DRUID Working Paper No. 11-09

Decomposing First Mover Advantages in the Mobile Telecommunications Industry

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This version: 30 July, 2011

Abstract:
We study first-mover advantages and organizational pre-entry experience in a market with highly heterogeneous consumers – the global mobile telecoms industry. Specifically, we consider the fact that early consumers will be different from later ones. We suggest that early entrants will attract higher-value consumers, which results in first-mover advantages. This effect will be enhanced if these firms have acquired prior technical experience. Conversely, later, mass-market adopters are attracted by established (domestic) brand names. Our empirical results from the global telecommunications industry support our assertions and provide importation insight for the study of first-mover advantages in high-technology industries.

Keywords: First-mover advantage; Mobile telecommunications; Consumer-centric; Pre-entry experience; Firm pre-entry experience

Jel codes:

ISBN 978-87-7873-320-7

INTRODUCTION

Following decades of research on first mover advantages across a number of disciplines (Lieberman and Montgomery 1988; Kerin, Varadarajan and Peterson 1992; Huff and Robinson 1994), recent studies on entry timing largely focus on the contingent nature of first mover advantages, or conditions under which firms may or may not gain an advantage from early entry. This stream of research studies both macro conditions of the external environment (Suarez and Lanzolla 2007) and micro conditions of the firm itself (Franco, Sarkar, Agarwal and Echambadi 2009). Our study extends this line of inquiry by focusing on the fit between the experience of the firm (micro) and the conditions of the external environment (macro), namely the demands of heterogeneous consumers. We focus on consumer preferences as an important environmental context because it is well established in the innovation diffusion literature that there are important differences between early- and late-adopting consumers of a new technology (Mahajan, Muller and Srivastava 1990; Rogers 1995). Specifically, research shows that early adopters are often high-intensity consumers (Cabral 1990, Grajek and Kretschmer 2009), suggesting that consideration of demand-side characteristics is important for competitive advantage (Adner and Zemsky 2006; Makadok 1998). However, the implications of consumer heterogeneity for our understanding of first mover advantages have not been explored.

We offer an integrated view of which types of firms enjoy advantages in a new market based on differences in consumer segments. This consumer-based view of advantages created by entrants suggests that some firms appeal most to early, high-valuation adopters, while others will be successful in attracting a large number of adopters, but not necessarily the highest-value ones. To assess the fit between firm characteristics and consumer preferences, we use data on the emergence of second-generation (2G) mobile phone markets across thirty countries. Our exceptionally detailed and comprehensive data allow us to show how an established brand name helps firms attract mass-market consumers (less valuable but in greater numbers), while the reputation developed by early entry and the possession of prior technological (2G) experience help firms attract more valuable technology-savvy and business consumers. Our findings contribute to research on pre-entry experience (Bayus and Agarwal 2007; Helfat and Lieberman 2002; Klepper and Simons 2000) by considering the fit between firm experience and consumer needs, and to the literature on the mechanisms driving first-mover advantages (Lieberman and Montgomery 1988; Robinson 1988; Robinson and Fornell 1985) by focusing on consumer-driven means of advantage creation.

Beyond addressing the importance of consumer heterogeneity as a conditioning factor for entry timing advantages, this study makes two additional contributions. First, we offer what to our

knowledge is the first study of entry timing advantages in mobile telecommunications, a vital and sizable global industry, that goes beyond a simple market share measure. Second, we make a methodological contribution by utilizing a two-step empirical approach that can be fruitful in the future for rigorous study of time-invariant factors such as entry timing and pre-entry experience.

CONCEPTUAL FRAMEWORK

Following some inconclusive and conflicting findings on first-mover advantages (Boulding and Christen 2003; Golder and Tellis 1993; Lilien and Yoon 1990), recent research has focused on the role of macro- (Suarez and Lanzolla 2007) and micro- (Franco et al. 2009) contingencies that drive first-mover advantages. The latter perspective suggests that firm level pre-entry experience (Helfat and Lieberman 2002; King and Tucci 2002; Klepper and Simons 2000) is important because the capabilities generated from experience help firms create and sustain first-mover advantages. For example, Franco *et al.* (2009) focus on how technological capabilities allow early entrants to be successful in the high-tech disk drive industry. However, for pre-entry experience to be useful in a new market or industry, the resulting capabilities must be valued and transferable across markets (Danneels 2007; Tripsas 1997). Thus, the fit between the prior organizational experience of a firm and market requirements – the macro-level conditions that drive entry order advantages – are key to generating competitive advantage.

One fruitful way to think about the requirements of the external environment is to consider the implications of a heterogeneous consumer base in the market (Adner 2002; Adner and Zemsky 2006). Research on innovation diffusion suggests that adopters can be divided into categories based on when they adopt the innovation, and that there are important differences between adopter categories. Rogers (1995), for example, highlights how early adopters are more likely to be technology-savvy and interested in the functionality offered by a new innovation, while later adopters may be driven more by the behavior of other adopters. Research on the adoption of innovations with network effects finds that early adopters of a new technology are likely to be those with the highest willingness to pay for the innovation, as they are willing to purchase without guaranteed network benefits and before the technology's commercial success is assured (Cabral 1990; Cabral, Salant and Woroch 1999, Farrell and Saloner 1986, Kretschmer 2008). Rogers (1995, pp. 269-270) cites early adopters as having more education, greater social status and mobility – all factors related to wealth (and implicitly willingness to pay). This suggests that early adopters can potentially be more valuable for firms supplying them, which aligns with suggestions from marketing practitioners that consumers that have been with the firm longest are generally the most profitable (Reichheld and Sasser 1990; Zeithaml, Rust and Lemon 2001).

Taken together, these perspectives on first-mover advantages – firm pre-entry experience and the characteristics of early and late adopters – offer up three claims for further empirical investigation. First, the point that early adopters will have a higher willingness to pay for the service or product than late adopters suggests a specific avenue for generating first-mover advantages. Early entrants to a new industry or market will be more profitable if firms can create switching costs to preserve their early consumers (Farrell and Klemperer 2007; Regibeau and Rockett 1996; Schilling 2002). This firm-level advantage will be built on the quality of the consumers the firm serves and not on market share or overall level of penetration. Presuming some fixed cost to serve each individual consumer, these early consumers will likely be the ones that utilize the firm's services and products more regularly, thus generating more net revenue for the firm. In short, we expect early entrants to capture consumers that are more profitable per person.

Second, the quest of early entrants to attract and keep more profitable consumers will be aided by pre-entry experience that helps them appeal to early adopters. Specifically, technological experience and a technology-focused brand will improve the performance of early entrants with early adopters, as this type of firm will be more likely to offer a product or service that those consumers value. This leads to the expectation that the positive effect of early entry will be stronger for firms with prior technological experience, as this experience will help them attract more valuable consumers. That is, technologically experienced firms will gain more from a window of opportunity through early entry.

Finally, late adopters will be driven more by adoption of others and marketing messages such as familiar brand names, as brand names have been found to be sustainable forms of advantage (Urban, Carter, Gaskin and Mucha 1986; Brown and Lattin 1994). These consumers are less technology-savvy than early adopters, and so a trusted brand name is a safer choice. We thus expect an established brand name and distribution network to provide a benefit to firms, but it will be largely the opposite of the benefit of early entry discussed above – brand names will help firms attract more consumers overall, but they will be less valuable on average than those attracted by early entrants. Hence, established brands will have higher market share, but not necessarily more high-value consumers.

These three arguments combined suggest that explicitly considering the implications of consumer heterogeneity for entrant firms can help advance research on first-mover advantages. Different consumers drive different paths to profitability, and the ability of firms to attract those consumers is contingent on entry timing, pre-entry experience and the fitness between the two. In this study and based on the theoretical perspectives offered above, we focus on three characteristics of firms – entry timing, technical experience, and established brand name – and two market outcomes –

average usage intensity and firm market share and subscribers – to investigate the different implications for firm profitability.

THE MOBILE TELECOMMUNICATIONS INDUSTRY

Mobile telecommunications, and specifically the launch of second generation (2G) networks,[1] has been one of the most successful and economically significant technology introductions in the past decades. Moreover, introductory offers (e.g. subsidized handsets), long-term contracts and network effects created through on-net discounts[2] (Laffont et al. 1998, Cabral 2011) suggest that early movers can indeed capture and keep early consumers through switching costs and network effects, giving rise to potential first-mover advantages (Lieberman and Montgomery 1989, Mueller 1997; Bijwaard et al. 2008). Indeed, prior research shows that early adopting consumers tend to be heavy users (Grajek and Kretschmer 2009, Cabral 2006), so that building an installed base early may increase firm revenues and profits by adding more consumers and attracting more profitable consumers, with the presumption that the industry's switching costs will help preserve this advantage even as competition increases.

The mobile telecommunications industry is a fruitful setting for our understanding of first-mover advantages and pre-entry organizational experience for several reasons:

First, the industry allows for a clear definition of first movers. Market structure in mobile markets was typically determined by granting licenses to a limited number of operators. Later, additional firms were granted a license to operate, which provides a clear distinction between first-movers and latecomers within a single technological generation. There is also a clear definition of firms with in-country telecommunications experience, though they may or may not possess experience in 2G: In most countries there was an incumbent for fixed-line telephony and firms may have offered 1G (analog) mobile services. While the technology of rolling out 2G was significantly different (fixed line was delivered through ducts as opposed to wireless transmission, while 1G towers and transmission technology were analog and significantly different from 2G), it provided incumbents with an established brand name that they could extend to mobile services.

Second, mobile phone users make two decisions: First they decide to adopt a mobile phone or not, and second they make (more or less) continuous usage decisions. This opens up at least two channels

[1] First Generation (1G) networks were generally unsuccessful at attracting adopters given their setup costs.

[2] That is, it is cheaper to call others on the same network than on competing networks.

for firm-level advantages: some firms may be good at attracting a larger volume of subscribers, and some firms may be successful at attracting higher-value users. Distinguishing between these two dimensions (consumer usage and market share) is important for identifying consumer heterogeneity as a driver of first-mover advantages as suggested by our conceptual considerations above.

Finally, the entry process is fairly regulated, which makes for a comparatively clean setting in which to study first-mover advantages. To operate a 2G network, operators needed a spectrum license, which was issued by the respective domestic governments. Governments typically issued between two and four licenses after determining permissible technological standards. This implies that a major factor confounding first-mover advantages with other sources of competitive advantage – access to better technologies – has been largely eliminated from our research setting.[3] Moreover, the technologies were specified beforehand and made available to the operators on a nondiscriminatory basis so that firms could enter as soon as they had the license and built the network infrastructure. Differences in development speed thus do not affect the likelihood of being a first mover in the industry.

DATA AND DESCRIPTIVE ANALYSIS

We draw our data predominantly from two sources used in previous studies (Genakos and Valletti forthcoming, Koski and Kretschmer 2005, Grajek and Kretschmer 2009): The Informa Telecoms & Media World Cellular GSM Datapack (Informa T&M) and Merrill Lynch's Global Wireless Matrix. The Informa T&M data covers the number of subscribers for individual mobile operators, average prices and technological standards in considerable detail. Informa T&M is a provider of market and business intelligence to commercial entities in the mobile and media industries. Buyers of this data base commercial decisions on the data, ensuring a high level of accuracy. Merrill Lynch publishes a quarterly report on the development of the global mobile telephony market as a service to clients and industry observers. Merrill Lynch reports, among other data, the total number of called minutes per operator, which we use to construct the average usage per consumer.[4]

To complement our main data, we use IMF's International Financial Statistics (for GDP) and World Bank's World Development Indicators (for population, telephone mainlines, and average cost of a

[3] We discuss in our robustness section the potential role technological heterogeneity could still play even in our controlled setting.

[4] We triangulated the above data with available public data sources (OECD's Communications Outlook, ITU's Telecommunications Indicators) and found that the variables common to both private and public data were comparable. We are therefore confident that our data is accurate.

local call). The disadvantage of the WDI database is that it only provides yearly time series. To arrive at quarterly data we linearly interpolated the variables.[5] We also gather data on firm structure and ownership to assess whether firms had access to knowledge from previous entries or incumbency through major shareholders. These data were drawn from company histories, news reports, and prior research on the evolution of the mobile telecommunications industry (Noam & Singhal, 1996). The authors and a research assistant collected data on firm experience, and resolved any uncertainty by group evaluation. In the case of firms with multiple investors, we considered an investor's prior experience relevant if the investor owned 25% or more of the firm, which is generally considered the cutoff between a financial and a strategic investment.

Our sample covers quarterly data on 90 mobile phone network operators in 30 countries from the fourth quarter of 1998 through the second quarter of 2004. We observe the profitability of each network at the SBU (i.e. country) level (*EBITDA*). We observe average usage on each operator's network (Minutes of use, *MoU*) as well as the number of subscribers (*CellSubs*)—including prepaid card users (*Prepay*)—and the price they pay for the service measured as average revenue per minute (*CellP*). Further, we have the number of subscribers and the price of the fixed-line telephone service in each country (*FixedSubs* and *FixedP*), the country's GDP and whether the country was among the first to adopt the 2G technology (*EarlyCountry*). If the firm was the first to offer service in the country, we tag them as an early entrant (*EarlyEntrant*).[6] Finally, we construct a set of dummy variables indicating if a firm had prior experience with 2G in other countries, prior 1G experience in the focal country or if it was a fixed-line incumbent to capture the different technology- and application-specific knowledge that the firm may have accumulated pre-entry (Sosa 2009). We expect prior 2G experience to bring technological experience (*Tech*), which might enable superior performance directly or via enhancing first-mover advantages. Conversely, prior engagement in fixed-line and 1G mobile services is expected to give operators resources that affect sales and brand image (*Brand*) in the focal country. Variable definitions and descriptive statistics are reported in Table 1, a full correlation matrix is in the Appendix.

[5] Experimenting with other interpolations does not change the results.

[6] In some cases, two firms entered at the same time and both were tagged as early entrants. In fact, 22 out of the 41 early entrants in our sample are of this sort. In general, there were only 3-4 firms in each market so finer-grained distinctions on entry timing have not been possible to investigate.

INSERT TABLE 1 ABOUT HERE

A first look descriptive statistics for the data suggests that two of our three primary independent variables – *EarlyEntrant*, *Brand* and *Tech* – are related to firm profitability (as measured by EBITDA margins). The data in Table 2 indicate that early entrants realize higher profits than later entrants, and that firms with prior in-country brand experience also have higher margins than those without. Firms with out-of-country 2G experience before entry show slightly lower profits on average. While these observations are purely descriptive, they are at least suggestive that these three measures capture important variation between firms.

INSERT TABLE 2 ABOUT HERE

As our goal is to provide a fine-grained analysis of the drivers of advantage based on entry timing and pre-entry experience, we look deeper than just EBITDA. As discussed above, mobile networks are predominately a fixed cost business (building the network) and in-country price competition largely standardizes prices in each country, so profits are driven in large part by the number of minutes of usage the company sells. Minutes sold can further be dissected into subscribers (*CellSubs*) and usage (*MoU*), since:

$$\#\,subscribers \times \frac{minutes}{subscriber} \equiv totalminutes$$

This theoretical relationship – that *CellSubs* and *MoU* drive *EBITDA* – can be tested within the data. To do so we first look at a correlation matrix.

INSERT TABLE 3 ABOUT HERE

Table 3 shows that the number of subscribers is positively related to EBITDA, but that usage and profits are negatively correlated. This negative relationship should disappear once we control for the number of subscribers since penetration is negatively correlated with usage as the marginal

consumers added to mobile networks over time are less intensive users.[7] This is supported in Table 4 in a simple regression with firm fixed effects. Here, both penetration (*CellSubs*) and usage (*MoU*) are strongly positively related to profitability. We therefore focus on understanding how our variables of interest – *EarlyEntrant*, *Brand* and *Tech* – relate to penetration and usage.

INSERT TABLE 4 ABOUT HERE

ANALYSIS AND RESULTS

As discussed above, the core regression analyses in this study focus on two dependent variables – usage (*MoU*) and penetration (*CellSubs*) – that are both strongly correlated with firm profitability. The challenge is that the decision to subscribe to a mobile network and how many minutes to use are largely made simultaneously and the endogeneity between the two make it difficult to cleanly identify the effect of firm-level variables on these outcomes. To address this, we utilize a two-step approach. First, we use simultaneous equations with instrumental variables to build models of penetration and usage that include many of the time-varying variables introduced earlier as well as firm fixed effects. Second, as our core variables of interest (*EarlyEntrant*, *Brand* and *Tech*) are firm specific and time-invariant, we extract the firm fixed effect from the first set of regressions and run second-stage regressions with the fixed effects as our dependent variables. This allows us to alleviate concerns about endogeneity and simultaneity in the first stage and then investigate time-invariant effects in the second stage. More detail and the results are given below.

Entry Timing and Mobile Networks: A Model of Usage and Subscriptions

We propose a simultaneous-equation model to investigate the nature of performance based on entry timing and pre-entry experience:

$$MoU_{ijt} = \alpha_{ij} + \delta_0 * MoU_{ij(t-1)} + \delta_1 * CellP_{ijt} + \delta_2 * CellP_{i(-j)t} + \delta_3 * FixedP_{it} + \delta_4 * CellSubs_{ijt} + \delta_5 * CellSubs_{i(-j)t} + \delta_6 * FixedSubs_{it} + \delta_7 * GDP_{it} + \delta_8 * Prepay_{ijt} + \varphi_t + \varepsilon_{ijt}, \quad (1)$$

$$CellSubs_{ijt} = \beta_{ij} + \gamma_0 * CellSubs_{ij(t-1)} + \gamma_1 * CellP_{ijt} + \gamma_2 * CellP_{i(-j)t} + \gamma_3 * FixedP_{it} + \gamma_4 * MoU_{ijt} + \gamma_5 * CellSubs_{i(-j)t} + \gamma_6 * FixedSubs_{it} + \gamma_7 * GDP_{it} + \gamma_8 * Prepay_{ijt} + \rho_t + \zeta_{ijt}, \quad (2)$$

[7] The dilution effect can be seen in Table 2 and is documented by Grajek and Kretschmer (2009).

where i, j, and t refer to country, mobile network operator, and time, respectively. Equation (1) seeks to explain the average usage intensity of a subscriber to a given operator with a number of factors including mobile phone and fixed-line prices, network sizes and other covariates relevant for usage. In particular, we consider own price ($CellP_{ijt}$), the average price of other mobile network operators in the country ($CellP_{i(-j)t}$), and the price of local fixed-line connection ($FixedP_{it}$) as well as an operator's own network of subscribers ($CellSubs_{ijt}$), subscribers to other mobile network operators ($CellSubs_{i(-j)t}$), and fixed-line subscribers ($FixedSubs_{it}$). Moreover, we control for GDP per capita (GDP_{it}) and the share of prepaid consumers in own subscriber base ($Prepay_{ijt}$). We control for global conditions affecting telecommunications (namely technological advances and the telecom recession of the early 2000s) with fixed effects for each time period (φ_t *and* ρ_t). Finally, we also include lagged usage ($MoU_{ij(t-1)}$) to control for consumer inertia and learning and operator-specific effects (α_{ij}), which capture the unobserved heterogeneity among operators.[8] Equation (2), which explains the number of subscribers to a given operator as a fraction of total population in the country, is specified analogously. We allow the error terms ε_{ijt} and ζ_{ijt} to be heterogenous and possibly correlated. Thus, we allow the subscription and usage of mobile phones by consumers to be a joint decision that may be influenced by the same missing factors in both equations.

Since equations (1) and (2) contain both lagged dependent variables and operator-specific fixed effects we apply the estimation method proposed by Arellano and Bond (1991), which delivers consistent estimates under the assumption of no serial correlation in the error term and is routinely used for this class of models. We instrument for prices, network sizes, and the prepay share, as they are potentially endogenous in both equations, as discussed in more detail in the Appendix. The goal of these equations is to obtain operator-specific effects, which we will then regress on our measures of entry timing and pre-entry experience.

Table 5 presents regression results of mobile phone usage and penetration equations (1) and (2). The test statistics of both the Arellano-Bond AR(2) test and the Hansen J test of overidentifying restrictions are not significant, giving us confidence in the instruments used for estimation.

INSERT TABLE 5 ABOUT HERE

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[8] These effects are often referred to as fixed effects, as they are invariant across time.

As discussed before, the results in Table 5 are not the focus of this study, as we use this regression to obtain firm-level operator-specific effects further investigated below. It is however worth briefly looking at the results. Lagged dependent variables are strong predictors in both equations confirming strong inertia in both usage and subscription choices. Moreover, own price and network size are negative and significant in the usage equation, as expected. This latter effect can be explained by less heavy users joining as the network grows, consistent with Grajek and Kretschmer (2009). The coefficient on price of other operators (negative and significant at the 10% level) provides some evidence of complementarity in usage of mobile phones across networks. This can be explained by reciprocity: users may tend to call back after being called. Prepay share and GDP are also significant and have the expected signs—negative and positive, respectively—in the usage equation. In contrast, own price is not statistically significant in the penetration equation and GDP is actually negative and significant. One explanation is that since the operator-specific effects account for a large part of cross-sectional variation in the data, the time-series variation in GDP and prices is not enough to generate the expected effect. In the case of GDP, we believe that higher GDP countries (with correspondingly larger absolutely changes in GDP over time) are likely to be countries where 2G was launched earlier (consistent with the 0.51 correlation between the *EarlyCountry* and *GDP* variables), so that these countries are further along their diffusion curve. Hence, large changes in GDP (mostly driven by firms in high-GDP countries) produce a smaller change versus the lagged dependent variable as the growth curve in that country is decelerating versus lower GDP countries. Exclusion of the GDP variable does not alter our second stage results. Interestingly, average usage intensity is estimated to be positive (at the 10% significance level) suggesting that high-intensity users may be more influential than low-intensity users in fueling mobile phone subscriptions. This finding is consistent with network effects being important for the later and less technically savvy subscribers.

To answer our core theoretical questions, we are primarily interested in the operator-specific effects from equations (1) and (2), and the relationships between these effects and our set of first-mover and firm experience variables. Before looking at those regressions, it is helpful to see the distribution of the effects visually, both overall and for early versus late entrants. These are shown in Figures 1a (for usage, *MoU*) and 1b (for penetration, *CellSubs*). From these graphs, we can see that these effects are generally normally distributed in each case. We can also see that early entrants seem to have an advantage over late entrants. This is especially pronounced for the *MoU* effects, where the distribution is clearly shifted to the right in the *Early Entrant* histogram. For the *CellSubs* histogram, the relationship is less obvious as the lowest group for *Early Entrants* is larger than for later entrants. However, the two highest bars are also larger for *Early Entrants*, suggesting that earlier entrants

seem to have a penetration advantage as well as a usage one, but the penetration effect may have higher variance as well, with some early entrants having very small market shares.

INSERT FIGURES 1a AND 1b ABOUT HERE

To investigate these relationships in more detail, we regress these operator-specific effects on our set of first-mover and firm experience variables and report the results in Table 6.[9] The first usage equation (1) shows that *EarlyEntrant* is positive and significant, suggesting that first movers do indeed attract more high-value consumers (those that use more minutes) and keep them even after entry by other firms. This suggests a uniform and continuous relationship between entry timing and the profitability of the consumers attracted by the firm. However, the coefficient on the interaction between *EarlyEntrant* and *Tech* is positive and significant in Model 3, while the main effect of *EarlyEntrant* drops out. This supports the second theoretical point offered earlier, namely that possession of pre-entry technological experience and technologically-focused reputation will reinforce an early entrant's ability to accumulate attractive and technology-savvy early adopters. This fully supports the contingent view of first mover advantages (Franco et al 2009; Parry and Bass 1990; Suarez and Lanzolla 2007), where early entrants only develop a usage-based advantage if they possess the requisite technological experience that appeals to the early consumers. Our third variable of interest, *Brand*, does not indicate any advantages in terms of usage intensity and the main effect of *Tech* is not significant in any model for usage.

INSERT TABLE 6 ABOUT HERE

In the penetration equations (4) through (6), however, we see that "brand operators" enjoy a significant advantage over firms without in-country marketing and distribution assets. The interaction term with *EarlyEntrant* and *Brand* is not significant, suggesting that the brand-based advantage in market share applies across early and late entrants. This supports our third theoretical suggestion that mere possession of a strong brand will help build a larger market share, but that the customers attracted will not necessarily be higher-value. In fact, all firms, including branded

[9] We focus on the two interactions that are theoretically of interest in this study, but have tested other interaction terms as well. The only significant interaction terms are included in Table 6.

operators are subject to the dilution effect that implies that growing one's network happens by adding lower-value consumers. The effect of *EarlyEntrant*, however, is more complex and once again depends on whether the firm possesses pre-entry technological experience. Model 6 shows that early entry is advantageous but only if the firm does not possess pre-entry technological experience, as the coefficient on *EarlyEntrant*Tech* more than cancels out the advantage of early entry. Pre-entry technological experience is negatively related to market share (in Models 4 and 5), specifically for those that enter early (Model 6). Thus, in terms of market share, the most advantaged firms are those that enter early and possess pre-entry marketing experience (*Brand*) but not technological experience (*Tech*). It thus appears that early movers with technological experience focus their efforts on securing usage advantages at the cost of giving up market share advantages. In contrast, early movers without technological experience strive for the brand-operator-like market share advantage.

The magnitudes of the advantages identified in Table 6 may seem small: they range from null (*Brand*) to 17.98 (*EarlyEntrant* and *Tech*) in terms of minutes of use and from -2.309 (*EarlyEntrant* and *Tech*) to 1.209 (*Brand*) in terms of penetration rate – approximately 10% of the average values shown in Table 1. To fully appreciate the estimated magnitudes, however, one needs to take into account the dynamic structure (i.e. the lagged dependent variables) and the interdependence of the estimated equations. Intuitively, the fixed effects alone do not reflect the fact that first-mover advantages are carried over from one period to the next by the lagged dependent variables and accumulate as a result. To address this, we calculate the usage and penetration advantages in the long run when the system of equations (1) and (2) reaches a steady state, i.e. $MoU_{ij(t)} = MoU_{ij(t-1)}$ and $CellSubs_{ij(t)} = CellSubs_{ij(t-1)}$. Calculated this way, the usage and the penetration effects associated with the combination of *EarlyEntrant* and *Tech* amount to 132.7 minutes and -2.6%, respectively, all else equal.[10] The Brand effects amount to -55.2 minutes and 6.2%. The magnitudes are thus much larger in the long run. Moreover, *Brand* yields a usage long-run disadvantage of 55.2 minutes while the short term effect in Table 6 is insignificant. This disadvantage is driven by the penetration advantage of 6.2%, which exerts downward pressure on average usage - later adopters are less intensive users, as shown by the negative coefficient on own subscribers in the usage equation in Table 5.[11]

Taken together, the results of our usage and penetration regressions suggest intricate first-mover advantages in the mobile phone industry, as simply being first to market is not normally enough to establish an advantage. Firms with pre-entry technological experience can capitalize on early entry

[10] We show the derivation of long-run advantages in the Appendix.

[11] This is also evident in the discussion on stagnant or even falling voice ARPU (Average Revenue per User) for most mature economies. See http://www.3g.co.uk/PR/Sept2007/5122.htm.

by attracting a higher quality installed base of consumers, but in turn face a penalty in market share. Conversely, possession of pre-entry in-country marketing experience allows firms to build a larger market share, but they are not able to attract more attractive consumers. And simply being first to market only has a direct effect on market share if the firm does not also possess pre-entry technological experience. These findings, potential mechanisms and implications are discussed later.

Robustness Checks and Endogeneity

We implemented a number of robustness checks to ascertain that our results are not an artifact of our specification. First, we excluded from the analysis countries with somewhat different characteristics than others. This meant excluding the U.S. alone (as the country has multiple different technological networks) and then all countries using Receiver Pays Policy (RPP, where the receiver of a call pays for minutes of usage as well). The former produces the same qualitative results, while the latter produces similar results with attenuated significance (as expected with a smaller sample and only 90 observations to begin with). Second, in some instances the same parent company owns or has a significant interest in multiple network operators, such as T-Mobile or Vodafone operating in multiple countries. To address this, we ran models with standard errors clustered at the parent company level, and obtained nearly identical results. Third, we included additional interaction terms in Table 6, but the only two that were significant are those reported in the paper.

It is also worth considering the endogeneity of entry timing. Most studies of first-mover advantages do not consider endogeneity (VanderWerf and Mahon 1997), but some recent ones have looked at whether their results may be subject to endogeneity (Franco et al 2009, Eggers 2010). Tests of endogeneity in the context of contingent first mover advantages, however, are difficult to interpret. For example, a common concern would be that only certain types of early entrants would be able to gain an advantage and so those would be the types of firms that enter early. This logic is consistent with the contingent view of first mover advantages – only certain types of early entrants will be able to gain an advantage. Thus, our results (for usage) would confirm that only high-quality early entrants are able to gain an advantage, and that "high quality" in this case means pre-entry technological experience. We tested this logic using data on the method of providing mobile licenses, with the idea that entrants chosen through more efficient processes (auction and comparative selection, or "beauty contest") would be more effective than those chosen by direct award.[12] The results for usage suggest that this is indeed the case, and that the key difference in quality is based on pre-entry technological experience. No such effect occurs for penetration (which is dominated by

[12] Results are available from the authors.

the uniform effect of pre-entry marketing experience). As a result, we look at this study as seeking to explain the endogeneity in advantage of early entrants in a way that is consistent with the contingent view of first mover advantages.

DISCUSSION

Our results suggest intricate patterns of first-mover advantages in the global mobile telephony industry. The theoretical framing of this study focuses on three types of firms – those that enter the industry (2G mobile network service) earlier than other firms, those that enter with pre-entry experience in 2G in another country, and those that enter with prior in-country experience (either in 1G or fixed line). Each of these types of firms exhibits some form of advantage in this industry, and these advantages can be tied to our consumer-centric view of entry timing and firm advantage. We discuss the results in greater detail below, with a focus on the underlying drivers of advantage.

We start with firms with in-country experience, modeled as firms that were either fixed-line incumbents and/or were active in 1G mobile telephony. Our regressions show that potential adopters across all consumer groups are more likely to choose an in-country incumbent as mobile operator, other things remaining equal (Table 6, Models 4-6). This points at two sources of first-mover advantages across technological generations: First, there is the possibility that existing fixed-line and 1G consumers are encouraged to subscribe to 2G services from the same supplier through direct advertising, discounts, etc. Specifically thinking about firms with 1G experience, these firms could easily transfer 1G subscribers to their 2G networks, for instance by allowing for exiting long-term 1G contracts without penalties. A second possible explanation is that incumbents enjoy higher reputation or awareness across all consumer groups, leading to a higher proportion of subscriptions even without pricing or other incentives. While it is difficult to unambiguously disentangle these two drivers, our evidence suggests that firms with previous in-country experience gain an advantage because they are able to attract a larger mass of low- to moderate-usage consumers, which increases profits in a fixed-cost business like mobile telephone networks.

The fates of the other two classes of firms – early entrants into the current generation (2G) and those with pre-entry experience in 2G in another country – are contingent on the other and differ dramatically for measures of customer attractiveness (usage) and market share (penetration). In terms of usage, the benefits of early entry are contingent on the possession of pre-entry 2G experience for the firm. Most early adopting consumers are technology-savvy (Rogers 1995) and tend to use their phones more intensively (Cabral 2006, Grajek and Kretschmer 2009). Thus, if there is an appropriate fit between the firm's experience (in this case pre-entry 2G) and the preferences of

the adopting consumers (early adopters in the early stages of the industry), the firm can build a sustainable advantage based on that fit (Table 6, Model 3). This "time window" for early entrants with the right experience is especially valuable as firms can sign up heavy users on long-term contracts, creating significant switching costs. Indeed, auxiliary results on the longevity of first-mover advantages (available from the authors) suggest that churn is fairly low and that on top of the monetary switching costs of breaking a long-term contract or waiting until it runs out, there are also significant non-pecuniary switching cost that extend beyond the average duration of a contract (such as concerns about number portability early in the industry's development). In any case, early entrants benefit from switching costs within a single technological generation, but that advantage is contingent on the possession of the type of experience that may appeal to their constituent users.

In terms of penetration and market share (Table 6, Models 4-6), however, the joint impact of early entry and pre-entry technological experience is quite different. In this case, early entrants can build an advantage only if they *do not* possess pre-entry technological experience in 2G. We suspect that this disadvantage for pre-entry technological experience is based on the fact that most firms with prior 2G experience are not domestic companies but multinational telecommunications companies. This fact may make them less attractive to the consumer base, especially to later adopters that may be swayed more by brand names. The near-perfect colinearity between our measure of *Tech* and any measure of being a foreign telecom company make it impossible to disentangle the two effects. But it is worth noting that early entrants without this "liability of foreignness" can build a market share advantage over later entrants. The considerable switching costs in the industry discussed above are the most likely source of this "classical" first-mover advantage in terms of market share.

CONCLUSION

In this paper, we take a consumer-centric perspective towards first-mover advantages in the global mobile telephony industry. Our data allow us to distinguish between different firm types based on their pre-entry experience and entry timing, and to investigate their profitability and the characteristics of their subscriber base. We find that first-mover advantages exist for early entrants through their ability to capture the most attractive (i.e. highest-usage) consumers, but that this advantage depends on the firm possessing pre-entry experience that fits with the likely preferences of early adopters. We also find that firms with in-country brand experience can build a larger market share among consumers, but that these are not necessarily the most valuable consumers.

We contribute to the strategy, marketing and economics literatures on first-mover advantages by emphasizing the role of consumer heterogeneity for studying entry timing advantages. Focusing on

consumer heterogeneity allows us to show that first-mover advantages are multifaceted and that researchers should take into account different measures of success. This implies that measuring first-mover advantages in terms of (persistent) market share differences or profits may be incomplete for more complex technologies. The theory and data let us refine our understanding of the underlying mechanisms for first-mover advantages (Lieberman & Montgomery, 1988), and we think that future research on first-mover advantages would benefit from incorporating consumers explicitly.

Our work also contributes to research on first-mover advantages by studying firm-level heterogeneity tied to firm-level experience. Pre-entry experience can both drive organizational advantage directly (Helfat and Lieberman, 2002; Klepper and Simons, 2000) and by conditionally affecting first-mover advantages (Franco et al, 2009). Our finding that incumbents of a previous technological generation may enjoy an advantage even if they do not enter the new generation straightaway suggests that future work on early-mover (or entry order) effects has to consider market positions in earlier generations. Distinguishing between previous- and current generation market positions may also help differentiate between sources of first-mover advantages: If they accrue mainly from being first in for the current generation, a competitive advantage would erode with technological change, and resources are technology-specific. Conversely, if advantages accrue from having held a prominent position in previous product generations, competitive advantage may be built on reputation that is largely independent of the active technology at any time.

We also contribute to the emerging literature on the evolving nature of firm-level advantages in the mobile telephony industry. Focusing on this global and economically important industry, our analyses show that different types of experience have helped firms improve their profitability, though in different ways, and that entry timing in this industry (given the significantly higher value of early consumers and the presence of switching costs) plays a vital role in understanding firm profitability. This has important implications for managers in this industry specifically, but also for other technology-driven and complex industries. Specifically, maximizing market share by entering early may involve a tradeoff as adopters attracted through introductory offers may not be commercially attractive as they are less intensive users of the secondary good or service.

Our study has several limitations and could be extended in several ways. First, we study a specific industry at a specific time. While we believe that the global telecommunications industry is a useful testing ground for more refined concepts of first-mover advantage, the validity of usage intensity as a measure of success as well as the differences between previous-generation incumbents and early current-generation entrants have to be identified in other industries. However, we believe that industries with similar product characteristics (i.e. a durable baseline product or service and repeated

purchases of auxiliary services) and similar technological dynamism and the associated generation changes would benefit from a similarly extended analysis of first-mover advantages.

Further, we do not have enough information to unambiguously identify the true drivers of first-mover advantages. Our different definitions of early movers, however, can be helpful in identifying likely sources of first-mover advantages, and in particular their longevity in technologically dynamic markets. Our results suggest that within a technological generation the early stages determine firm success for this generation, but that there is a degree of transferability of advantages across generations, as indicated by the positive effect of previous-generation incumbents. This is consistent with at least two distinct drivers of first-mover advantages. First, early movers benefit most from consumer inertia due to switching costs. Combined with the finding that the first subscribers to a technology tend to be heavy users, it allows early entrants to lock in the most profitable consumer group. Second, incumbents, i.e. early entrants in previous generations of the technology, seem to benefit from transferring subscribers across technological generations or reputation effects. This is consistent with our finding that incumbents' advantage manifests in market penetration rather than consumer profile because both reputation and transferring subscribers across generations are likely to affect all consumer groups. Taken together, our results give some indication of where to search for further information on the nature of first-mover advantages in future research.

This study looks at entry order advantages and the role of firm-level experience. We specifically consider the fact that early adopting consumers will be different from late adopting ones. We suggest that early entering firms will attract higher-value consumers, which is a key source of first-mover advantages. This effect is stronger for firms with strong technological experience as early adopters are generally more technology-oriented than late adopters. Conversely, firms with existing marketing and branding resources in a particular country will do better at attracting a high volume of lower-value consumers – standard late adopters influenced by brand effects and awareness. Our empirical results on the global mobile telecommunications industry confirm our expectations and help us offer important depth to the discussion about first-mover advantages and the contingent role of firm pre-entry experience.

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Fig. 1a. Histograms of Firm Fixed Effects from Usage Intensity Regression

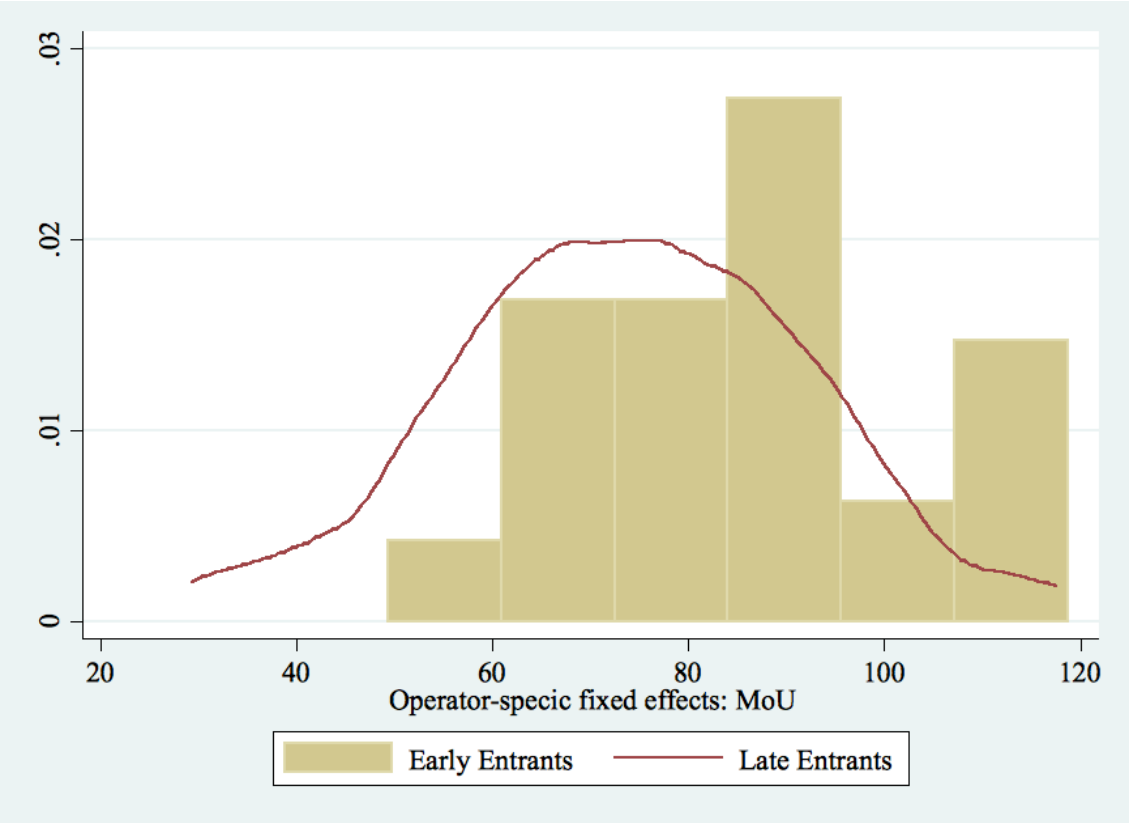
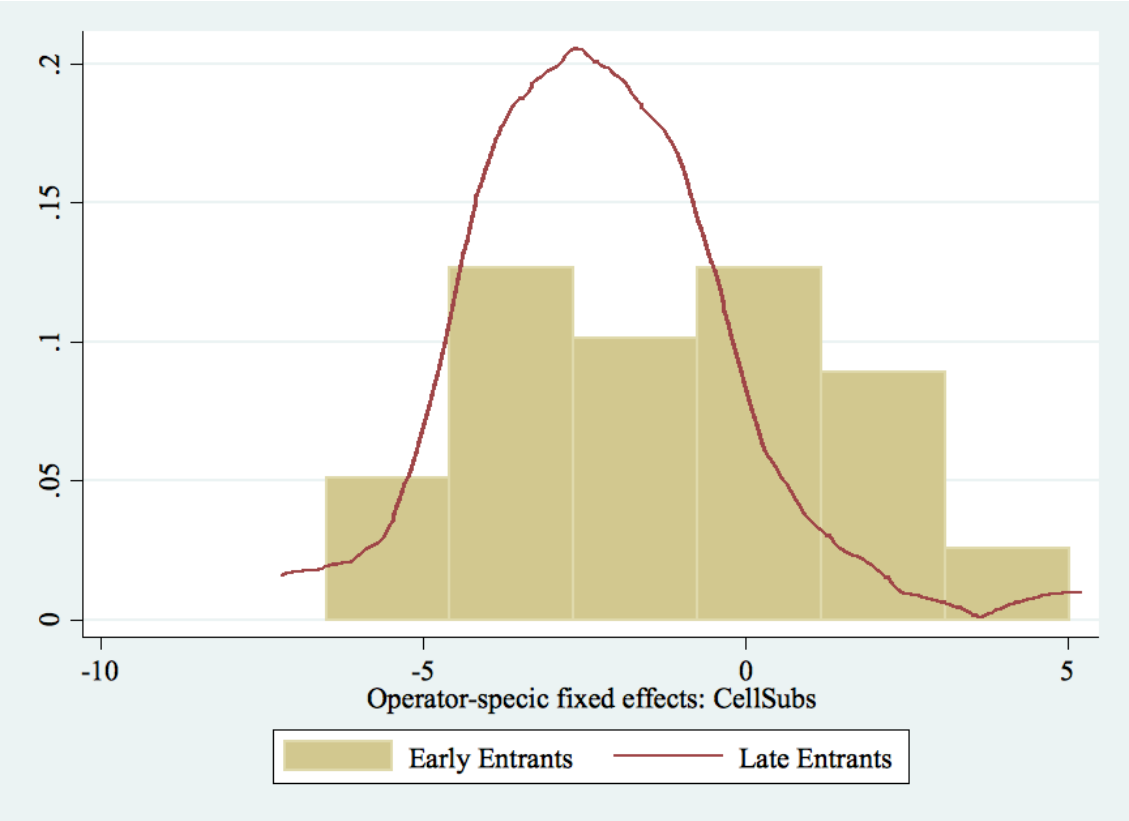


Fig. 1b. Histograms of Firm Fixed Effects from Penetration Regression



Tab. 1. Variable definitions and descriptive statistics

Variable	Definition	Obs.	Mean	Std. Dev.	Min	Max
MoU	Average monthly minutes of use (number of minutes)	1044	172.82	102.91	56	660
CellSubs(j)	Subscribers to a given operator as population's share (%)	1044	16.80	11.89	0.10	51.90
CellSubs(-j)	Subscribers to competing operators as population's share (%)	1044	34.11	17.61	1.10	83.41
FixedSubs	Fixed-line subscribers as population's share (%)	1044	48.05	16.56	10.49	75.67
CellP(j)	Average revenue per minute of a given operator (US cents)	1044	20.87	8.59	0	53.68
CellP(-j)	Average revenue per minute of competing operators (US cents)	1044	20.72	7.96	3.38	53.68
FixedP	Price of a local fixed-line connection (US cents)	1044	8.46	5.45	0	19
GDP	GDP per capita (000's US dollars)	1044	20.37	10.53	0.89	47.84
Prepay	Share of prepay users among given operator's subscribers (%)	1044	43.11	28.07	0	95.20
EarlyEntrant	First 2G mobile network operator in a given market (dummy)	1044	0.47	0.50	0	1
Brand	Incumbent fixed-line operator or or 1G service operator in a given market or both (dummy)	1044	0.59	0.49	0	1
Tech	Operator that have prior experience in rolling out 2G service in another market (dummy)	1044	0.36	0.48	0	1
EarlyCountry	Country that launched 2G mobile telephony before 1995 (dummy)	1044	0.70	0.46	0	1

Tab. 2. Descriptive statistics of EBITDA by key independent variables

	Variable = 1			Variable = 0		
Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
EarlyEntrant	472	0.37	0.09	528	0.23	0.22
Brand	588	0.33	0.14	412	0.25	0.23
Tech	347	0.26	0.22	653	0.31	0.16

Tab. 3. Correlations between profitability, usage and penetration

	EBITDA	MoU	CellSubs(j)
EBITDA	1.0000		
MoU	-0.1483	1.0000	
CellSubs(j)	0.4911	-0.1776	1.0000

Tab. 4. Results of simple profit regressions with firm fixed effects

Dependent variable:	EBITDA
CellSubs	0.766***
	(0.075)
MoU	0.048***
	(0.011)
r2	0.117
N	1000

* p<0.1, ** p<0.05, *** p<0.01

Tab. 5. Mobile phone usage and penetration regression results

EQUATION:	MoU(t)	CellSubs(j)(t)
	(1)	(2)
MoU(t-1)	0.845***	
	(0.028)	
CellSubs(j)(t-1)		0.858***
		(0.034)
CellP(j)	-1.517***	0.051
	(0.565)	(0.043)
CellP(-j)	-0.743*	0.053
	(0.413)	(0.046)
FixedP	0.456	-0.019
	(1.364)	(0.075)
MoU(t)		0.006*
		(0.003)
CellSubs(j)(t)	-1.239**	
	(0.496)	
CellSubs(-j)(t)	-0.053	0.012
	(0.221)	(0.023)
FixedSubs	0.027	-0.006
	(0.497)	(0.033)
Prepay	-0.325	0.043**
	(0.278)	(0.018)
GDP	1.581***	-0.083***
	(0.447)	(0.030)
AR(2) test	-1.39	-1.41
Hansen J statistic	72.55(178)	63.22(178)
Observations	1044	1013
Clusters	90	90

* p<0.1, ** p<0.05, *** p<0.01; robust standard errors in parentheses

Coefficients on time fixed effects not reported

Tab. 6. Regression of operator-specific effects on experience indicators

EQUATION:	MoU			CellSubs(j)		
	(1)	(2)	(3)	(4)	(5)	(6)
EarlyEntrant	12.298***	19.507***	4.853	0.636	0.933	1.592***
	(3.989)	(6.394)	(5.133)	(0.462)	(0.749)	(0.591)
EarlyCountry	-1.756	-1.356	-0.018	1.490***	1.506***	1.267**
	(4.492)	(4.473)	(4.460)	(0.520)	(0.524)	(0.513)
Brand	-0.904	3.965	1.063	1.209**	1.409**	0.957**
	(4.079)	(5.283)	(4.083)	(0.473)	(0.619)	(0.470)
Tech	1.891	0.850	-5.423	-1.380***	-1.423***	-0.441
	(4.181)	(4.218)	(5.240)	(0.484)	(0.494)	(0.603)
EarlyEntrant* Brand		-11.792			-0.485	
		(8.206)			(0.961)	
EarlyEntrant* Tech			17.984**			-2.309**
			(8.063)			(0.928)
Constant	74.866***	72.454***	75.708***	-3.281***	-3.380***	-3.389***
	(5.348)	(5.574)	(5.241)	(0.620)	(0.653)	(0.603)
R^2	0.104	0.125	0.154	0.298	0.300	0.346
Observations	90	90	90	90	90	90

* p<0.1, ** p<0.05, *** p<0.01

Table A1. Full correlations between all variables in the analysis (N = 1044)

	EBITDA	MoU	CellSubs(j)	CellSubs(-j)	FixedSubs	CellP(j)	CellP(-j)	FixedP	GDP	Prepay	EarlyEntrant	EarlyCountry	Brand	Tech
EBITDA	1.00													
MoU	-0.16	1.00												
CellSubs(j)	0.50	-0.17	1.00											
CellSubs(-j)	-0.22	-0.01	0.26	1.00										
FixedSubs	-0.20	0.25	0.22	0.44	1.00									
CellP(j)	-0.04	-0.55	0.00	-0.05	0.10	1.00								
CellP(-j)	-0.15	-0.49	-0.05	-0.01	0.09	0.83	1.00							
FixedP	-0.04	-0.49	0.32	0.37	0.07	0.40	0.44	1.00						
GDP	-0.21	0.29	0.12	0.25	0.74	0.27	0.26	0.13	1.00					
Prepay	0.12	-0.57	0.06	0.01	-0.43	0.09	0.14	0.30	-0.44	1.00				
EarlyEntrant	0.38	-0.22	0.39	-0.16	-0.03	0.10	0.06	0.07	-0.08	0.14	1.00			
EarlyCountry	-0.09	0.04	0.36	0.50	0.59	0.21	0.20	0.32	0.51	-0.09	0.15	1.00		
Brand	0.21	0.18	0.18	-0.34	0.00	-0.01	-0.04	-0.02	0.19	-0.23	0.18	-0.09	1.00	
Tech	-0.12	-0.33	-0.29	-0.11	-0.37	0.14	0.17	0.00	-0.28	0.34	-0.05	-0.19	-0.21	1.00

Appendix

A1. Instruments used in the estimation of the model

To build the model reported in Table 5, we utilize three sets of instrumental variables. The first group was proposed by Arellano and Bond (1991) to solve concerns about autocorrelation resulting from models with fixed effects and lagged dependent variables. These instruments allow us to consistently estimate the coefficients for those lagged dependent variables.

The second set of instrumental variables tackles possible endogeneity of mobile phone and fixed-line prices in equations (1) and (2). Making use of the panel nature of the data, we construct these instrumental variables based on the geographical proximity between countries (for a very similar approach, see Hausman, 1997). To the extent that there are some common cost elements in the telephone service provision across regions (e,g, costs of equipment and materials), we can instrument for prices in a given country by average prices in all other countries of the region. For instance, prices in the UK can be instrumented for with a mobile and a fixed-line price index for the rest of Western Europe. To arrive at an operator-specific instrumental variable in the case of mobile telephones, we further condition it on the technological standards deployed by each operator. For instance, we instrument for price of a Chinese operator using the GSM standard with prices of GSM operators from other Asian-Pacific countries; the price of a Chinese CDMA with prices of CDMA operators from other Asian-Pacific countries; and so on.[13] To gain on efficiency, we additionally include lagged values of these geography-based instruments.

The third set of instrumental variables addresses possible endogeneity of the prepay share, usage and the penetration variables. For these variables we used values lagged by two and three periods. Note that we cannot use the values lagged by one period, because the Arellano-Bond estimation method involves first-differencing of the estimated equation. Follow-up tests confirm that these are not correlated with the error terms in the regressions.

Finally, it is important to note that the identification of the simultaneous variables in equations (1) and (2) rests on the exclusion restrictions: i) current usage does not depend on lagged penetration (it only depends on current penetration) and ii) current penetration does not depend on lagged usage (it only depends on current usage).

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[13] The classification of countries into regions we apply follows the Informa T&M classification and includes: USA/Canada, Western Europe, Eastern Europe, Asia/Pacific, Africa, and Americas.

A2. Derivation of the long-run advantages

We start by defining the expected long-run equilibrium levels of penetration and usage of an operator j as:

$MoU^*_{ij(t)} = MoU^*_{ij(t-1)}$ and (3)

$CellSubs^*_{ij(t)} = CellSubs^*_{ij(t-1)}$, (4)

respectively. Since the long-run equilibrium is by definition time invariant, we can omit the time subscripts and rewrite (1) and (2) using the definitions (3) and (4) to obtain formulas for the expected long-run values of usage and penetration:

$$MoU^*_{ij} = \frac{1}{1-\hat{\delta}_0}\left(\hat{\alpha}_{ij} + \hat{\delta}_4 CellSubs^*_{ij} + \boldsymbol{X}_{ij}\hat{\boldsymbol{\delta}}\right), \quad (5)$$

$$CellSubs^*_{ij} = \frac{1}{1-\hat{\gamma}_0}\left(\hat{\beta}_{ij} + \hat{\gamma}_4 MoU^*_{ij} + \boldsymbol{X}_{ij}\hat{\boldsymbol{\gamma}}\right), \quad (6)$$

where the hat stands for estimated value, the vector $\boldsymbol{X}_{ij}$ contains all other explanatory variables in equations (1) and (2) besides own usage and penetration, and $\hat{\boldsymbol{\delta}}$ and $\hat{\boldsymbol{\gamma}}$ are vectors of the associated parameter estimates. The differences between a first mover (*k*) and a follower (*l*) in a long-run equilibrium controlling for all other things—i.e. all variables in the vector $\boldsymbol{X}_{ij}$—are then:

$$MoU^*_{kj} - MoU^*_{lj} = \frac{1}{1-\hat{\delta}_0}\left(\hat{\alpha}_{kj} - \hat{\alpha}_{lj} + \hat{\delta}_4\left(CellSubs^*_{kj} - CellSubs^*_{lj}\right)\right) \text{ and} \quad (7)$$

$$CellSubs^*_{kj} - CellSubs^*_{lj} = \frac{1}{1-\hat{\gamma}_0}\left(\hat{\beta}_{kj} - \hat{\beta}_{lj} + \hat{\gamma}_4\left(MoU^*_{kj} - MoU^*_{lj}\right)\right). \quad (8)$$

Thus, to calculate average long-run differences between the first movers (with technological experience) and the followers in our sample we substitute the estimates from tables 3 and 4 for the respective parameters in (7) and (8) and solve the system of equations. Note that the difference $\hat{\alpha}_{kj} - \hat{\alpha}_{lj}$ in (7) equals to the estimated usage advantage of early entrants with technological experience over late entrants without technological experience (17.984 + 4.853 – 5.423) and the difference $\hat{\beta}_{kj} - \hat{\beta}_{lj}$ in (8) equals to their penetration disadvantage (-2.309 + 1.592 – 0.441).

The long-run differences between operators with established brands and the remaining operators can be calculated in an analogous way.