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Mapping technological diffusion: What can business learn from the case of worldwide mobile telephony?

by

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Abstract

The “bottom of the pyramid” literature advises multinational companies to launch disruptive innovation in less developed countries before launching it in developed countries. We examine this statement by an explorative quantitative study of mobile telephony in 70 developed and less developed emerging countries. A discriminant function analysis indicates that on average the speed of mobile telephony diffusion (calculated using Griliches’s epidemic diffusion model) is higher in emerging countries than in developed countries. We rank the 70 countries according to descending rate of diffusion growth or diffusion speed and compare mobile telephony diffusion between regions. We find that former communist European countries, Portugal, Brazil, and Israel have the highest speed of mobile telephony diffusion; North American and Scandinavian countries have the lowest diffusion speed. We also explore how the presence of a bottom of the pyramid population affects mobile telephony growth, which results into some remarkable findings.

Keywords: explorative quantitative research, technology diffusion, mobile telephony, emerging countries, bottom of the pyramid

1. Introduction

Prahalad and Hart (2002) coined the term 'bottom of the pyramid'. They called out to multinationals not to solely look at the top of the global income pyramid –the triad markets and rich people in emerging countries–, but at the entire world including the poor people at the bottom of the income pyramid. As Prahalad and Hart (2002) reminded multinationals of the large untapped market in developing countries and warned multinationals that they had to serve the needs of the poor in order to survive in the 21st century, the idea of doing business at the bottom of the pyramid gradually gained attention.

One of the tenets the bottom of the pyramid business field is a focus on technological innovation. Hart and Christensen (2002) advise companies to launch a disruptive product innovation first at the bottom of the pyramid at the same time as or even before launching it in developed countries.

Since many new products fail to satisfy the company's expectations (Booz, Allen, and Hamilton, 1968) and the choice where and when to bring an innovation into the marketplace is crucial for its success (Rogers, 2003), research exploring the factors that affect the diffusion of an innovation is relevant and bound to contribute to future international business strategy.

In order to understand what drives innovation at the top and at the bottom of the pyramid, we discuss a known example of technological innovation with worldwide success: mobile telephony.

Using quantitative data from secondary sources we explore the diffusion of cellular mobile telephony in 70 developed and emerging countries. We calculate the speed of diffusion for each country and analyze the findings on the level of developed

versus emerging countries and on regional level. We further compare the findings with data on the composition of the bottom of the pyramid in 16 emerging countries to explore how the presence of a poor population determines technological diffusion.

2. Scope of the research

Mobile telephony

Mobile telephony is one of the salient technologies of the 20th century. Not only has mobile telephony changed the lives of people in developed countries, but it also managed to break through in developing countries. Mobile telephony disrupted the telecommunication industry: people could not only communicate from a distance (as with telegraphy or fixed telephony), but they could also communicate instantly, no matter where they were. The diffusion of mobile telecommunication got a boost from the transition from analogue to digital telephony in the early 1990s (Gruber and Verboven, 2001). As a result fixed telephony in developed countries is in demise: the number of telephone mainlines has been dropping since 2000 (UNDP, 2002; 2007) and providers of mobile telephony services are preparing the end of fixed telephony.

As is characteristic for a disruptive innovation, mobile telephony has disturbed the balance of power in the market (Iyer, LaPlaca, and Sharma, 2006) by targeting not only high-end consumers in mainstream markets (high-income countries), but also less-demanding consumers in non-traditional markets (low- and middle-income countries, including the poor) (Christensen, 2003). Mobile telephony has increased connectivity around the globe and has provided people with a feeling of security. Mobile telecommunication spurred other product and service innovations: apart from

phoning, mobile phones are used to send text messages, take and send pictures and videos, check e-mail, or pay for a parking lot.

Hart and Christensen's advice to choose the bottom of the pyramid as the primary market for innovation (and not the developed countries) raises many questions, most importantly which factors determine the success of an innovation, and whether these factors differ between developed countries and the bottom of the pyramid. The well-known case of mobile telephony allows us to examine which low- and middle-income countries are more prone to adopting technological innovation. Before deciding whether to enter the bottom of the pyramid, companies need a good understanding of how the markets there work, on both the demand and the supply side. Prahalad and Hart (2002) may emphasize the population size of developing countries as a reason why companies should no longer ignore the bottom of the pyramid, but population size does not necessarily lead to a large and profitable product market. A large population does not equal a large demand and the efforts needed to make supply meet demand may be quite considerable. Just like the population size could be too large to ignore, so could be the supply costs or the opportunity costs of the introduction.

Companies should consider both opportunities and obstacles in developing countries and evaluate whether the efforts to overcome these obstacles do not cannibalize other business activities. High production or opportunity costs may result in the company deciding not to enter the markets at the bottom of the pyramid. Christensen and Hart's suggestion to launch an innovation first in low- and middle-income countries may not be interesting for all companies or all sectors.

We chose the diffusion of mobile telephony as a case for the present study for three reasons. Firstly, other diffusion studies that have chosen mobile telephony as a

case do not compare developed countries, emerging countries, and the bottom of the pyramid. Secondly, reliable data on the diffusion of mobile telephony exist to study, even for developing countries. Our objective is to examine what companies can learn from the different diffusion paths of mobile telephony in developed versus emerging countries.

The bottom of the pyramid

Prahalad and Hart (2002) define the bottom of the pyramid as the four billion poorest people in the world (about 72 % of the world population). Of these about 72 % live in Asia; 12 % in Africa; 9 % in Latin America and the Caribbean; and 6 % in Eastern Europe (Hammond *et al.*, 2007).

People at the bottom of the pyramid spend most of their income on food (a market of $2,895 billion), followed by energy ($433 billion), housing ($332 billion), transportation ($179 billion), health ($158 billion), information and communication technology ($51 billion), and water ($20 billion). For most sectors expenditures per household from the bottom of the pyramid in Latin America are higher than in other continents (Hammond *et al.*, 2007). ICT expenditure by poor households in the median Latin American country is $107, twice as high as in Asia ($54) and Eastern Europe ($56), and three times higher than in Africa ($34). On all continents the ICT market is mainly located in urban areas; people in rural areas have less access to ICT services and are less likely to own a phone.

One reason that people are at the bottom of the pyramid is that they are not integrated in the global formal market economy (Hammond *et al*., 2007; De Soto, 2000; Hart, 2005). The lack of integration is noticeable in the unmet needs (the poor don’t have access to a bank account, telephone, clean water, or electricity), the

dependence on the informal sector, and the “poor penalty” (the fact that the poor often pay higher prices for goods and services or have to put more effort into acquiring goods and services than rich people do) (Hammond *et al.*, 2007).

3. Review of the literature

In our study of the diffusion of a disruptive innovation (mobile telephony) we turn to the bottom of the pyramid literature as well as the diffusion of innovations theory.

Bottom of the pyramid

Prahalad and Hart (2002) elaborate on the opportunities for multinationals at the bottom of the pyramid. They focus on the introduction of sustainable technologies in developing countries. They point to developing countries' lack of adequate infrastructure, which provides possibilities for technology leapfrogging. They point to developing countries' large unmet needs (non-consumption), which provides a vast untapped market, and to low quality of products, which provides weak competition. They point to developed countries' presence of incumbents and strong institutions, which can provide strong resistance for the diffusion of an innovation.

Hart and Christensen (2002, p. 52) call developing countries ideal target markets for disruptive technologies with global potential for two reasons. Firstly they state that there is room for companies to add features to the low-cost products that they offer in developing countries (and therefore increase costs) and then approach the markets in developed countries with an extended and more costly version of the product. Secondly, they state that the biggest competitor in developing countries is non-consumption, resulting into a large pending demand.

Despite a lower income, Prahalad and Hammond (2002) and De Soto (2000) agree that there is a pending demand in developing countries for both basis and luxury products. Although telecommunication is not a priority as people first aim to satisfy their needs for food, clothing, housing, and a good health, it can ameliorate the living conditions of the poor. In remote areas, telecommunication increases access to the market, reducing time spent on searching market information.

Diffusion of innovation

Prahalad and Hart (2002) highlight the vast potential market in low- and middle-income countries. Their emphasis on population size and profits driven by volume bring us to examine the diffusion of innovations.

A large population does not assure a fast and widespread adoption of an innovation. Potential adopters assess an innovation on various criteria: relative advantage, compatibility, simplicity (or complexity), and trialability (Rogers, 2003). The observability of an innovation facilitates the assessment of the innovation by potential adopters.

Does mobile telephony have a relative functionality advantage over fixed telephony (because people always have a phone at hand in time of need, no matter where they are)?

Is mobile telephony compatible with people's needs (of being able to phone someone whenever, wherever) and experiences (with fixed telephony)?

Isn't mobile telephony too complex for people who have never used a fixed telephone (as in many low-income countries)? Experience with fixed telephony (as in high-income countries) diminishes the complexity of mobile telephony.

Can customers evaluate the risks of mobile telephony (trialability)? Risks include the financial risk of the purchase compared to personal income (relatively low in high-income countries, higher in middle- and low-income countries), the risk that the phone does not function well, the health risks (such as the affect of radiation coming from the device), the psychological and social risk of the purchase (the effect on the customer's image and self-image), the environmental risk, and the risk to waste time on the product search (Mühlbacher, Leihs, and Dahringer, 2006).

Potential customers have to be able to gather information about the innovation and to purchase it. The innovative company, through its marketing and distribution activities, has to assure an effective stream of information and a sufficient supply of the product.

Certain factors within a country can affect the demand side (the evaluation of innovation characteristics by potential customers) and the supply side (marketing and distribution activities of companies) of the diffusion of an innovation. Which factors influence diffusion of mobile telephony will be discussed subsequently.

Diffusion of mobile telephony

Most diffusion research so far examined the diffusion of innovation in high-income countries (Talukdar, Sudhir, and Ainslie, 2002). Only one third of all diffusion studies (not only studies about the diffusion of product innovations) deals with low- and middle-income countries (Rogers, 2003, p. 58). Several studies that examine the diffusion of mobile telephony include low- and middle-income countries (see Table 1), but only Rouvinen (2006) explicitly compares diffusion between developed and developing countries. No study includes a comparison of diffusion data with data concerning the bottom of the pyramid.

Study	Countries	Period
Rouvinen (2006)	75 developed and 90 developing countries	1993 - 2000
Dekimpe, Parker, and Sarvary (1998)	184 countries on five continents	1979 - 1992
Talukdar, Sudhir, and Ainslie (2002)	1 low-income, 8 middle-income, and 22 high-income countries	1975 - 1997
Ahn and Lee (1999)	5 low-income, 41 middle-income, and 18 high-income countries	1997
Gruber (2001)	10 Central and Eastern European countries	1990 - 1997
Madden and Coble-Neal (2004)	10 low-income, 20 middle-income, and 28 high-income	1995 - 2000
Madden, Coble-Neal, and Dalzell (2004)	8 low-income, 20 middle-income, and 28 high-income countries	1995 - 2000

Table 1. Studies on the diffusion of mobile telephony

Rouvinen (2006) investigated the difference in the diffusion of digital mobile telephony between developed and developing countries, He concluded that the speed of diffusion did not statistically significantly differ between developed and developing countries. He examined the effect of socio-economic factors on diffusion. Trade (as the sum of export and import compared to GDP), the penetration of fixed telephony and analogue mobile telephony, and market competition generally stimulate diffusion of mobile digital telephony. So does the overall (non-telecom) technological level, but only in developing countries. A large agrarian sector and standard competition generally inhibit diffusion. So does political freedom (more democracy), but only in developing countries. The size of the population living in the largest city only increases diffusion in developed countries. The positive effect of the total population size is larger in developing countries than in developed countries. Illiteracy and income turn out to be not statistically significant.

Dekimpe, Parker, and Sarvary (1998) propose a new method to model the diffusion of new products. Their model includes several exogenous and endogenous factors that may determine the penetration and the penetration growth of a new product within the first year after its introduction in a country. They tested their model on the penetration of the cellular phone within a country's population for 184 countries (55 in Africa, 37 in Asia, 32 in Europe, 45 in the Americas, and 15 in other regions). They conclude that the crude death rate (a proxy for poverty), the number of ethnic groups, and the number of major population centres decrease the first-year penetration percentage, while population growth and the number of competitors increase it. The crude death rate and the number of ethnic groups also decrease penetration growth, while the number of major population centres increases it. Population growth and the number of competitors have no statistically significant impact on penetration growth. GNP per capita, whether a country had a communist system, and two endogenous factors (the total number of other countries that have adopted the innovation and the number of countries among the World Bank Group the country belongs to) have no impact on first-year penetration or on penetration growth.

Talukdar, Sudhir, and Ainslie (2002) examined the diffusion of cellular phones and five other new consumer durables in 31 countries, including eight middle-income countries and one low-income country. They found that the penetration potential and the speed of diffusion in developing countries are lower than in developed countries. The higher income per capita, international trade, and urbanization are, the higher the penetration potential. The higher income inequality, the proportion of dependents (children and elderly) within the population, and the number of people on a waitlist for a fixed telephone connection, the lower the penetration potential (these coefficients are however not statistically significant). Newspaper penetration has a

statistically significant positive effect on the speed of diffusion, while television penetration and the amount of international phone calls have a positive, but statistically insignificant effect on the speed of diffusion. Illiteracy, ethnic heterogeneity, and the Gini Index have a negative effect on the speed of diffusion; the effects of illiteracy and ethnic heterogeneity are significant. The share of women in the labour force has a positive, but statistically insignificant impact on the speed of diffusion.

Ahn and Lee (1999) examined the demand for mobile telephony in 18 high-income countries, 41 middle-income countries and 5 low-income countries. They found that the connection fee, the local call rate, and the monthly charge negatively determine the probability of subscribing to mobile telephony; only the effect of monthly charge is statistically significant. The number of fixed telephone lines and GDP per capita has a statistically significant, positive influence on mobile subscription probability. The rate of digitalization seems to have no effect.

Gruber (2001) studied the diffusion of mobile telecommunications in ten Central and Eastern European countries (one high-income and nine middle-income countries). He found that the penetration of fixed telephony and the waiting list for a fixed telephone connection have a significant, positive effect on diffusion. Income per capita, urbanization, and the transition from planned to market economy do not influence the diffusion of mobile telephony.

Madden and Coble-Neal (2004) studied the relation between fixed telephony and mobile telephony (in 10 low-income, 20 middle-income, and 28 high-income countries). They find that mobile telephony is a substitute for fixed telephony (contrary to prior research that found that they are complements).

Madden, Coble-Neal, and Dalzell (2004) examined the impact of economic factors on the diffusion of mobile telephony in 8 low-income countries, 20 middle-income countries, and 28 high-income countries. They found that income growth boosts diffusion, especially in low- and middle-income countries. Low monthly charges stimulate diffusion. People in low-, middle-, and high-income countries are equally sensitive to price changes.

4. Data and methodology

We chose to compare the diffusion of mobile telephony across developed and emerging countries. The developed countries are high-income countries that are members of the Organisation for Economic Co-operation and Development (OECD) (UNDP, 2007). The emerging or catching-up economies are Brazil, Russia, India, and China (BRIC-countries), European catching-up economies, and other emerging markets (UNECE, 2007; MSCI, 2006). Table 2 provides an overview of the observed countries.

In order to calculate the growth rate of the diffusion of mobile telephony we used secondary data from the database of the United Nations, which refers to ITU estimates for data on information and telecommunication technology (United Nations Statistics Division, 2008). We used data for Cellular Mobile Phone Subscribers (per 100 inhabitants) from 1980 until 2006, comprising both analogue and digital mobile telephony. Because the number of subscribers per 100 inhabitants, rounded to one decimal, can equal zero even when there is a small number of subscribers, and the natural logarithm of zero does not exist, we set the number of subscribers for the early years of diffusion to 0.001 subscribers per 100 inhabitants.

DEVELOPED COUNTRIES (23)	EMERGING OR CATCHING-UP ECONOMIES (47)		
	BRIC COUNTRIES (4)	EUROPEAN CATCHING-UP ECONOMIES (26)	OTHER EMERGING COUNTRIES (17)
Australia	Brazil	Albania	Argentina
Austria	China	Armenia	Chile
Belgium	India	Azerbaijan	Colombia
Canada	Russian Federation	Belarus	Egypt
Denmark		Bosnia and Herzegovina	Indonesia
Finland		Bulgaria	Israel
France		Croatia	Jordan
Germany		Czech Republic	Korea, Republic of
Greece		Estonia	Malaysia
Iceland		Georgia	Mexico
Ireland		Hungary	Morocco
Italy		Kazakhstan	Pakistan
Japan		Kyrgyzstan	Peru
Luxembourg		Latvia	Philippines
Netherlands		Lithuania	South Africa
New Zealand		Moldova	Thailand
Norway		Poland	Turkey
Portugal		Romania	
Spain		Serbia and Montenegro	
Sweden		Slovakia	
Switzerland		Slovenia	
United Kingdom		Tajikistan	
United States		The former Yugoslav Republic of Macedonia	
		Turkmenistan	
		Ukraine	
		Uzbekistan	

Table 2. List of examined countries

The year of introduction of mobile telephony varies widely across countries. As we were primarily interested in the rate of diffusion, we eliminated the timing of introduction effect by transforming the time variable (from 1980 to 2006) to a 'years since introduction' variable (from 0 to 26 years) (Dekimpe, Parker, and Sarvary, 1998). As there were no cellular mobile telephone subscribers (except in Finland) in the year 1980, the left-hand truncation bias in our study is limited.

We calculated the rate of growth of mobile telephony within each country using Griliches's epidemic diffusion model (Griliches, 1957). This model is used in other mobile telephony studies such as by Gruber (2001) and Gruber and Verboven (2001).

The logistic diffusion curve is defined as $P = K / (1+e^{-(a+bt)})$ with

P the number of cellular mobile telephone subscribers per 100 inhabitants

K the ceiling

t the time variable (0 to 26 years since introduction)

b the rate of growth coefficient, the rate of adjustment, or measure for the speed of diffusion

a the constant that shifts the diffusion curve on the horizontal time-axis.

The ceiling *K* is unknown as most countries have not yet reached the level of saturation. Gruber and Verboven (2001) point out that it is difficult to estimate the ceiling when diffusion in most countries has not yet reached the maturity stage. As a proxy for market potential penetration ceiling within a country Dekimpe, Parker, and Sarvary (1998, p. 121) use "the percentage of the literate population living in urban areas having a sufficient income to afford basic telephone services." We chose not to adopt this definition as our data indicate levels of cellular mobile telephone subscribers exceeding 100 per 100 inhabitants and this would be impossible when only accounting for literate people in urban areas. We set the ceiling at 100 subscribers per 100 inhabitants. In the case of mobile telephony this may even be an underestimation.

To estimate the parameters we transform the logistic diffusion function into a linear equation $\ln[P/(K-P)]= a + bt$ (Griliches, 1957). We estimated the linear equation for each of the 70 countries separately. All growth rates $\hat{b}$ turned out to be significantly different from zero and the regressions fit the data quite well as the R^2's for almost all regressions were higher than 0.90. The rate of diffusion growth $\hat{b}$ measures the speed at which the number of adopters of an innovation grows relative to the number of non-adopters (Gruber and Verboven, 2001). We ranked the countries

by their rate of diffusion growth. Canada has the slowest rate of diffusion growth (0.337). The Czech Republic has the fastest growth rate (0.982); mobile telephony diffused nearly three times faster there than in Canada. The average rate of diffusion growth (weighed by population size) equals 0.605. Half of the examined countries had a rate of diffusion growth larger than 0.635. Appendix Table A1 reports the results of all 70 countries.

After obtaining the growth rates for all countries we examined whether there is a difference in rate of mobile telephony diffusion between developed and emerging countries. We performed a two-group discriminant function analysis which calculates and compares the averages of the two pre-defined groups (developed versus emerging countries) (Meyers, Gamst, and Guarino, 2006). Contrary to the findings of Rouvinen (2006), the discriminant analysis showed that the average diffusion growth rate in developed countries (0.512) is statistically significantly different from the average growth rate in emerging countries (0.676) (the F-test of equality of group means is significant at a p-value of 0.000; Meyers, Gamst, and Guarino, 2006). The average growth rate of the high-income OECD countries is lower than that of emerging countries, contrary to the findings of Talukdar, Sudhir, and Ainslie (2002).

Finally, we compared the diffusion of cellular mobile telephony in sixteen of the seventy observed countries with data about the presence 'the bottom of the pyramid' within those countries. We retrieved the country data about the bottom of the pyramid from Hammond *et al.* (2007) which provides data about the bottom of the income pyramid the percentage of national expenditure for information and communication technology coming from the bottom of the pyramid.

5. Findings and discussion

Mobile telephony diffusion in developed and emerging countries

The 15 countries with the highest speed of mobile telephony diffusion are catching-up economies and part of Central and Eastern Europe and the Commonwealth of Independent States (see Table 3), of which the Czech Republic had the highest diffusion speed (0.982). Low-income country Tajikistan remarkably has the second highest speed of diffusion (0.965). All other European catching-up economies are part of the 30 countries with the highest diffusion speed, except Azerbaijan (0.641), Uzbekistan (0.562), and Turkmenistan (0.346).

Country	Rate of diffusion growth
1. Czech Republic	0.982
2. Tajikistan	0.965
3. Albania	0.919
4. Romania	0.914
5. Moldova	0.867
6. Lithuania	0.865
7. Ukraine	0.863
8. Slovakia	0.828
9. Russian Federation	0.824
10. Kazakhstan	0.823
11. Kyrgyzstan	0.794
12. Poland	0.789
13. Bulgaria	0.785
14. Georgia	0.785
15. Bosnia and Herzegovina	0.779
17. Serbia and Montenegro	0.775
18. Croatia	0.760
20. The former Yugoslav Republic of Macedonia	0.738
21. Slovenia	0.734
23. Estonia	0.715
24. Belarus	0.714
26. Hungary	0.701
27. Latvia	0.684
30. Armenia	0.655
33. Azerbaijan	0.641
42. Uzbekistan	0.562
68. Turkmenistan	0.346

Table 3. Diffusion speeds for European catching-up economies

Of the so-called BRIC-countries (see Table 4), Russia has the highest speed of mobile telephony diffusion (0.824), followed by Brazil (0.723), China (0.653), and low-income country India (0.634).

Country	Rate of diffusion growth
9. Russian Federation	0.824
22. Brazil	0.723
31. China	0.653
36. India	0.634

Table 4. Diffusion speeds for 'BRIC'-countries

The Arab states in the sample have a mediocre growth rate: Morocco (0.635), Jordan (0.607), and Egypt (0.572) (see Table 5). Apart from Brazil and China, the countries from Asia and from Latin America have a diffusion speed lower than median. Of these Latin American countries, Argentina has the fastest diffusion growth rate (0.542) and Colombia the slowest (0.466). Of the Asian countries, South Korea has the fastest diffusion speed (0.553) and Malaysia the slowest (0.413).

Country	Rate of diffusion growth	Region
19. Israel	0.739	
22. Brazil	0.723	Latin America
31. China	0.653	East Asia and the Pacific
32. South Africa	0.653	Sub-Saharan Africa
35. Morocco	0.635	Arab States
36. India	0.634	South Asia
37. Jordan	0.607	Arab States
40. Egypt	0.572	Arab States
41. Turkey	0.566	Southern Europe
43. Korea, Republic of	0.553	East Asia and the Pacific
45. Argentina	0.542	Latin America
46. Mexico	0.541	Latin America
48. Indonesia	0.530	East Asia and the Pacific
50. Chile	0.517	Latin America
52. Pakistan	0.501	South Asia
53. Philippines	0.498	East Asia and the Pacific
56. Thailand	0.489	East Asia and the Pacific
57. Peru	0.478	Latin America
59. Colombia	0.466	Latin America
64. Malaysia	0.413	East Asia and the Pacific

Table 5. Diffusion speed in other emerging countries

The high-income OECD-countries score relatively low (see Table 6). The two North American countries are amongst the 4 countries with the slowest rate of diffusion growth: 0.372 for the US and 0.337 for Canada (which is also the slowest growth rate in the entire sample). The Nordic countries are also amongst the countries with the slowest speed of diffusion. In the Nordic region Iceland has the fastest diffusion speed (0.455) and Finland the slowest (0.342). Among the OECD-countries, most Western European countries and Australia and New Zealand have a mediocre rate of diffusion growth. Luxembourg is the first Western European country in the ranking with a rate of growth of 0.635 (the median). The Southern European countries score remarkably higher. Portugal has the 17th highest growth rate in the sample (0.777); Greece (0.702), Italy (0.678), and Spain (0.666) score higher than the median value.

Country	Rate of diffusion growth	Region
16. Portugal	0.777	South Europe
25. Greece	0.702	South Europe
28. Italy	0.678	South Europe
29. Spain	0.666	South Europe
34. Luxembourg	0.635	Western Europe
38. Ireland	0.581	Western Europe
39. Germany	0.580	Western Europe
44. Belgium	0.542	Western Europe
47. Netherlands	0.539	Western Europe
49. United Kingdom	0.523	Western Europe
51. Austria	0.511	Western Europe
54. France	0.497	Western Europe
55. Australia	0.493	Oceania
58. Switzerland	0.469	Western Europe
60. Iceland	0.455	Nordic Region
61. Sweden	0.444	Nordic Region
62. Japan	0.439	East Asia and the Pacific
63. New Zealand	0.430	Oceania
65. Denmark	0.389	Nordic Region
66. Norway	0.386	Nordic Region
67. United States	0.372	North America
69. Finland	0.342	Nordic Region
70. Canada	0.337	North America

Table 6. Diffusion speeds for high-income OECD-countries

Mobile telephony diffusion and the bottom of the pyramid

Connecting the diffusion of mobile telephony to the 'bottom of the pyramid' literature sheds light on some problems. Hammond *et al.* (2007) provide data about the composition of the bottom of the pyramid for 16 countries in the present study: seven countries from Central and Eastern Europe (Belarus, Kazakhstan, Russia, Tajikistan, Macedonia, Ukraine, and Uzbekistan), two East Asian countries (Indonesia and Thailand), four Latin American countries (Brazil, Colombia, Mexico, and Peru), two South Asian countries (India and Pakistan), and one Sub-Saharan country (South Africa) (see Appendix Table A2).

For these 16 countries, we find that the correlation between the growth rate of mobile telephony and the percentage of the population belonging to the bottom of the pyramid is negative (-.114), but not statistically significant. The correlations between the growth rate and the level of the largest bottom of the pyramid income segment within a country () and between growth rate and the portion of the bottom of the pyramid living in urban areas () are positive, but also not statistically significant.

The findings suggest that in countries with a bottom of the pyramid population, the larger the part of the population belonging to the bottom of the income pyramid, the slower the diffusion of mobile telephony. Similarly, the more people in the poorest income segment, the slower the diffusion of mobile telephony. These effects are however not significant.

The speed diffusion in the countries of Central and Eastern Europe and the Commonwealth of Independent States is high. From the seven countries of this region for which we have bottom of the pyramid data, four have more than 85 % of the national population belonging to the bottom of the pyramid.

Almost the entire population of Tajikistan belongs to the poorest income segments of the bottom of the pyramid (with an income per capita of $1,500 or less). About a quarter of them live in urban areas. About 90 % of national ICT expenditure comes from the bottom of the pyramid. Tajikistan is still in the early stages of mobile telephony diffusion: in 2005 there were 4.1 cellular mobile telephony subscribers per 100 inhabitants. The question is in which layers of the population mobile telephony currently diffuses, whether mobile telephony will diffuse in the future at the high rate estimated in this study, and how the large presence of the bottom of the pyramid will affect this diffusion.

Uzbekistan has a similar income distribution as Tajikistan. More than 90 % of the national population belongs to the poorest income segments of the bottom of the pyramid (with an income per capita of $1,500 or less). Uzbekistan's growth rate (0.562) is however lower than Tajikistan's (0.965) despite a smaller share of national ICT expenditure coming from the bottom of the pyramid and more of the poor living in urban areas.

Kazakhstan and Belarus show a similar pattern. Both have about 90 % of the population belonging to the bottom of the pyramid: between 30-50 % in the lowest income segment ($1,500 per capita or less) and between 50-70 % in urban areas. The share of national ICT expenditure coming from the bottom of the pyramid is about 75 % for both. Both have a high growth rate (0.823 for Kazakhstan, 0.714 for Belarus) and by 2006 had reached more than 50 cellular mobile telephone subscribers per 100 inhabitants.

Russia, Ukraine, and Macedonia show a similar pattern: a growth rate of about 0.84, 60 % of the population belonging to the bottom of the pyramid of which 60 % lives in urban areas and more than half has an income per capita of $1,500 or more,

and about one third of ICT expenditure comes from the bottom of the pyramid. Both countries had reached more than 60 cellular mobile telephone subscribers per 100 inhabitants by 2005. (Macedonia resembles Russia and Ukraine, except that its growth rate, percentage of the bottom of the pyramid living in urban areas, and percentage of ICT expenditure coming from the bottom of the pyramid are a bit lower.)

We found that the speed of diffusion in the countries of Latin America was below average. For the four countries of this region for which we have bottom of the pyramid data (Brazil, Colombia, Mexico, and Peru), about one third of the population belongs to the bottom of the pyramid (with the exception of Peru where this share is 90 %), and more than 60 % of the bottom of the pyramid lives in urban areas. Apart from Peru, the share of ICT expenditure coming from the bottom of the pyramid is less than one third. In Brazil and Peru about two third of the bottom of the pyramid live on less than $1,500 per capita per year; in Colombia and Mexico the bottom of the pyramid is more equally distributed among income segments, with a bit over half of them living on more than $1,500 per capita.

Within South Asia, India's growth rate (0.634) is a bit higher than Pakistan's (0.501). In both countries 95 % or more of the population belongs to the bottom of the pyramid, of which about 25 % lives in urban areas. The main differences lie in the share of ICT expenditure coming from the bottom of the pyramid (53 % in India; 92 % in Pakistan), and the distribution of the bottom of the pyramid across income segments (in India almost half of the population has an income per capita of $1,000-$2,000; in Pakistan more than 85 % of the population lives on less than $1,000 per capita).

The speed of diffusion in the countries of East Asia and the Pacific is below average. Indonesia's growth rate (0.530) is a bit higher than Thailand's (0.489) even though more people in Indonesia belong to the bottom of the pyramid and especially to the poorest incomes segment. Perhaps an explanation for this could be found in the fact that in Indonesia a larger share of the bottom of the pyramid lives in urban areas than in Thailand. Indonesia is comparable to Pakistan and Uzbekistan (the growth rate, share of total population belonging to the bottom of the pyramid, and composition of the bottom of the pyramid).

The only Sub-Saharan country in our study (South Africa) has 75 % of the population living at the bottom of the pyramid (especially in lower income segments), of which almost half live in urban areas. Only 14 % of ICT expenditure comes from the bottom of the pyramid.

6. Conclusion and limitations

Hart and Christensen (2002) inspired our research concerning the introduction of a product innovation (mobile telephony) in low- and middle-income countries and the diffusion of innovation with those countries.

The poor have other priorities than telecommunication: the ICT market is the sixth market in terms of revenue, after food, energy, housing, transportation, and health. Latin American ICT expenditure is higher than in Asia, Eastern Europe, and Africa. This does not necessarily mean that Latin American countries are the most attractive primary markets for the introduction of product innovation.

Contrary to Rouvinen (2006) and Talukdar, Sudhir, and Ainslie (2002) our discriminant analysis indicates that there is a significant difference in average diffusion growth rates between developed and emerging countries and our findings

suggest that the speed of diffusion is larger in emerging countries than in developed countries. Most of the countries with the highest growth rates are emerging countries, more specifically European catching-up economies. Brazil, Russia, India, and China have a mediocre growth rate, with the rate of the Russian Federation as the highest. The countries with the lowest growth rate are mostly high-income OECD countries, especially the United States, Canada, and the Nordic countries.

The speed of diffusion is lower in countries with a larger portion of the population belonging to the bottom of the pyramid, especially to the poorest income segments. Higher growth rates are found in countries where a larger portion of the bottom of the pyramid lives in urban areas. These correlations, however, are not significant.

Our study has some limitations that provide inspiration for future research.

Firstly the study observes a limited set of countries. It may be interesting to repeat the study with the inclusion of non-emerging low- and middle-income countries, as they accommodate a large proportion of the bottom of the pyramid.

Secondly it is difficult to generalize conclusions about the diffusion of mobile telephony to other sectors. Other industries with potential for business at the bottom of the pyramid are energy, water, and home appliances.

Thirdly the study assigned the ceiling in the diffusion model with a theoretical value of 100 cellular mobile telephony subscribers per 100 inhabitants in all countries alike. Our findings would become more accurate when first estimating the penetration ceiling for each country and then recalculating the growth rates. According to Talukdar, Sudhir, and Ainslie (2002) the penetration potential in developing countries is lower than in developed countries. As many emerging countries are still in the beginning or in the growth phase of diffusion, we cannot make any observations about their penetration potential. In developed countries the number of mobile telephone

subscribers has exceeded 100 per 100 inhabitants. We expect that, when we recalculate the growth rates based on estimated values for penetration potential, the difference in average growth rate between developed and emerging countries would enlarge. In the present study we calculated growth rates assuming that the penetration potential in developed countries is lower than in reality. The calculated growth rates are therefore an overestimation of the true growth rates as the ceiling in developed countries was set lower and is therefore sooner to reach than in reality. We calculated growth rates assuming that the penetration potential in emerging countries may be higher than in reality. The calculated growth rates are therefore an underestimation of the true growth rates as the ceiling in emerging countries was set higher and is therefore later to reach than in reality.

Fourthly the study does not test which country characteristics have an effect on the diffusion of mobile telephony. Diffusion studies about mobile telephony have identified several such country characteristics, although they do not always agree on the statistical significance of certain factors.

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Appendix

Country	Rate of diffusion growth	Region	R^2	Number of observations
Czech Republic	0.982	Central and Eastern Europe and the Commonwealth of Independent States	0.998	16
Tajikistan	0.965	Central and Eastern Europe and the Commonwealth of Independent States	0.957	10
Albania	0.919	Central and Eastern Europe and the Commonwealth of Independent States	0.934	10
Romania	0.914	Central and Eastern Europe and the Commonwealth of Independent States	0.928	13
Moldova	0.867	Central and Eastern Europe and the Commonwealth of Independent States	0.904	12
Lithuania	0.865	Central and Eastern Europe and the Commonwealth of Independent States	0.974	15
Ukraine	0.863	Central and Eastern Europe and the Commonwealth of Independent States	0.969	14
Slovakia	0.828	Central and Eastern Europe and the Commonwealth of Independent States	0.955	16
Russian Federation	0.824	Central and Eastern Europe and the Commonwealth of Independent States	0.983	15
Kazakhstan	0.823	Central and Eastern Europe and the Commonwealth of Independent States	0.946	13
Kyrgyzstan	0.794	Central and Eastern Europe and the Commonwealth of Independent States	0.997	8
Poland	0.789	Central and Eastern Europe and the Commonwealth of Independent States	0.978	15
Bulgaria	0.785	Central and Eastern Europe and the Commonwealth of Independent States	0.991	14
Georgia	0.785	Central and Eastern Europe and the Commonwealth of Independent States	0.806	12
Bosnia and Herzegovina	0.779	Central and Eastern Europe and the Commonwealth of Independent States	0.933	11
Portugal	0.777	South Europe	0.995	18
Serbia and Montenegro	0.775	Central and Eastern Europe and the Commonwealth of Independent States	0.941	10
Croatia	0.760	Central and Eastern Europe and the Commonwealth of Independent States	0.957	17
Israel	0.739		0.989	17
The former Yugoslav Republic of Macedonia	0.738	Central and Eastern Europe and the Commonwealth of Independent States	0.975	11
Slovenia	0.734	Central and Eastern Europe and the Commonwealth of Independent States	0.965	16
Brazil	0.723	Latin America	0.894	16
Estonia	0.715	Central and Eastern Europe and the Commonwealth of Independent States	0.987	16
Belarus	0.714	Central and Eastern Europe and the Commonwealth of Independent States	0.951	14

Country	Rate of diffusion growth	Region	R^2	Number of observations
Greece	0.702	South Europe	0.956	14
Hungary	0.701	Central and Eastern Europe and the Commonwealth of Independent States	0.988	17
Latvia	0.684	Central and Eastern Europe and the Commonwealth of Independent States	0.991	15
Italy	0.678	South Europe	0.989	21
Spain	0.666	South Europe	0.993	21
Armenia	0.655	Central and Eastern Europe and the Commonwealth of Independent States	0.910	10
China	0.653	East Asia and the Pacific	0.962	20
South Africa	0.653	Sub-Saharan Africa	0.958	17
Azerbaijan	0.641	Central and Eastern Europe and the Commonwealth of Independent States	0.919	13
Luxembourg	0.635	Western Europe	0.957	22
Morocco	0.635	Arab States	0.977	20
India	0.634	South Asia	0.988	12
Jordan	0.607	Arab States	0.969	17
Ireland	0.581	Western Europe	0.987	22
Germany	0.580	Western Europe	0.961	22
Egypt	0.572	Arab States	0.924	20
Turkey	0.566	Southern Europe	0.966	20
Uzbekistan	0.562	Central and Eastern Europe and the Commonwealth of Independent States	0.930	13
Korea, Republic of	0.553	East Asia and the Pacific	0.974	21
Belgium	0.542	Western Europe	0.976	20
Argentina	0.542	Latin America	0.964	18
Mexico	0.541	Latin America	0.924	19
Netherlands	0.539	Western Europe	0.980	21
Indonesia	0.530	East Asia and the Pacific	0.985	23
United Kingdom	0.523	Western Europe	0.919	22
Chile	0.517	Latin America	0.988	18
Austria	0.511	Western Europe	0.965	22

Country	Rate of diffusion growth	Region	R^2	Number of observations
Pakistan	0.501	South Asia	0.948	17
Philippines	0.498	East Asia and the Pacific	0.989	16
France	0.497	Western Europe	0.978	21
Australia	0.493	Oceania	0.967	20
Thailand	0.489	East Asia and the Pacific	0.941	21
Peru	0.478	Latin America	0.958	17
Switzerland	0.469	Western Europe	0.975	20
Colombia	0.466	Latin America	0.944	13
Iceland	0.455	Nordic Region	0.924	21
Sweden	0.444	Nordic Region	0.915	26
Japan	0.439	East Asia and the Pacific	0.978	26
New Zealand	0.430	Oceania	0.980	19
Malaysia	0.413	East Asia and the Pacific	0.994	21
Denmark	0.389	Nordic Region	0.977	25
Norway	0.386	Nordic Region	0.959	26
United States	0.372	North America	0.962	23
Turkmenistan	0.346	Central and Eastern Europe and the Commonwealth of Independent States	0.758	9
Finland	0.342	Nordic Region	0.972	27
Canada	0.337	North America	0.940	21

Source: own calculations based on data from United National Statistics Division, 2008.

Table A1. Country overview

Country	BOP (millions)			BOP income segments						% of ICT
	millions	% of total population	% that lives in urban area	BOP 3000	BOP 2500	BOP 2000	BOP 1500	BOP 1000	BOP 500	expenditure coming from the BOP
				% of national population						
CENTRAL AND EASTERN EUROPEAN COUNTRIES AND THE COMMONWEALTH OF INDEPENDENT STATES										
Belarus	8.9	87.3	68.7	10.3	17.9	25.9	23.1	9.7	0.4	74.5
Macedonia	1.2	58.2	54.1	10.7	13.6	13.6	12.7	6.8	0.8	21.3
Tajikistan	6.7	99.7	26.9	0.5	1.5	6.1	19.1	49.9	22.6	90.5
Kazakhstan	14.2	91.8	53.4	7.5	13.3	20	27.8	21.7	1.5	73.7
Russia	71.9	61.4	60	12.1	13.9	13.9	12.1	7.8	1.5	34.9
Ukraine	27.9	60.5	60.6	16	18.6	15.7	8.4	1.7	0.1	30.3
Uzbekistan	23.7	99.5	36.5	0.5	1.2	3.1	11.4	48.7	34.5	57
LATIN AMERICA										
Brazil	124.5	70.7	78.2	7	8.6	11.8	15.2	18.6	9.5	27.2
Colombia	25.2	57.6	73.8	9.5	10.6	11.8	11.9	10.3	3.4	11.5
Mexico	72.4	69.6	68.7	9.3	12.7	16.6	16.3	11.9	2.7	29.5
Peru	24.7	90.4	61.5	5	9	14.9	24.4	29.1	8	46.1
SOUTH ASIA										
India	924.1	95	22	3.2	7	15.1	31.8	35.9	2	52.6
Pakistan	129.1	100	28.5	0.3	0.9	2.3	9.8	52.3	34.4	92.3
EAST ASIA AND THE PACIFIC										
Indonesia	206.8	99.1	45.1	1	2.4	6.1	17.1	51.9	20.6	78.9
Thailand	43.3	75.4	18.5	8.4	11.8	16.8	22.5	15.1	0.7	28.6
SUB-SAHARAN AFRICA										
South Africa	31.7	74.4	46.9	4.8	6.7	9.8	15.1	23.5	14.5	13.8

Source: Hammond *et al.*, 2007

Table A2. Data about the bottom of the pyramid in 16 of the observed countries