



# Market structure, regulation and the speed of mobile network penetration<sup>☆</sup>

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## ABSTRACT

The speed of market penetration (i.e. diffusion) is an important summary measure of how well the market works for potential consumers of a new product. This paper identifies the structural features associated with rapid diffusion of mobile telephony. We use a sample of thirty countries over the 16 years in which average penetration rose from 2% to 97% of the population (earlier studies observed only the initial years of diffusion during which there was typically only one or two networks). We find that both the number of networks and the history of market structures matter for the speed of consumer uptake. The market structure effect does not appear to work exclusively through the level of prices. Digital technology, standardization, privatization and independent regulation are also important positive factors, and we identify the speed and dimensions of catch-up.

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## 1. Introduction

In the context of a growing market with consumer network externalities, the speed of a new product's market penetration (i.e. diffusion) is an important summary measure of how well the market is performing for potential consumers. Delays in uptake can result in large welfare losses.<sup>1</sup> When the market is regulated, it is particularly important to understand how the various potential regulatory levers (e.g. number of firms, public ownership, price controls) affect the diffusion process. As penetration approaches saturation, usage becomes the more important indicator of market performance, but

new consumer products continue to be developed and their speed of diffusion is of considerable significance. In this paper we focus on understanding the central period of diffusion in which average market penetration across the more developed economies rose from less than 2% to nearly 97% over 16 years.

Like any other product, the demand for mobile phone services is influenced by a range of marketing and technical factors that constitute the overall product 'offer'. This offer includes price level, price structure (e.g. cost of sending relative to receiving a call), reach (geographic coverage) and reliability. Individual elements of the product offer are difficult to observe and measure on a consistent basis either internationally or over time. Furthermore, the optimal balance in the offer can be sensitive to national idiosyncrasies. In fact, one of the theoretical virtues of a competitive market is that it creates incentives for firms to respond to these idiosyncrasies and to provide the most attractive offer to consumers. This leads us to focus on the structural characteristics of the market that drive competition. The aim of this paper is to identify those structural features that are associated with the competitive environment which maximizes the rate of diffusion of mobile telephony through the population.

Mobile network penetration has been expanding rapidly in recent years, though there are signs it is reaching maturity in the advanced countries. We employ a panel of 29 OECD countries and China over the period 1991–2006. We include China because of its scale and

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<sup>1</sup> See Hausman (1997).

economic growth at the time, but we also test for robustness using the OECD-only sample.<sup>2</sup> This period covers the core of the penetration phase in each market.<sup>3</sup>

We focus on three structural features: the number of firms; ownership (i.e. privatization); and the existence of an independent industry regulator. Although the number of mobile networks is tightly regulated, we also investigate the potential endogeneity of market structure. Earlier work on telecom market penetration (including fixed line) focused on demographic and technology factors, privatization, first new entry and the early part of the diffusion process.<sup>4</sup> The latter two limitations appear to be important because, by using data that more completely covers the core diffusion years for the countries in our sample and distinguishing between different numbers of firms, we find substantial effects beyond the simple monopoly versus duopoly dichotomy.<sup>5</sup> Thus, while previous work has typically found that opening the market beyond monopoly is beneficial, it provides little guidance for important competition policy issues such as the number of operators to be licensed or merger regulation. The previous empirical literature also has little to say about regulatory institutions. Our main contributions are to distinguish the fine-grained effects of each extra entrant and technological factors, and to estimate our model over the core years of the diffusion process.<sup>6</sup> Having identified the key structural features associated with rapid diffusion, we go on to ask whether the effect of a more competitive structure works mainly through the average price level as distinct from non-price-level elements in the offer.

The remainder of this paper is structured as follows. In the next section, we review some related literature on competition, ownership and regulation in telecoms markets. Section 3 sets out the econometric methodology and Section 4 describes the data. Section 5 presents and discusses the empirical results, including tests for endogenous market structure. Section 6 concludes.

## 2. Entry, ownership and regulation in mobile telecommunications

We identify three structural dimensions to telecommunications competition: the number of networks; private (versus state) ownership; and the existence and independence of an industry regulator.

A number of studies of mainly fixed line telecom markets have found that 'competition' is associated with higher penetration, productive efficiency, lower service price and better service quality. Neither the fixed line studies nor early mobile studies were able to address questions relating to the extent of oligopolistic competition. There was very little experience of other than monopoly and duopoly market structures and, importantly, only the early part of the mobile diffusion process was observable in the data. Market structure in

fixed line studies has mainly been measured by either a binary competition variable<sup>7</sup> or indirect proxies from other telecom segments.<sup>8</sup> For mobile diffusion, Gruber and Verboven (2001a,b) include a duopoly dummy variable which they find to be statistically significant but quantitatively small. Liikanen et al. (2004) include two market structure variables: the number of firms and a 3-firm Herfindahl index. Both are entered linearly and neither is statistically significant. The most recent observation in these papers is 1998 which, as shown in the next section, is still early in the diffusion process.<sup>9</sup>

Our dataset includes a richer range of market structures from monopoly up to seven networks, and our empirical model allows for a very flexible relationship between the number of networks and diffusion. Given specific network effects and high investment costs, it is not clear that this relationship should be monotonic. For example, switching costs between operators, including pecuniary externalities that can be created by the price structure in mobile telephony (e.g. on-net calls may be charged at a discount to off-net), can result in incentives to compete for the market even when there are relatively few competitors. On the other hand, it is possible that if there are 'too many' operators who are unlikely to leave the market, the achievable market share may be small and they may each have a reduced incentive to invest in activities that would attract new consumers into the market.<sup>10</sup> Consequently, we allow for possible non-monotonicity in the relationship between consumer uptake and the number of firms.

In practice, there is no free entry into mobile network markets because they are highly regulated. Entry is tightly controlled by licensing, and the number of licences is chosen by the government or a regulator.<sup>11</sup> Spectrum width provides a technological constraint on the number of licences. Garrard (1998) provides detailed country studies of market evolution up to 1997 in each of the countries in our sample. The evidence is that entry is determined by technology and politics, and not by the standard economics of free entry. Nearly all countries require licences to operate telecom services, in addition to appropriate spectrum allocation.<sup>12</sup> Once the number of licences has been determined, they are allocated administratively or by some form of contest. There is usually no shortage of potential entrants. For example, even as early as 1989 all seven US regional Bell companies, five other US cellular operators, four from the UK, three from France and several others joined the contest for the second German licence to be awarded.<sup>13</sup>

The timing of entry depends on political context and technological opportunities, most notably the advent of digital. Digital technology encouraged regulators to issue more licences as more spectrum was

<sup>7</sup> For example, Ros (1999, 2003); Fink et al. (2001). Boylaud and Nicoletti (2001) do measure competition by a continuous variable: the market share of new entrants.

<sup>8</sup> See, e.g., Li and Xu (2002, 2004); Wallsten (2001, 2004).

<sup>9</sup> Considering 2G diffusion, Koski and Kretschmer (2005) construct a dummy variable only for three or more competitors, which they find significant.

<sup>10</sup> For example, Sutton (1991, pp.48–54) develops a symmetric Cournot model with endogenous investment in quality. If the number of firms is fixed, his equation (1) shows that investment in perceived quality increases in the number of firms up to  $N=3$ , but decreases in  $N$  for  $N>3$ . This is a simple model of a non-network industry and the precise result is sensitive to functional form. However, it illustrates how investment incentives need not be monotonic in market structure.

<sup>11</sup> See, for example, Gruber and Verboven (2001a,b). Mergers are also regulated though they may be more likely to be approved if the market is perceived as sufficiently competitive. Mergers were not a substantial issue in the period and countries in our sample.

<sup>12</sup> The only European exception was Sweden, where theoretically anyone could set up a network. "In practice, however, Televerket was able to create a de facto monopoly... since it had complete control of all the regulatory aspects that must be addressed if competition is to be effective, including spectrum allocation and interconnection" (Garrard, 1998, p.265). Consequently, a licensing regime in the hands of an independent regulator was created in 1992.

<sup>13</sup> In fact, they joined with local German partners to form ten competing consortia. The winning group led by Mannesmann built the network which eventually launched in June 1992. A third licence was awarded in 1992 particularly aimed at improving services in the recently reunified East.

<sup>2</sup> The Chinese mobile network market has grown fast but it is not immediately clear whether this is a distinct phenomenon or if it is following a similar pattern to OECD countries conditional on its market structure. As the market with the highest number of mobile phone subscribers and the largest market potential, China also provides a robustness check on our core relationship between structure and diffusion.

<sup>3</sup> In contrast, fixed-line markets have stagnated with a national average fixed-line penetration in our sample growing slowly to just under 51% in 2000 then shrinking (see Table 1 below).

<sup>4</sup> For work on fixed line penetration, see for example: Ros (1999, 2003); Wallsten (2001, 2004); Fink et al. (2001); McNary (2001); Li and Xu (2002, 2004); Gasmil et al. (2006). The effect of competition has been tested using either a binary dummy variable (e.g., Fink et al., 2001; Ros, 1999, 2003) or indirect proxies of competition from other telecom segments (e.g., Li and Xu, 2002, 2004; Wallsten, 2001, 2004). Work on mobile penetration has investigated the early stages of diffusion and focused on technological constraints, technology 'generations', industry standards, and entry regulation (e.g. Gruber and Verboven, 2001a,b, whose data covers the period 1984–97). Our work is most closely related to the latter. See also Liikanen et al. (2004) for technological generation effects, Koski and Kretschmer (2005) for 2G diffusion 1991–99, and Grajeck and Kretschmer (2009) for usage intensity in 2G.

<sup>5</sup> The number of mobile networks is regulated and limited for reasons including spectrum scarcity. We later investigate possible endogeneity.

<sup>6</sup> There appears to be little econometric research on the relationship between industrial organization and the uptake of consumer goods in other markets.

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