A STRATEGIC APPROACH TO NETWORK VALUE IN INFORMATION MARKETS

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Abstract

This paper extends previous research on network effects by proposing a theoretical model that studies the role that firm strategy plays in markets where network effects are important. We suggest that, instead of the exogenous character usually attributed to network effects, firms can influence them through their strategies. Moreover, we develop a causal relationship between network effects and network value, understanding that the latter is a better approach to the value the firm may generate in information markets. Our premise is that companies, by influencing users' expectations, users' coordination and perceived compatibility, can leverage network effects and network value. The strategies for increasing network value that we empirically test in the mobile telecommunications industry are entry timing, internationalization and switching costs management. Finally, this study not only seeks to understand the impact of firm strategy on network value, but also analyzes its subsequent impact on firm performance. Our main conclusion is that, in markets with network effects, strategy matters.

Key words: network value, network effects, time in the market, internationalization, switching costs, performance.

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1. INTRODUCTION

In recent years, the study of information markets has emerged as an important research theme in the management literature. They are governed by a unique set of features and characteristics that may render some well-established models and previous findings invalid. In these markets, where network effects are important, the installed base can be considered a key strategic asset for firms to assess their competitive position (McIntyre and Subramaniam, 2009; Shankar and Bayus, 2003). However, although recent literature recognizes that the foundations of network effects have received an increasing amount of attention from researchers (Varian and Shapiro, 1998; Farrell and Klemperer, 2007), a deeper understanding of the role that firm strategy plays in network industries is needed.

So far, previous attempts to link strategy and information markets have been limited to theoretical works aimed at studying how firms should develop strategies for competing in information markets (Hill, 1992; Shapiro and Varian, 1998; Farrell and Klemperer, 2007). However, few empirical studies have explored strategies for exploiting network effects. Therefore, there is a clear mismatch between theoretical and empirical research (Stango, 2002; Viard, 2007; Chen and Hitt, 2007).

The limited empirical work that can be found in the literature focuses on technological standards competition (Cowan, 1990; David, 1985; Garud and Kumaraswamy, 1993) and only a few papers have examined strategies to increase installed base in markets with network effects, such as entry timing and learning orientation (Schilling, 2002), product diversification (Tanriverdy and Lee, 2008), or pioneer's advantages (Eisenman, 2006). These previous studies tend to establish direct connections between firms' strategies and performance without designing a model that shows the specific elements that interplay in presence of network effects. Additionally, network effects are present in these studies but they do not provide any specific measure that captures them.

Building on the premise that understanding the drivers of network effects will allow firms to adopt a more proactive position to leverage them in their industries, this paper proposes a theoretical model that analyses the determinants of network effects that the firm can control. We extend previous research by suggesting that network value, defined as "the value stemming from other consumers already using the product" (McIntyre and Subramaniam, 2009:1496), is more accurate than network
effects for assessing a firm's competitive position. Our rationale is that network value is what eventually influences firm performance.

The literature on network effects (Katz and Shapiro, 1994) has identified three elements that act as antecedents of the intensity of network effects, namely, users' expectations, users' coordination and compatibility among competing networks. We believe that firms, by managing these elements through their strategy, can leverage network effects and network value in the industries they operate in. In particular, we study how the entry timing strategy followed by firms, their internationalization and the level of switching costs are related to users' expectations, users' coordination and compatibility among competing networks and, eventually, to network value.

By focusing on endogenous or firm-initiated efforts that shape the firm's competitive destinies in information industries, we bring a strategy dimension into research in this field. We also contribute to the existing literature by discussing the relationship between network effects and network value by proposing a measure of network value that tries to overcome some of the weakness that previous literature has identified on Metcalfe's law. Finally, this study not only seeks to shed light on prior findings by including the effect of firm strategy on network value, but also analyzes its subsequent impact on firm performance.

We empirically illustrate the conceptual model with an application to the European mobile communications industry using a longitudinal panel spanning the period 1998 to 2008. The data refers to the network value and competitive performance of 65 companies in 20 European markets. We find that entry timing is positively related to network value, while the level of switching costs is negative, by affecting users' expectations, users' coordination and compatibility among competing networks. On the contrary, the international firm scope seems not to have any significant influence on network value. Our results also reveal that network value is a critical determinant of firms' profitability. Thus, in the European mobile communications industry, operators leverage network effects in their respective markets, which reinforces the idea that network effects can be understood as endogenous.

The paper is organized as follows. In Section 2, we develop our theoretical model paying special attention to the relationship between network effects and network value and between the latter with its
main antecedents: expectations, coordination and compatibility. Section 3 provides a theoretical explanation of the three determinants that capture firm strategy. In particular, we explore the effect of entry timing, internationalization, and switching costs on network value. We also analyze the relationship between network value and the competitive performance of firms. The estimation procedure is described in Section 4, while Section 5 describes the data from the European mobile communications industry and the variables used. In Section 6, we provide evidence of the impact of entry timing, internationalization and switching costs on network value and the influence of the latter on firm performance. We close the paper by discussing its main findings and its managerial and policy implications.

2. LITERATURE REVIEW

Installed base, network effects and network value

The installed base is "the cumulative number of users at any given time in the product's life" (McIntyre and Subramaniam, 2009:1495). In the specific context of information industries, the installed base is the number of users who can interchange information, for example, by fax, mobile phone or e-mail. A growth in the number of users consuming the service also increases the possibilities of communication among them and, thus, the utility they receive. This situation, in which the utility of a user increases with the installed base, is what the literature calls network effects or network externalities.\(^1\)

Network effects exist when "the utility that a user derives from consumption of the good increases with the number of other agents consuming the good" (Katz and Shapiro, 1985: 424). The installed base as the key element that produces network effects has been highlighted by different authors (Shapiro and Varian, 1998; Suárez, 2005). Farrell and Klemperer (2007) distinguish between total and marginal network effects. The former refer to the increase in the utility of current customers when an additional user is incorporated into the network, while the latter refer to the increase in the incentives.

\(^1\) Although several authors have distinguished between them (Chou and Shy, 1996; Liebowitz and Margolis, 1994), we will use both terms indistinctly.
of potential users to adopt the technology when the installed base grows. Due to possible economic and technological incompatibility between two firms' services or products (García-Mariñoso, 2001; Grajek, 2009), network effects often appear linked to the users of each firm instead of being linked to the installed base of the industry as a whole. As a consequence, this study will limit the scope of the network to the firm's installed base because the products or services of different firms do not necessarily facilitate interchanges of information. So, the larger the number of users of a firm, the stronger the network effects (Shankar and Bayus, 2003) and the more possibilities the firm has to maintain its current users and to increase the incentives of potential adopters to join its network.

Due to the existence of network effects, both current and potential users incorporate network size into their utility function. This has a clear influence on customers' willingness to pay, which implies that the installed base of a company is a key asset in order to be able to compete in this kind of markets (Shapiro and Varian, 1998; Shankar and Bayus, 2003). Accordingly, we can speak about network value as "the value stemming from other consumers already using the product" and it "is a reflection of the benefits associated with a large cohort of fellow adopters (installed base) for the product" (McIntyre and Subramaniam, 2009:1496). Network value depends on the installed base and users' utility in the presence of network effects. When the installed base grows, so does the network value as a result of network effects.

A firm with a larger network value will also have a better competitive position, not only because of its current market share, but also because the probability of future dominance is higher. In this context, current users' will have incentives to stay within the firm's network and the incentives of potential users will also increase, which enhances both the total and marginal network effects. The literature has referred to this process by which firms achieve increasing returns over time as path dependence, positive feedback or as a winner-takes-all process (Arthur, 1990). The strengthening of the network value may guarantee future performance and increase competitive advantage when firms display stronger network effects than their rivals.
Expectations, coordination and compatibility in network markets

It is important to identify the circumstances under which network effects lead to a reinforcement of network value over time. The literature on network industries has highlighted the existence of three main elements in information markets that interplay with network effects: users’ expectations, users’ coordination and compatibility among competing networks (Katz and Shapiro, 1994).

The current installed base of a firm affects users’ expectations about which firm will dominate the market in the future (Brynjolfsson and Kemerer, 1996; Farrell and Saloner, 1986). Users prefer to consume goods and services from a firm with a larger installed base (Kim and Kwon, 2003; Birke and Swann, 2006). As a consequence, expectations are important because, if consumers believe that a firm will dominate the market, then it will (Katz and Shapiro, 1985).

Given that expectations condition the size of the installed base and the network value, firms have strong incentives to launch signals to influence user expectations about their future dominance of their network. These signals can be quantitative or qualitative. Among the former, we can mention the size of the installed base (Brynjolfsson and Kemerer, 1996; Farrell and Saloner, 1986) or the early achievement of a large market share (Suárez, 2005). Qualitative signals include brand value or reputation (Katz and Shapiro, 1994) or the preannouncement of a new product or service that is not yet on the market, as in the case of the battle between Div-X and DVD (Dranove and Gandal, 2003).

While expectations have an individualist orientation, coordination requires a plural action. Users’ coordination implies that several users join a system that allows them to exchange information with one another (Katz and Shapiro, 1994). Coordination is difficult for several reasons: confusion about what other people will do, different expectations about the dominant network, fear of taking the first decision, etc. Farrell and Klemperer (2007) suggest inertia as a possible instrument that drives coordination. Inertia arises because later adopters choose a firm with a larger installed base even though there are better options. The literature has also referred to inertia as bandwagon effects, which assumes that users enjoy doing the same thing that other people do (Leibenstein, 1950; Rohlfis, 2001). This means that consumers are conformists because they have a “desire to join the crowd” (Grajek, 2009). As a consequence, a firm with a larger network value will increase its probability of being
selected by users through inertia. Examples of how inertia can determine the standard chosen by the industry even though it is not the best option are the QWERTY keyboard (David, 1985) or the light power technology for power reactors (Cowan, 1990).

The third element in markets with network effects is compatibility. Compatibility arises when the products of different firms can be used together (Katz and Shapiro, 1985). In these situations, the scope of the users' network includes the installed base of the reference firm as well as the base of compatible industry competitors (Grajek, 2009). Thus, users will prefer compatibility because it offers them greater communications possibilities. Incompatibility prevents firms from achieving a maximum network size since users are fragmented in different networks and are not able to interchange information. In the presence of incompatibility, the network value will be lower and the user's perceived utility will be suboptimal (Katz and Shapiro, 1994; Lee and Mendelson, 2007).

Compatibility is also preferred by small rivals. It is a less risky option for entering into a market and allows them to exploit the network effects that come from the larger installed bases of their rivals. Therefore, compatibility often neutralizes the competitive advantage of a large network (Farrell and Klemperer, 2007) and so larger competitors with a good reputation or a high brand value choose incompatibility to deter the entry of new rivals (Katz and Shapiro, 1994). However, incompatibility is also a risky option because users' trust in a new network will be lower (Katz and Shapiro, 1985).

An example of the trade-off between large and small companies with respect to compatibility can be found in the competition between Microsoft and Apple. In recent years, Apple has designed a strategy based on increasing the compatibility between its computers and Windows applications. Apple has opted for compatibility to increase users' utility and reduce the obstacles they perceive if they choose its network. The increase in network value derived from being able to exchange compatible information with other Macintosh users has put Apple in a better competitive position. Microsoft, on the contrary, has made no effort to be compatible with other operating systems because it has the largest network value and the positive feedback helps it to continue growing.

It is important to note that compatibility is not always a decision of the firm. For instance, in regulated markets such as mobile communications, the European Union decided to impose
compatibility in supranational arenas, establishing a common technological standard among networks (Fuentelsaz, Maicas and Polo, 2008). This proactive regulation tries to avoid a less efficient technology being imposed as the standard in a market due to path dependency (David, 1985; Park, 1997).

Expectations and coordination has to do with users' behavior whereas compatibility is a firm or external agent decision that influences network choice. In a context of compatibility, incentives to join the network will be higher and, consequently, network effects will be stronger. A firm has to take decisions that influence the expectations and coordination of potential users of its network. A firm also has to decide (when the legal framework allows the possibility) about the compatibility or incompatibility of its product. All these choices will have a direct impact on its installed base and network value as result of network effects. These relationships are summarized in Figure 1.

**FIGURE 1. NETWORK VALUE AND EXPECTATIONS, COORDINATION AND COMPATIBILITY**

Our next step is to develop the hypotheses that will be empirically tested. We analyze three possible determinants that, through their influence on expectations, coordination and perceived compatibility, would reinforce the action of network effects and the achievement of a higher network value. Finally, we aim to test the effect of network value on performance to determine its strategic significance.
3. HYPOTHESES

Determinants of network value

First Mover Advantages (FMA). The study of FMA has been one of the cornerstones of the strategy and management literatures (Carpenter and Nakamoto, 1989; Kalyanaram and Urban, 1992; Lambkin, 1988; Lieberman and Montgomery, 1983). FMA have also played an important role in a more specific context: research into network effects (Farrell and Klemperer, 2007; Katz and Shapiro, 1994; Maicas and Sese, 2008; Srinivasan, Lilien and Ragaswamy, 2004).

In markets with network effects, firms will try to build a large installed base as an indicator of future dominance (Brynjolfsson and Kemerer, 1996). These efforts will be especially important in the early stages of competition in these markets, since an early superiority becomes a signal to users about the future dominance of the firm and increases the probability of its survival in the market (Arthur, 1990). As a result of early entry, the firm would be able to determine the dominant design (Arthur, 1989) and influence the formation of users' preferences (Carpenter and Nakamoto, 1986) since pioneers usually receive disproportionate attention from consumers because of the newness of their product (Lieberman and Montgomery, 1983). Thus, we propose that a firm with a longer time in the market has a larger network value because of having more time to make efforts in the expectations' management of users through the achievement of an early installed base before the entry of rivals in the market.

It is also important to note that the inertia that we have discussed above will lead late users to choose the firms with a larger installed base. If a pioneer is able to convince early users about its dominance, late consumers will prefer to follow them into the same network and the pioneers' product will become the standard in the industry (Schmalensee, 1982; Carpenter and Nakamoto, 1986; Farrell and Klemperer, 2007). Having achieved a leading position, the pioneers' installed base will persist because of the difficulty of modifying users' preferences (Lieberman and Montgomery, 1983). This is the main idea of the bandwagon effects we have previously referred to.
Accordingly, we expect that time in the market increases the firms’ opportunities to influence user expectations about their networks. As a result of inertia, the network value of a firm that has been in the market a long time will be higher.

**H1. The time that a firm has been operating in the market has a positive effect on its network value**

*Internationalization.* The literature has tended to study markets with indirect network effects in which diversification on complementary products plays an important role (Hill, 1992; Schilling, 2002; Tanriverdi and Lee, 2008). However, less attention has been kept to other kind of growth strategies in markets with direct network effects such as international diversification, especially when international network effects operate (Gruber and Verboven, 2001).

International diversification is defined as “expansion across the borders of global regions and countries into different geographic locations, or markets” (Hitt, Hoskisson and Kim, 1997: 767). Internationalization is, nowadays, an important topic of discussion because many industries are trying to compete globally (Barkema and Drogendijk, 2007; Grant, 2005). As a result of these global strategies, not only are firms present in several countries, but customers also “think” globally. National and regional preferences are disappearing as a consequence of a process of homogenization derived from technology, communication and travel (Grant, 2005). This means that customers are becoming more and more familiar with international firms and their brands. The internationalization of firms could be a means of attracting the interest of users in different countries since users value established brands (Lane and Jacobson, 1995). We expect that the internationalization of a firm will have a clear influence on its network value through its impact on expectations, coordination and perceived compatibility.

First, internationalization can be understood as a signal that influences users’ expectations about the future dominance of the firm network. There is an advantage for a firm entering a new local market when it is also operating in other countries. The international firm will have a larger perceived installed base compared to new domestic firms. Even, the literature has highlighted the existence of *international* network effects when “the utility of each consumer rises with the increase in the number
of consumers who use the same brand regardless of whether they live in their own country or abroad” (Shy, 2001: 92). Thus, an international firm will reinforce the positive expectations of users about its survival in the future on the basis of being present in other countries and the familiarity of domestic users with its brand through the leverage of international network effects.

Consequently, we also expect that internationalization will facilitate coordination by international bandwagon effects. If users know that a firm has been chosen by users in other countries, inertia could lead them to make the same choice in their national market. Users will have more incentives to choose the international firm, replicating the choices of foreign users, since they want to imitate global trends (Grant, 2005). In this sense, the firms with international presence try to create interdependences among different countries, which results in the relatedness between the competitive position in one national market with the competitive position in others national markets (Ghoshal, 1987: 425).

Finally, it is also important to note that compatibility among inter-country networks is necessary to influence user’s decisions. The firms that offer comparable, seamless and compatible services across international markets will obtain the commitment of users that realize international information exchanges (Sarkar, Cavusgil and Aulakh, 1999). For example, in the case of roaming in mobile telephony, a user will be more willing to choose a firm network if he or she knows that the same company will guarantee the service abroad in similar economic terms with the same handset. In this sense, Gruber and Verboven (2001) suggest that with GSM wide-ranging international roaming, users have more incentives to adopt mobile communications since they benefit from international network effects.

As a consequence, we expect that the presence of the firm in several countries will create a larger network value through its influence on expectations and coordination since firms try to compete globally in order to attract users across countries. Compatibility will reinforce the influence of internationalization on network value by allowing international network effects.

**H2. The international presence of the firm has a positive effect on its network value**
Switching costs. Switching costs are present in all information markets and its management has a strategic dimension (Shapiro and Varian, 1998; Gomez and Maicas, 2008). Consumer switching costs appear when “consumers who have previously purchased from one firm have (or perceive) cost of switching to a competitor’s product, even when the two firms’ products are functionally identical” (Klemperer, 1995: 515). The literature has highlighted how switching costs can increase the market power of a firm, allowing it to create entry barriers (Karakaya and Stahl, 1989; Kerin, Varadarajan and Peterson, 1992) and obtain abnormal returns that derive in the achievement of sustainable competitive advantages (Amit and Zott, 2001; Klemperer, 1987; Lieberman and Montgomery, 1988; Schamalensee, 1982). However, the effectiveness of this mechanism as the base for sustainable competitive advantages in information markets has been questioned (Mata, Fuerst and Barney, 1995). The effect of high switching costs may derive in the loss of network value through their impact on expectations and coordination, as we argue below.

As we have explained in Section 2, network value depends on the installed base and users’ utility in the presence of network effects. While switching costs has been used as an instrument to maintain installed base by reducing customers desire to leave their current provider (Burnham, Frels and Mahajan, 2003), there is a reduction on users’ utility due to the increase of switching costs (Maicas, Polo and Sese, 2009) since switching from one provider to another is costly and users perceive the threat of an opportunistic firm behavior that could derive in a future increase of prices in a bargain-then-rip-off pricing strategy (Farrell and Klemperer, 2007). It is not surprising that current users create a firm image based on untrustworthy derived from its future opportunism (Mata et al., 1995). Since potential users tend to form expectations about the future survival of firm with not only quantitative signals such as installed base, but also qualitative signals as brand image or reputation (Katz and Shapiro, 1994), they will be reluctant to choose a firm with higher switching costs. In this sense, Frels, Shervani and Srivastava (2003) comments that a network of previous adopters is believed to influence adoption among non-adopters by providing opinions by word of mouth and observation. The negative experience of current installed base will derive in the formation of negative expectations about a firm network with higher switching costs that prevent users’ coordination to this network, with a negative impact on network value. In this sense, Mata et al. (1995: 490) explain that “the value of opportunities
lost because of a reputation for exploiting captured customers can be much larger than the value extracted from those captured customers”.

Finally, switching costs are especially high when networks are incompatible. Technological incompatibility is one of the main drivers of consumer switching costs (Garcia-Maniñoso, 2001) since it is costly to abandon a network because of learning costs or loss of communication possibilities with current users. Economic or artificial incompatibility also arise when the costs of communication among users is cheaper if they belong to the same network (Grajek, 2009). In this case, economic incompatibility increases pecuniary switching costs derived from losing saves in the costs of communicating with users of the previous network. Thus, incompatibility will reinforce the negative effect of switching costs on utility and, consequently, on network value.

\[H3. \text{Switching costs have a negative effect on firm network value}\]

Network value and performance

In information markets, current performance is strongly dependent on past events (Farrell and Klemperer, 2007; McIntyre and Subramaniam, 2009). Users prefer to belong to networks which have been previously chosen by other users. This is the positive feedback that “reinforces that which gains success or aggravates that which suffers loss” (Arthur, 1996: 100).

The literature has suggested that a continuous increase in network value is followed by an increase in the willingness to pay to have access to that network (Doganoglu and Grzybowskii, 2007) and the subsequent decrease of the marginal costs of each information interchange (Arthur, 1990). This is because the value does not lie in the product itself, but in the size of the network (De Palma and Leruth, 1996; Grajek, 2009). The product is more valuable as more people use it (Doganoglu and Gryzbowski, 2007). While a greater network value permits a higher price, marginal costs decrease as more and more information ties are taking place. In spite of a large initial investment in research and development, the marginal costs of producing an additional exchange are relatively cheap (Shapiro and Varian, 1998) since information markets are knowledge-based (Arthur, 1990).
We expect that a firm with a larger network value will also obtain a higher marginal net income from each information exchange derived from a higher price and lower marginal costs. Thus, performance will be positively related to network value.

**H4. Network value has a positive effect on firm performance**

Figure 2 summarizes our four hypotheses.

**Figure 2. Determinants of network value and firm performance**

![Diagram showing the relationship between network value and firm performance]

### 4. Methods

In this section, we develop two econometric models that help to describe and empirically examine the determinants of network value and the impact of the latter on firm profitability. First, we present separately the model components — determinants of network value and firm profitability. Then, we discuss the procedure to estimating the system of equations.

**Network value model**

We model network value of company $i$ (competing into market $k$) in period $t$ ($NETWORK VALUE_{ikt}$) as a function of the time in the market that the firm $i$ is competing in the market ($TIME_{ikt}$), the international presence of the company $i$ ($INTERNATIONALIZATION_{ikt}$), and the switching costs of the firm $i$ ($SWITCHING COSTS_{ikt}$). To control for additional sources of variation in network value, we introduce a set of control variables that include the population in the market $k$ ($POPULATION_{kt}$), the number of firms competing in the market $k$ ($FIRMS_{kt}$) and year effects ($YEAR$). We represent the network value model in Equation (1) as follows:
NETWORK VALUE_{ikt} = \beta_0 + \beta_1 TIME_{ikt} + \beta_2 INTERNATIONALIZATION_{ikt} + \beta_3 SWITCHING COSTS_{ikt} \\
+ \beta_4 POPULATION_{ikt} + \beta_5 FIRMS_{ikt} + \beta_6 YEAR + \epsilon_{ikt}

(4.1)

Profitability model

Consistent with the proposed conceptual framework, we relate the network value of the firm to performance outcomes. We model performance of firm \(i\) in period \(t\) (PERFORMANCE_{ikt}) as a function of network value. As common practice in profitability models suggests, especially in industries with increasing returns where is a path dependency from performance on previous periods, we also control for past realizations of the dependent variable (PERFORMANCE_{ikt-1}). We control for additional factors that potentially affect profitability, including the population in the market (POPULATION_{kt}), the number of firms in the market (FIRMS_{kt}) and time controls (YEAR). In Equation (2), we represent the profitability model as follows:

\[
\text{PERFORMANCE}_{ikt} = \lambda_0 + \lambda_1 \text{PERFORMANCE}_{ikt-1} + \lambda_2 \text{NETWORK VALUE}_{ikt} + \lambda_3 \text{POPULATION}_{kt} \\
+ \lambda_4 \text{FIRMS}_{kt} + \lambda_5 \text{YEAR} + \phi_{ikt}
\]

(4.2)

Estimation procedure

We estimate equations (4.1) and (4.2) as follows. We propose static panel estimators to explore the determinants of network value (Hypotheses 1 to 3). To explore the determinants of network value, we estimate a fixed effect model where network value is the dependent variable. The fixed effects estimation method is used in longitudinal panel analyses and allows the unobserved individual effects to be correlated with the included variables (Greene, 2003). The existence of these individual effects has been tested by the Lagrange multiplier of Breusch and Pagan (1980) and the preference for fixed effects estimation over random effects derives from the test of Hausman (1978). However, dynamic panel estimators are considered for the profitability model (Hypothesis 4) since the lagged performance is introduced as explanatory variable on the performance equation (4.2).

We test Hypothesis 4 by estimating a System Generalized Method of Moments model (System GMM), proposed by Arellano and Bover (1995) and fully developed by Blundell and Bond (1998). System GMM is frequently used in profitability models in which current performance is highly
conditioned by firm performance in the previous period. Jointly with the lagged performance, we also include network value as a regressor to test the impact of our key element on the competitive performance of firms.

5. DATA

Research Setting: the European mobile communications industry

Telecommunications in general and mobile communications in particular are paradigmatic examples of direct network effects (Doganoglu and Grzybowski, 2007; Maicas, Polo and Sese, 2009). Srinivasan et al. (2004) suggest that mobile communications present a high degree of network effects. In fact, they rate among the highest in a list of 45 goods and services that are believed to be intensive in network effects. Consequently, this industry constitutes an ideal context for testing and analyzing network value.

Several reasons can be provided for considering the mobile communications industry to be an attractive laboratory for our research purposes. First, the European mobile communications industry represents a large, fruitful and growing portion of Europe's economy. This industry has become an important source of wealth in Europe, since the telecommunications industry made up 2.83% of the GDP at the end of 2007, whereas, for example, agriculture constitutes 1.82% (World Bank Group, 2010). It has grown impressively in recent years: its average penetration rate increases from around 30% at the end of 1998 to slightly over 120% in the middle of 2008 (Merrill Lynch, 2010).

Second, as we have already said, the mobile telecommunications industry is a paradigmatic case of information markets in which information ties are essential to generate direct or pure network effects (Birke and Swann, 2006). The product does not have value in itself, but in the size of its installed base (De Palma and Leruth, 1996; Shanker and Bayus, 2003).

Finally, in the European mobile telecommunications industry, expectations, coordination and compatibility, the three elements that guide the relationship among installed base, network effects and network value, are clearly present. Katz and Shapiro (1994) have highlighted the importance of
expectations and coordination in the choice of a mobile communications provider. Compatibility has been especially significant in the European context and has been previously discussed in the literature (Gandal, 2002; Fuentelsaz, Maicas and Polo, 2008). The European Union first established a technological compatibility for the EU members through the GSM standard in the early 90's. As a consequence, a user can employ his handset to make calls to the telephones of any firm in the country without technological compatibility restrictions and can use the same handset in any European country thanks to the roaming service. Nevertheless, in spite of this technological compatibility imposed by institutions, an economic incompatibility appeared since there are important price differences between on-net and off-net calls (Grajek, 2009).

Sample

Our database includes the whole population of mobile communications providers that operated in twenty European markets between the last quarter of 1998 and the second quarter of 2008. The availability of this large time period is important because our sample does not suffer from survival bias for the period under analysis. Our data comes from multiple sources, but the main one is the Merrill Lynch Global Wireless Matrix. This publication provides quarterly information on several of the variables of interest such as the name of the firms, the number of subscribers, the number of firms per market and their performance. We have also collected information about the date of entry of the firms and their shareholder structure, mainly from industry reports and the corporate information of the firms.

Measurement of Variables

Network value. The literature offers different approaches to the measurement of the network value of a firm. Swann (2002) describes the traditional ways to determine it. One option, called Sarnoff's Law, measures network value through the size of the installed base, \( n \) (Reed, 1999).

Nevertheless, our interest in this research is in information markets. The possibilities of communication increase as the number of users consuming the good and, thus, their perceived utility
grow. According to Church and Gandal (2004:3), a user's link to the network has no value except to facilitate the transmission of information to, and from, other users. Farrell and Klemperer (2007) suggest that the users of a communication network gain directly when other users adopt it because they have more opportunities for interaction with peers. Thus, a second option for measuring network value is to proxy it by the number of possible communication ties that exist among the users of the same network. This is known as Metcalfe's Law and is measured as $n*(n-1)$. With this measure, we focus on the possibilities of connectivity between users (Ross, 2003).

However, Metcalfe's Law has been criticized for giving the same importance to all users (Grajek, 2009; Briscoe, Odlyzko and Tilly, 2006). Farrell and Klemperer (2007:1975) suggest that early adopters' preferences are more important than later adopters', first adopters having an "excess early power" to determine the dominant network in the future. Early adopters generate more network value to the firm than later ones because of the inertia operating in these markets. For this reason, the literature has suggested a third approach that considers a decreasing marginal network value as $n*log(n)$, namely Zipf's Law (Briscoe et al., 2006). The expression $n*log(n)$ recognizes the user connectivity that we have referred to as well as the differences between early and late adopters. As a consequence, we will use this measure of network value (NETWORK VALUE).

However, the previous measure of network value confers to all firms the same capability of reinforcing their own network value through positive feedback, without consideration of networks effects that are capable to leverage in function of the rivalry in each market. For example, suppose the existence of two markets A and B with two firms operating in each one, firm 1 and 2, and that the market share are the following:

\[\text{The European countries considered in our research are Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland and United Kingdom.}\]
In the two markets, firm 1 has the same network value (1,200 * log(1,200)) and offers more communication possibilities than firm 2. However, users of firm 1 in market A have twice the probability of making off-net calls (40%) than users of firm 1 in market B (20%). Accordingly to the literature and anecdotal evidence, in telecommunications markets there is a tendency to penalize off-net calls through a higher price than on-net calls (Birke and Swann, 2006; Grajek, 2009). Thus, users of firm 1 in market B receive a higher utility to have selected firm 1 over firm 2 than in network A. In other words, the network of firm 1 in market B is more attractive than in market A and can leverage stronger network effects, given price differences between on-net and off-net calls.3

In this study, we advance in the measure of network value through the use of a corrected measure of Zipf's Law, with the aim of considering the competitive advantage of each firm in its market as a function of the differences among rivals’ network sizes. Thus, the measure we propose takes into account the probability to make on-net calls to off-net calls for each firm in each market. With this ratio, we reward those firms that have achieved a larger installed base in comparison with its direct rivals in their specific market and penalize those ones that create more disutility to their users in the way of superior costs derived from economic incompatibility.

In order to calculate an expected probability to make on-net calls to off-net calls, we borrow the example provided by Birke and Swann (2006) who develops a likelihood matrix that offers the pattern of calls between rival networks in a given market. Let's suppose that there are four operators (i = 1, ..., 4) competing in a market and that the market share of each one is given by mi. Assuming that there is not price differences between on-net and off-net calls and accepting that the calls from one network to other network are proportional to the sizes of the installed bases, the expected call probability among

---

3 The literature has referred to this phenomenon as tariff or price-mediated network effects (Laffont, Rey and Tirole, 1998; Birke and Swann, 2006), which leads to artificial or economic incompatibility among networks.
users of different networks is given by the product of their respective market shares as it is given by
the following matrix:

<table>
<thead>
<tr>
<th>Calls from Network</th>
<th>To Network</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>m1 m1</td>
<td>m1 m2</td>
<td>m1 m3</td>
<td>m1 m4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>m2 m1</td>
<td>m2 m2</td>
<td>m2 m3</td>
<td>m2 m4</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>m3 m1</td>
<td>m3 m2</td>
<td>m3 m3</td>
<td>m3 m4</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>m4 m1</td>
<td>m4 m2</td>
<td>m4 m3</td>
<td>m4 m4</td>
<td></td>
</tr>
</tbody>
</table>

Source: Birke and Swann (2006)

The probability of making on-net calls is given by the elements of the matrix diagonal \((m_i, m_i)\),
whereas the off-diagonal elements refers to off-net calls among networks \((m_i, m_j)\) for each firm. Thus,
the probability to make on-net calls to off-net calls for each firm is given by the following ratio:

\[
m_i/m_i / \sum m_i m_j = m_i / \sum m_j \quad [i \neq j]
\]

By modifying the previous measure of network value with this ratio, the corrected network value
\((NETWORK VALUE')\) is expressed as:

\[
n_i^* \log (n_i)^* m_i / \sum m_j \quad [i \neq j]
\]

Thus, the corrected network value will be higher when: a) There is a higher installed base that
allows higher communications possibilities among its current users; b) There is a larger difference
among network sizes of the reference firm and its rivals than confers it a competitive advantage to
leverage stronger network effects and make its network more attractive to potential users. This
measure not only includes the size component, but also the rivalry dimension in order to detect the
network that results more attractive to users in a given market. This corrected network value becomes
a strategic measure very useful for weighting up the market position of each firm in its specific competitive environment.

*Performance (PERFORMANCE).* Firm profitability is measured through EBITDA (Earnings Before Interests, Taxes, Depreciation and Amortization) divided by the total revenues of the firm.

*Time in the market (TIME).* Different concepts of pioneering have been used when modelling first mover advantages. Srinivasan et al. (2004) consider the pioneer to be the first firm to commercialize a new product. Lieberman and Montgomery (1988) suggests some alternative measures such as the numerical order of entry, rates of company survival, advantages duration or time from pioneer entry. Brown and Lattin (1994) suggest time in the market as an adequate measure of FMA. Accordingly, our variable counts the number of months that a firm has been operating in the market.

*International presence (INTERNATIONALIZATION).* International diversification has been measured with variables such as international sales over total sales (Strike, Gao and Bansal, 2006), number of workers abroad (Brock, Yaffe and Dembovsky, 2006), sales in a country weighted by the importance of this market (Hitt et al., 1997), number of international subsidiaries (Barkema and Drogendijk, 2007; Strike et al., 2006) and number of countries in which firm operates (Brock et al., 2006). In this study, we have identified the number of countries in which the firm is present around the world with an ownership of above 50%.

*Switching costs (SWITCHING COSTS).* According to the existing literature, there is an important gap between the theoretical and the empirical research on switching costs (Stango, 2002; Grzybowski, 2007; Chen and Hitt, 2007; Viard, 2007). Only a few articles have tried to properly measure their magnitude. To advance in this direction and given the available information, we use a model proposed by Shy (2002). This author develops a method for estimating switching costs among firms in a context where we only need to have information about prices and market shares. It is important to note that Shy’s method has been used previously in the literature with very similar purposes to ours (Carlsson and Löfgren, 2006; Krafft and Salies, 2008).
Shy (2002) considers a market with two firms (A and B). Consumers are assumed to be distributed between the firms so that, initially, \( N_A \) consumers have already purchased brand A (type \( a \) consumers) and \( N_B \) consumers have already purchased brand B (type \( b \) consumers). \( p_A \) and \( p_B \) represent firm A and B prices, respectively, and \( s \) is the cost of switching brands. The utility \( U_A(U_B) \) for a user who is now buying from A (B), can be written as:

\[
U_A = \begin{cases} 
-p_A & \text{staying with brand A} \\
-p_B - s & \text{switching to brand B}
\end{cases}
\]

The number of subscribers for A (B), \( n_A(n_B) \) in the following period is given by,

\[
n_A = \begin{cases} 
0 & \text{if } p_A > p_B + s \\
N_A & \text{if } p_B - s \leq p_A \leq p_B + s \\
N_A + N_B & \text{if } p_A < p_B - s
\end{cases}
\]

If we assume that the firm’s production costs are zero, the profit, \( \pi_A(p_A, p_B) \), of each firm is:

\[
\pi_A(p_A, p_B) = p_A n_A
\]

Shy (2002) postulates that the pair of prices that solve the problem for firms A and B and constitute a Nash-Bertrand equilibrium are:

\[
p_A = \frac{(N_A + N_B)(N_A + 2N_B)s}{(N_A)^2 + N_AN_B + (N_B)^2} \quad \text{and} \quad p_B = \frac{(N_A + N_B)(2N_A + N_B)s}{(N_A)^2 + N_AN_B + (N_B)^2}
\]

Shy (2002) extends the model to a multi-firm industry. He considers the possibility of more than two firms, each indexed by \( i, i = 1, \ldots, I \). The expressions for switching costs in a multi-firm industry are:

\[
s_i = p_i - \frac{N_i p_i}{N_i + N'}, \text{ if } i \in \{1, \ldots, I-1\} \quad \text{and} \quad s_I = p_I - \frac{N_I p_I}{N_I + N'}
\]

In this model, it is important to have a precise measure of the sizes and prices. Sizes are incorporated into the switching costs function through the market shares of the firms. A more controversial issue is to define prices in mobile communications. Prices usually vary depending on the
characteristics of the user, the receiver of the phone call (on-net vs. off-net calls) or the time of the day. To solve this problem, Shy (2002) derives prices from the Average Revenue per User (ARpU) in his calculation of switching costs in mobile communications in Israel. Furthermore, the use of ARpU is also motivated by "its widespread use in industry and regulatory circles" (McCloughan and Lyons, 2006:523). An additional advantage of ARpU is that it makes comparisons among countries possible.

**Control variables.** Besides the variables described to test the proposed hypotheses, our model also controls for additional covariates. First, we control for the population in each national market (POPULATION), which we expect to have a positive relationship with network value and performance, since the communication possibilities in each national market will be higher. We also control for country-specific rivalry by taking into account the number of firms operating in each market (FIRMS). This variable is expected to negatively affect firm performance. However, the relationship between the number of firms and network value is not so clear. A higher number of firms would probably derive in smaller networks, decreasing network value. But also the increase in the number of firms could constitute an improvement in the competitiveness of the market that derives in price reductions. It might enhance users' utility and technology adoption, with a subsequent increase of network value. Finally, the model also includes year dummies in order to control for time-specific influences (YEAR).

**Descriptive Statistics**

Descriptive statistics are shown in Tables 2 and 3. The first includes the determinants of the network value model and the second those of the profitability model. The existence of missing values in our dependent variables means that we are left with 2,032 observations for the network value model and 1,991 for the profitability model.

As can be seen in Table 3, the average European firm has been operating in the market for nine years (107.5 months), it has presence in 8 countries around the world and presents positive switching costs of around 17 euros per user. The average number of firms per market is 3. When we analyze the correlation matrix, we can observe that both network value and corrected network value are especially correlated with population and also with time in the market. Nevertheless, the correlation among the
independent variables is moderate. Table 4 shows that the average performance is larger than the performance in the previous period, with a positive relationship with network value but negative with population and number of firms.

It is important to note that our first measure of network value \((\text{NETWORK VALUE})\) is larger (15.28) than the average corrected network value \((\text{NETWORK VALUE}')\) (9.25). The inclusion of the specific rivalry in the market where the firm is operating assumes the consideration of a disutility caused by the additional costs derived from existing off-net calls. Additionally, we can observe in Table 2 that the correlation of independent variables changes according to the measure of network value. When we take into account the competitive position of the firm in the measure of network value, the correlation with time in the market and the internationalization decreases while the correlation with switching costs increases. In Table 3, we can also observe that the correlation with performance and lagged performance it is higher to the corrected network value than to traditional network value. Thus, taking into account the competitive advantage that a firm could have as a result of higher differences in network sizes increases the explanation of performance behaviour.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. NETWORK VALUE</td>
<td>15.28</td>
<td>24.09</td>
<td>-0.37</td>
<td>140.08</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. NETWORK VALUE'</td>
<td>9.25</td>
<td>17.14</td>
<td>-0.13</td>
<td>105.38</td>
<td>0.92</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. TIME</td>
<td>107.48</td>
<td>44.36</td>
<td>3.00</td>
<td>258.00</td>
<td>0.36</td>
<td>0.34</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. INTERNATIONALIZATION</td>
<td>7.95</td>
<td>7.04</td>
<td>1.00</td>
<td>28.00</td>
<td>0.25</td>
<td>0.20</td>
<td>0.27</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. SWITCHING COSTS</td>
<td>17.22</td>
<td>11.19</td>
<td>-18.28</td>
<td>56.51</td>
<td>0.07</td>
<td>0.15</td>
<td>0.25</td>
<td>0.14</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. FIRMS</td>
<td>3.27</td>
<td>0.65</td>
<td>2.00</td>
<td>5.00</td>
<td>0.16</td>
<td>0.04</td>
<td>-0.12</td>
<td>0.11</td>
<td>0.02</td>
<td>0.02</td>
<td>0.34</td>
</tr>
<tr>
<td>7. POPULATION</td>
<td>27.12</td>
<td>25.64</td>
<td>3.87</td>
<td>82.541</td>
<td>0.72</td>
<td>0.55</td>
<td>0.03</td>
<td>0.08</td>
<td>-0.02</td>
<td>0.34</td>
<td>1</td>
</tr>
</tbody>
</table>
Determinants of Network Value

Table 4 reports the parameter estimated for the fixed effects models. All the equations present heteroskedasticity and autocorrelation consistent (HAC) estimates. To test our hypotheses, eight regressions with two dependent variables are run: network value (NETWORK VALUE) from equation A.1 to A.4 and corrected network value (NETWORK VALUE') from B.1 to B.4. Equations A.1 and B.1 only include the control variables, while the remaining explanatory variables are added consecutively in a nested way, so that Models A.4 and B.4 present the estimation that includes all the explanatory variables. The hypothesis that the independent variables are jointly equal to zero is rejected for the two models ($\rho < 0.01$), as can be inferred from F-test (not shown). Thus, compared with equations with no explanatory variables, the full models (A.4 and B.4) show a significant better fit.

Model A.2 shows that the variable time in the market presents a positive and highly significant sign, which supports Hypothesis 1: network value increases with the time that the firm has been operating in the market. Model A.3 adds the variable internationalization whose value is also positive but not significant, thus Hypothesis 2 cannot be accepted. Finally, model A.4 also includes the variable switching costs, with a negative and significant coefficient: the presence of switching costs decreases the network value, as proposed in Hypothesis 3. The F-test, which compares different nested
models is also shown at the end of Table 5 and confirms that the estimation presented in column A.4 is the one that best fits our data. In this model, the global fit is quite satisfactory, with an R-squared around 0.6. In any case, it is also important to note that the value of the coefficients of the main explanatory variables of the model remains highly stable in all the estimations. With respect to control variables, population in each national market and number of firms have a positive and significant influence in network value, jointly with time dummies which are globally significant.

If we consider the set of models that use the corrected network value as dependent variable, the sign and significance of the main coefficients does not change. As can be seen in Table 4, time in the market increases corrected network value and switching costs decrease it, supporting respectively Hypotheses 1 and 3. Internationalization has not a significant effect on network value, which leads us not to accept Hypothesis 2. These coefficients remain highly stable in all the estimations. As for control variables, time dummies are globally significant and population preserves its positive and significant influence on network value. However, number of firms loses its positive significance. The F-test confirms that B.4 is the estimation that best fits our data when network value is measured through this corrected way. In this model, R-squared presents here a value of 0.46. Note that the measure of network value that takes into account the disutility perceived by the existence of rivals networks in the presence of economic incompatibility reduces the coefficients of the main explanatory variables although the sign of the relationship with network value does not change.
<table>
<thead>
<tr>
<th></th>
<th>NETWORK VALUE</th>
<th>NETWORK VALUE'</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(A.1)</td>
<td>(A.2)</td>
</tr>
<tr>
<td>TIME</td>
<td>0.242***</td>
<td>0.229***</td>
</tr>
<tr>
<td></td>
<td>(5.70)</td>
<td>(5.46)</td>
</tr>
<tr>
<td>INTERNATIONALIZATION</td>
<td>0.230</td>
<td>0.168</td>
</tr>
<tr>
<td></td>
<td>(1.02)</td>
<td>(0.79)</td>
</tr>
<tr>
<td>SWITCHING COSTS</td>
<td></td>
<td>-0.539**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(-2.60)</td>
</tr>
<tr>
<td>FIRMS</td>
<td>1.899</td>
<td>1.971</td>
</tr>
<tr>
<td></td>
<td>(1.12)</td>
<td>(1.17)</td>
</tr>
<tr>
<td></td>
<td>(3.48)</td>
<td>(3.47)</td>
</tr>
<tr>
<td>YEAR Dummies</td>
<td>YES***</td>
<td>YES***</td>
</tr>
<tr>
<td>Constant</td>
<td>-176.4***</td>
<td>-186.8***</td>
</tr>
<tr>
<td></td>
<td>(-3.74)</td>
<td>(-4.01)</td>
</tr>
<tr>
<td>Number of observations</td>
<td>2,032</td>
<td>2,032</td>
</tr>
<tr>
<td>R2</td>
<td>0.524</td>
<td>0.530</td>
</tr>
<tr>
<td>F-Test vs. 1</td>
<td>32.55***</td>
<td>16.70***</td>
</tr>
<tr>
<td>F-Test vs. 2</td>
<td>1.03</td>
<td>3.68**</td>
</tr>
<tr>
<td>F-Test vs. 3</td>
<td>6.74**</td>
<td></td>
</tr>
</tbody>
</table>

* t statistics in parentheses
* * p < 0.10, ** p < 0.05, *** p < 0.01
Performance and Network Value

The results of the estimations of the performance model are shown in Table 5. Model C.1 introduces the control variables and the lagged performance, whereas Models C.2 and C.3 add network value and corrected network value, respectively. Our specification choice is based on a System GMM with first differences, one-step estimation and robust to heterokedasticity. To assess the validity of the System GMM estimators, we run the Arellano-Bond test for first-order and second-order serial correlation. Table 5 reports the significant m1 and insignificant m2 serial correlation statistics. This indicates that there is not second-order correlation on the level of residuals. The Hansen test is also reported and its not significance validates the robustness of our estimations.

Lagged performance has a positive and significant influence on performance with a coefficient that remains highly stable in the three estimations. This means that performance in the previous period positively influences the current performance. This result justifies the use of GMM estimator in this part of our analysis. Firm network value has, as expected, a positive and significant impact on performance (Models C.2 and C.3), which supports Hypothesis 4. The number of firms has negative and significant influence on firm performance as a result of increasing rivalry and year dummies are also statistically significant. However, population does not seem to influence on performance in any of the three models. In this case, the influence of corrected network value on firm performance is slightly higher than the traditional network value.
<table>
<thead>
<tr>
<th></th>
<th>PERFORM&lt;sub&gt;t&lt;/sub&gt;</th>
<th>(C.1)</th>
<th>(C.2)</th>
<th>(C.3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERFORMANCE&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.711***</td>
<td>0.675***</td>
<td>0.674***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(18.14)</td>
<td>(29.22)</td>
<td>(29.13)</td>
<td></td>
</tr>
<tr>
<td>NETWORK VALUE</td>
<td></td>
<td></td>
<td>0.000972</td>
<td>0.00104***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(4.10)</td>
<td>(4.17)</td>
</tr>
<tr>
<td>NETWORK VALUE'</td>
<td>0.00104***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.17)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIRMS</td>
<td>-0.0241***</td>
<td>-0.0243***</td>
<td>-0.0229***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-2.90)</td>
<td>(-3.08)</td>
<td>(-2.86)</td>
<td></td>
</tr>
<tr>
<td>POPULATION</td>
<td>0.000195</td>
<td>-0.000491</td>
<td>-0.000212</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.95)</td>
<td>(-1.58)</td>
<td>(-0.85)</td>
<td></td>
</tr>
<tr>
<td>YEAR Dummies</td>
<td>YES*</td>
<td>YES**</td>
<td>YES**</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.184***</td>
<td>0.190***</td>
<td>0.187***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5.83)</td>
<td>(7.61)</td>
<td>(7.41)</td>
<td></td>
</tr>
<tr>
<td>Number of observations</td>
<td>1,991</td>
<td>1,991</td>
<td>1,991</td>
<td></td>
</tr>
<tr>
<td>m1</td>
<td>-2.08**</td>
<td>-2.29**</td>
<td>-2.28**</td>
<td></td>
</tr>
<tr>
<td>m2</td>
<td>0.44</td>
<td>0.33</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>Hansen Test</td>
<td>37.66</td>
<td>33.80</td>
<td>33.44</td>
<td></td>
</tr>
<tr>
<td>F-Test vs. 1</td>
<td>16.79***</td>
<td>17.38***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\* \( p < 0.10 \), \** \( p < 0.05 \), \*** \( p < 0.01 \)
7. DISCUSSION AND CONCLUSIONS

This paper has advanced in the study of markets with network effects from a strategic perspective. With this aim we propose a theoretical model in which firm’s strategy may condition network effects and firm profitability through the three main elements that the literature has remarked in information markets, i.e.: expectations, coordination and compatibility.

Probably the main contribution of the paper is that the observation of network effects through network value, together with the development of the subsequent theoretical model, has allowed us to endogenize network effects. The underlying idea for the endogenous character of network effects is that firm strategy can lead them to company’s own interest.

Our results reveal the importance of entry timing strategy in markets with network effects. This result is highly consistent with previous findings in the literature (Gomez and Maicas, 2008; Usero and Fernández, 2009). Switching costs has also appeared as a key strategy weapon that influences network value. In this case, high switching costs has been probed to dissuade the firm network selection by potential users with the subsequent negative effect on network value. Users distrust firms with high switching costs since they anticipate an opportunistic behaviour of firms (Mata et al., 1995), decreasing the effectiveness of network effects. Consequently, firms have to find a trade-off between create high switching costs in their customers to retain them and being not so aggressive to be perceived by potential customers as an appealing and trustworthy alternative. Contrary to our ex ante expectations, operating in several international markets has not been found a remarkable strategy that influences users’ expectations and, thus, its effect on network effect is not significant. The explanation we can provide to this unexpected finding is twofold. First, while it is true that several mobile service providers are competing globally, users are restricted in their choices to companies operating in their local markets. In mobile telecommunications, users take into account only the network of the country where they live, whereas in other kind of information industries such as software, hardware, or online auctions, users do not perceive national boundaries in their decisions. Second, the internationalization of mobile operators could have become a strategic necessity. This seems to be clear from the analysis of the industry evolution in the last years in which international diversification followed by the main
operators has been quite similar. Thus, the non significance of international presence on network value could respond to these particularities in the mobile communications industry.

Our study does not dwell on the role that strategy plays on network value. It also confirms how network value constitutes an element that is positively related to firm performance. Our main premise at this point is that users are willing to pay more for being part of a network firm with a larger installed base since the product does not have any value in itself. The value resides in the communication ties that the firm network offers to users and this allows firms to increase the price of their product or service.

In analyzing the previous relationships, this research has tried to respond to a more accurate meaning of network value. Traditionally, network value has been considered to be proportional to network size, since the installed base has been found the main driver of network effects. Although this is reasonable, in this paper we have added a strategic dimension to the traditional approach. We corrected previous measures by considering not only the own network of the firm, but also rivals’ network, that is, market competition is introduced in assessing network value. Although the main findings do not substantially change, the corrected measure we use shows a lower network value, which is perfectly understandable as we consider market competition.

Our research has several managerial implications. It recommends paying special attention to entry timing strategies in information markets. Firms should try to attract users to their network as soon as possible to gain competitive advantage. Because of this, it is not surprising to observe that bargain-then-rip-off strategies are very common in the first stages of market evolution as an adequate mechanism to attract users that will be locked-in at a later stage. According to the previous reasoning, entry timing and price strategy have to be considered simultaneously when network effects are important. However, firms in these markets should be aware of not overexploiting their customers when lock-in is a likely market outcome. As being observed, the perception of high switching costs by users may anticipate a later opportunistic firm behaviour that could derive in the reduction of incentives to enter into the relationship with the firm. This study also shows managerial insights on the international diversification for mobile operators. Apparently, international presence has no
significance over network value, which, in our view, does not mean that firms must not pay attention
to their international strategy, but rather it could has become a strategic necessity to survive in the
industry.

We should not forget that our research setting is referred to an industry in which the regulator
plays a key role. For this reason, several policy implications can also be derived. Importantly, the
effectiveness of FMA in the mobile communications industry depends on the winning of a licence that
is granted by national institutions and that is compulsory to compete. Governments should be aware of
the direct impact that their decisions have on competition in each local market. A reduced number of
licenses or restrictive criteria to start an activity could reduce the number of competitors. This initial
restriction could constitute an entry barrier in the future because a firm that cannot obtain a licence at
the first stage of competition will lose time in the market, which has been revealed as a valuable
resource. Additionally, our results show the important effect of switching cost to reduce the network
value and consumers' welfare in information markets. Thus, the regulator has to take decisions being
conscious of that switching costs are a constant in the industry that can be harmful for customers'
interests. Indeed, in the context of mobile communications, the regulator has already recognized the
importance of this dimension, reducing switching barriers and developing several measures lead to
make switching easier and less costly. Mobile number portability is, perhaps, the most remarkable
effort in this direction and it has had, according to the literature, the desired effects (Lee, Kim, Lee and
Park, 2006).

To our knowledge, our paper is one of the first attempts to empirically integrate network effects
into firm strategy. However, several issues deserve further attention. First, we use a corrected measure
of network value which does not confer the same importance to all users and it also takes into account
market position of each firm. However, while it is true we make an effort to incorporate several
dimensions in our network value approach, this measure has several limitations. First, it does not
consider the existence of industry network effects derived from the existence of technological
compatibility among networks as a result of European regulation. Second, the tendency to make on-net
communications only includes market shares and not price differences that leverage the firm's
network effects in a context of economic incompatibility. Precisely, a firm that offers a price for on-net calls under the average price will attract more users, increasing the value of the network. Due to these limitations, future research should try to find a measure of network value that includes the existence of industry network effects and the price dimension. Another possible extension would be to incorporate the existence of social network effects that reinforce network value. Users do not only select a firm because they believe it will be bigger than the others. Consumers’ behaviour is also influenced by the previous decisions of the people who are socially related to them.

International presence has been showed not to have any significant impact on network value. However, internationalization is expected to confer brand familiarity that may shape expectations and coordinate users to the same network. Although some explanations have been developed, a better understanding about how the internationalization process have influenced firm performance in these markets until becoming an strategic necessity is needed.
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