
India	www.trai.gov.in
Indonesia	www.depub.gov.id
Italy	www.communicazioni.it
Japan	www.soumu.go.jp
Malaysia	www.mcmc.gov.my
Philippines	www.dotcmain.gov.ph
Russia	www.minsvyaz.ru
S. Korea	www.kcc.go.kr
Singapore	www.ida.gov.sg
Taiwan, ROC	www.ncc.gov.tw
Thailand	www.mict.go.th
UK	www.ofcom.org.uk
USA	www.fcc.gov

Appendix B. Per capita GDP for four groups countries (US$)

See Table B1.

Table B1
Per capita GDP for four groups countries (US$)

Per capita	GDP (US$)	1997	1998	1999	2000	2001	2002	2003	2004	2005
G7	USA	30,510	31,834	33,216	34,886	35,562	36,553	37,646	38,917	41,768
	France	24,151	24,774	24,591	22,123	21,499	23,560	28,771	33,460	33,967
	Japan	34,203	31,179	35,478	37,544	31,636	31,057	33,674	34,323	34,827
	Germany	25,626	26,214	25,619	22,640	22,459	24,279	29,170	33,348	33,880
	UK	22,343	23,810	23,168	24,094	23,707	26,513	26,936	27,297	32,730
	Italy	20,305	20,764	20,504	18,689	19,060	20,823	26,946	28,813	30,379
	Canada	21,042	20,106	20,356	20,942	19,955	20,123	22,833	25,174	32,100
NIE	H.K	26,763	25,247	24,312	24,814	24,086	23,577	22,801	23,684	24,517
	Singapore	24,901	20,966	20,977	23,135	20,735	21,192	22,073	15,199	26,901
	Taiwan	11,743	12,659	13,392	13,819	12,121	12,437	12,788	13,362	14,340
	S. Korea	11,442	7608	9747	11,127	10,179	11,480	12,687	14,110	16,308
ASEAN	Malaysia	4622	3318	3626	3869	3663	3870	4097	4110	4940
	Thailand	2570	1885	2043	2018	1849	2022	2147	2535	2869
	Philippines	1137	893	1023	992	921	980	980	1045	1168
	Indonesia	1071	467	688	738	694	768	844	1059	1094
BRIC	Brazil	5052	4750	3203	3544	2957	2632	2865	3343	4274
	Russia	3024	1886	1254	1709	2146	2347	3097	4212	5260
	China	722	760	788	833	933	985	1093	1269	1717
	India	437	434	455	459	474	479	549	577	726

Appendix C. Fixed domestic exchanged lines (unit: thousand)

See Table C1.

Table C1
Fixed domestic exchanged lines (unit: thousand)

Fixed DELs (0 0 0)	1997	1998	1999	2000	2001	2002	2003	2004	2005
USA	172,452	179,822	183,521	187,002	190,994	186,232	182,933	177,947	175,350
Japan	65,735	67,488	70,530	61,960	61,330	60,770	60,575	59,610	58,780
Germany	45,200	46,530	48,210	50,220	52,450	53,780	54,233	54,574	55,046
France	33,700	34,099	33,888	34,081	34,084	34,124	33,913	33,703	33,697
Italy	25,698	25,986	26,502	27,300	27,353	27,142	26,596	25,957	25,049
U.K	31,879	32,829	34,021	35,047	35,660	34,517	34,121	33,700	31,796
Canada	18,660	19,294	20,051	20,840	21,126	20,622	20,612	20,563	20,780
Taiwan, ROC	10,862	11,500	12,044	12,642	12,858	13,099	13,355	13,530	13,615
S. Korea	20,422	20,089	25,619	25,863	25,775	25,735	25,128	23,568	23,745
H.K.	3647	3729	3869	3926	3898	3832	3806	3763	3798
Singapore	1685	1778	1851	1936	1948	1927	1890	1857	1844
Malaysia	4223	4384	4423	4628	4710	4670	4572	4446	4366
Thailand	4827	5038	5216	5591	6049	6567	6632	6812	7035
Philippines	4500	5300	5987	6909	6939	6914	6693	6473	6367
Indonesia	4982	5572	6080	6662	7219	7750	8058	9992	12,772
Brazil	17,039	19,987	24,985	30,926	37,430	38,811	39,205	39,579	39,853
China	70,310	87,421	108,715	144,829	180,368	214,222	262,747	311,756	350,445
India	17,802	21,594	26,511	32,436	37,848	39,860	42,090	44,870	48,836
Russia	28,250	29,246	30,949	32,070	33,278	35,500	36,100	38,500	40,100

Appendix D. Mobile subscriber (unit: thousand)

See Table D1.

Table D1
Mobile subscriber (unit: thousand)

Mobile subscribers (0 0 0)	1997	1998	1999	2000	2001	2002	2003	2004	2005
United States	55,312	69,209	86,047	109,478	128,375	140,767	158,722	182,140	213,000
Japan	36,804	46,912	56,799	66,784	74,819	81,118	86,655	91,474	96,484
Germany	8276	13,913	23,446	48,202	55,126	59,128	64,800	71,316	79,200
France	5817	11,210	21,434	29,052	36,997	38,585	41,702	44,544	48,099
Italy	11,738	20,489	30,296	42,246	51,246	53,003	55,918	57,171	60,000
UK	8841	14,878	27,185	43,452	46,283	49,228	54,400	61,091	65,500
Canada	4266	5365	6911	8727	10,862	11,861	13,222	14,984	17,017
Taiwan, ROC	1492	4727	11,235	17,661	21,786	24,391	25,090	22,760	22,171
S. Korea	6879	14,019	23,443	26,816	29,046	32,342	33,592	35,050	38,342
H.K	2230	3174	4275	5234	5702	6219	7349	8214	8693
Singapore	832	1095	1631	2747	2992	3313	3577	3997	4385
Malaysia	2000	2150	2717	5122	7385	9053	11,124	14,611	19,545
Thailand	1977	2204	2339	3056	7550	16,117	22,825	27,248	27,379
Philippines	1344	1734	2850	6454	12,159	15,201	21,860	32,936	34,779
Indonesia	916	1066	2221	3687	6415	11,340	17,888	30,081	46,910
Brazil	4550	7368	15,033	23,188	28,746	34,881	46,373	65,606	86,062
China	13,233	23,863	43,296	85,260	144,820	206,620	269,953	334,824	393,406
India	882	1195	1884	3577	6432	12,688	26,154	47,300	90,000
Russia	485	747	1371	3263	7750	17,609	36,890	74,350	118,980

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