THE RIMINI CENTRE FOR ECONOMIC ANALYSIS

WP 03_08

Nicoletta Corrocher
CESPRI, Bocconi University, Milan

Lorenzo Zirulia
University of Bologna, Department of Economics, Bologna
CESPRI, Bocconi University, Milan
Rimini Centre for Economic Analysis, Rimini

"ME AND YOU AND EVERYONE WE KNOW: AN EMPIRICAL ANALYSIS OF LOCAL NETWORK EFFECTS IN MOBILE COMMUNICATIONS"

The *Rimini Centre for Economic Analysis* (RCEA) was established in March 2007. RCEA is a private, non-profit organization dedicated to independent research in Applied and Theoretical Economics and related fields. RCEA organizes seminars and workshops, sponsors a general interest journal *The Review of Economic Analysis*, and organizes a biennial conference: *Small Open Economies in the Globalized World* (SOEGW). Scientific work contributed by the RCEA Scholars is published in the RCEA Working Papers series.

Me and you and everyone we know: an empirical analysis of local network effects in mobile communications

Nicoletta CORROCHER[1],
CESPRI, Bocconi University, Milan

Lorenzo ZIRULIA,
University of Bologna, Department of Economics, Bologna
CESPRI, Bocconi University, Milan
Rimini Centre for Economic Analysis, Rimini

Abstract: This paper aims at investigating the importance that consumers assign to local network effects (i.e. the extent to which they take into account their contacts' operators in determining their choices) and at identifying which individual characteristics affect consumers' preferences in relation to local network effects.

Based on a sample of 193 Italian students, we find that consumers are highly heterogeneous with respect to the evaluation of the importance of their friend/family's operator when choosing their own provider, and that such heterogeneity is associated to specific characteristics related to individual innovativeness and patterns of mobile phone usage. In particular, consumers who are more interested in local network effects are typically sophisticated users, who use intensively voice services and who are early adopters. Interestingly, consumers who pay attention to local network effects end up spending relatively little in proportion to their intensity of use.

[1] Corresponding author. E-mail to nicoletta.corrocher@unibocconi.it. Comments are welcome.

1. Introduction

In mobile communications, termination-based price discrimination occurs when firms fix tariffs for calls that terminate on other operators' network (off-net calls) that are higher than tariffs for calls that terminate on their own network (on-net calls). This practice, which is commonly observed in real markets, is usually justified by the difference in marginal cost between on-net calls and off-net calls, since the second ones include the access cost paid by the originating firm to the receiving one. Another effect of termination-based price discrimination, however, is to induce "artificial" network effects. Since individuals typically call a small subset of the entire population (e.g., family members and friends), network effects are *local*, in the sense that, *ceteris paribus*, for a consumer is convenient to adopt the same operator of the consumer she calls more frequently.

Notwithstanding the possible relevance of this effect, the evidence on this kind of local network effects in mobile communications is scant (Birke and Swann, 2005; Birke and Swann, 2006). For this reason, our goal in this paper is twofold: first, we intend to investigate the importance that consumers assign to local network effects (i.e. the extent to which they take into account their contacts' operators in determining their choices); second, we want to identify which individual characteristics affect consumers' preferences in relation to local network effects.

Our empirical exercise was carried out in a population of 193 Italian students, from which we collected various information related to mobile phone usage. Our results suggest that consumers are highly heterogeneous with respect to the evaluation of the importance of their friend/family's operator when choosing their own provider, and that such heterogeneity is associated to specific characteristics related to individual innovativeness and patterns of mobile phone usage. In particular, consumers who are more interested in local network effects are typically sophisticated users, who use intensively voice services and who are early adopters. Interestingly, consumers who pay attention to local network effects end up spending relatively little in proportion to their intensity of use. We believe that our results can be of interest both to managers, involved in determining pricing strategies of mobile

operators, and to policy makers, since sound theoretical arguments suggest that local network effects can increase firms' market power.

The rest of the paper is organized as follows. Section 2 provides a short overview of the literature on global and local network effects. After highlighting the main features of the mobile communications sector, section 3 discusses and provides evidence on the issue of local network effects with reference to the mobile communications industry. At the end of this section we formulate our research questions. Section 4 describes our sample and section 5 reports the results of the empirical analysis. Finally, section 6 concludes.

2. Global and local network effects: background literature

The aim of this section is to briefly introduce the notion of (local) network effects. In the section 3 we will then apply this notion to the case of the mobile communications service industry.

The literature on network effects has started with the seminal contribution of Rohlfs (1974). As Church and Gandal (2004) point out, a network effect exists "*if the value [of adopting a system component] increases in the number of other adopters that (ultimately) join the network by purchasing compatible products*" (Church and Gandal, 2004; p.4). The source of benefits positively depends on the size of the network when adoption occurs. The larger the network, the greater are the benefits from adoption. Networks effects can be direct and or indirect. Direct networks effects arise when adopters become part of a network by purchasing a product that provides a (direct) connection between the adopter and other users who bought the same product[2]. Having a large network of compatible mobile phone users for instance makes new users more likely to join. In the case of indirect networks effects, adopters gain utility from the joint consumption of two components that interact to form a system. In this case, the product (hardware component) has no direct value for the adopter unless it

[2] Typical examples of direct network effects are present in the telephone exchange and the fax.

is used together with another product (software component); here vertical compatibility (between the system components) matters[3].

In the case of a single good, the literature has emphasised the role of expectations and the existence of multiple equilibria (Katz and Shapiro, 1994). Networks of different sizes (to which different levels of social welfare are associated) can be sustained in equilibria with self-fulfilling expectations, and several mechanisms have been suggested to avoid the risk of inefficiencies. In case of competition between incompatible goods (Katz and Shapiro, 1985), multiple equilibria also emerge quite naturally, where one of the firms ends up monopolizing the market. In a dynamic perspective, small "historical accidents" can determine the winning firm (Arthur, 1989).

More recently, the literature has considered the issue of local network effects (Swann, 2002). Network effects are local if the value for a consumer of adopting a product or a technology is increasing in the number of adopters in a subset of the population, which varies among consumers. In the case of adoption of consumers, this subset typically coincide with the consumers' social neighbourhood, while for firms this is defined by the business network the firm is embedded in. Local network effects are very common in communication networks, where consumers primarily consider the patterns of adoption by agents in their social neighbourhood, but for software programs as well, where consumers are concerned with the decision of people with whom they usually exchange data and information.

Some recent contributions have studied local network effects both from a theoretical and empirical perspective. On the theoretical side, for instance, Sundararajan (2004) analyses a simultaneous move game of adoption with incomplete information and shows how the resulting network of adopters is influenced by the underlying social structure. More directly related to this paper, Banerji and Dutta (2006) consider a duopoly in a market with functionally homogeneous goods, where groups of

[3] Examples of indirect network can be found in the field of computing (operating systems and application software) and consumer electronics (video cassette systems, compact disks).

consumers interact only with some of the other groups. They show that, for some structures of social networks, firms can obtain positive profits even with Bertand competition, if products are partially compatible. In this case, segmented markets can emerge, whereby different groups of consumers are served by different firms. This means that the existence of consumers' social structure may soften competition[4]. On the empirical side, Tucker (2004) analyses the adoption of a video-messaging technology by employees of a financial firm, and finds support for the hypothesis that the choice of adopting of an employee is influenced uniquely by people she communicates with. The papers by Birke and Swann (2005, 2006), who considered local network effects in mobile communications as we do, are discussed at length in the next section.

3. Local network effects in the mobile communications service industry

In the case of the mobile communication sector, technology–driven direct network effects arise for non-voice services such as text messages and video calls, while indirect network effects are associated to new services related to 3G mobile phones. In this paper we focus on induced networks externalities, which follow from firms' pricing strategies. In particular, we are concerned with termination-based price discrimination (Laffont et al., 1998), which occurs when firms fix tariffs for calls that terminate on other operators' network (off-net calls) that are higher than tariffs for calls that terminate on their network (on-net calls).

Termination-based price discrimination induces network effects because, *ceteris paribus*, it is convenient to adopt the operator with the largest customer base. However, network effects are local, since individuals typically call a small subset of the entire population. In other terms, it is an individual's social network which constitutes the relevant reference group which influences his/her choice of operator.

[4]The result that local network externalities lead to "co-existence" is also commonly found in the literature on technology adoption (e.g. Cowan and Miller, 1998).

From the empirical point of view, some detailed evidence on this issue is provided by Corrocher and Zirulia (2006)[5], who analyse the industry in Italy. In this market, which is one of the most developed in Europe, tariff plans with termination-based price discrimination appeared in 1997, when two firms were active in the Italian market, TIM, the former fixed-line monopoly and leader in the mobile communications market, and Vodafone. However, they became popular in the period 1999-2000, when competition became more intense with the entry of a third operator, WIND. In these two years, 73.81% of all the newly introduced contracts were discriminating between off-net and on-net calls. The percentage for TIM was 83.67%, for Vodafone was 23.08%, for Wind was 53.33%. In the following years, the percentage of contracts featuring termination-based price discrimination remained high, even if at a lower level. In the two-year period 2001-2002, the overall percentage of discriminating contracts was 47.83 % (52.38% for TIM, 47% for Vodafone, 25% for Wind); in the period 2003-2005, when a fourth firm (3) entered the market, the figures were 48.15% for the entire market, 60% for TIM, 33.3% for Vodafone, 53.3% for Wind and 52.63% for 3. Overall, this evidence shows that Italian operators tried to induce pecuniary network effects: this is particularly true for the largest firm, TIM, but it applies also to the followers.

In considering local network effects in mobile communications, this paper takes as a starting point the contributions of Birke and Swann (2005 and 2006), but it tackles the issue from a different perspective. Those papers aim at studying and measuring consumers' coordination in operator choices in presence of network effects induced by firms' pricing strategies. In Birke and Swann (2006), the authors find evidence of coordination of operators within UK families that cannot be reconduced to overall market shares. In Birke and Swann (2005), the authors look at the coordination within each consumer's social network for a population of students at Nottingham University. They find that the probability the students have the same operator is higher, the higher the frequency with which they call each other.

[5] The strategy of termination-based price discrimination is also important in other countries such as the UK (Valletti and Cave, 1998).

These two papers infer the importance of local network effects from the existence of coordination within subgroups (family and groups of friends). However, they do not provide *direct* evidence that consumers look at their contacts' provider when choosing their own operator. Their analysis is static, so that they do not offer evidence of a coordination process, which presumably occurs over time. The supportive evidence the authors provide is mixed. In Birke and Swann (2005), the authors show that friends do not coordinate the choice of handsets, which could prove that there are no unobserved characteristics that lead friends to make similar choices if not related to the induced newtork externalities. However, in Birke and Swann (2006), they show the existence of a disprortionate share of on-net calls *unrelated* to price differentials, which indeed does suggest a form of coordination among friends in operator choices independently from local network effects (or, at least, some other factors exist that leads friends to choose the same operator).

It is worth mentioning that in principle there are reasons why consumers could be unaffected by their contacts when choosing their operator[6]. First, since communication is guaranteed by full compatibility among operators, there are no technical obstacles for those who choose an operator which is not popular within their social neighbourhood. Therefore the benefit stemming from the existence of local network effects is purely pecuniary. Second, the size of the network depends on the intensity of use of mobile phones. For instance, if the usage of mobile phones by a specific consumer is limited, consumers bear a small total cost differential associated to termination-based discrimination between different operators. In particular this cost is smaller than the search cost to be paid to screen different options. If this is true, then firm's strategies aimed at enforcing termination-based price discrimination might not be as successful as they expect.

[6]As the Italian case shows, firms also offer contracts without termination-based price discrimination. Consumers can choose operators which offer contracts such that the operators of their family and friends do not affect prices. It is true that even in this case the operators of a consumer's social network affect his/her choices (intuitively, a non-discriminating tariff plan is more attractive for users whose contacts are uniformly distributed across operators), but the choice is not linked to a network externalities argument.

Given this background, we aim at investigating two research questions. First, we want to produce direct evidence on the importance consumers attribute to local network effects, i.e. if they take into account their contacts' operators when making their choices. Second, we want to determine which factors at the individual level affect such attitude. In this respect, we rely on the idea the consumers are heterogenous, not only in terms of willingness to pay and modes of service usage, but also in their degree of sophistication or knowledge base. Consumers can be categorized not only in relation to their speed of adoption (Rogers, 2003), but also in their pattern of consumption. Even more, it is possible that early adopters in this sector are not the most sophisticated users (or "lead users" à la von Hippel, 1988). In the mobile communications industry, it is possible to identify two main classes of lead users: "the technological early adopters", and "the emotional early adopters". The first category is composed by those individuals who use the devices in a professional way, exploiting all the included features. The second category of lead users - the emotional early adopters – is represented by people who are not necessarily technological experts, but who have a great sensibility to technical changes and innovations. They have low price elasticity and pay great attention to their life-style and tend to buy experimental products just launched on the market. Quite interestingly, their interests and needs, unlike the technological early adopters' ones, will be probably common to the mass market in the near future. In terms of managerial implications, our point is that the different degrees of consumer sophistication may have important consequences on firms' pricing strategies.

The possibility that local network effects can constitute a source of market power, as we mentioned in the previous section, has obvious managerial implications for firms in mobile communications. In this industry, the substantial homogeneity of the service provided would lead towards strong forms of competition, with negative effects on firms' profits. Operators, then, are in search of strategies to escape the "Bertrand paradox". Furthermore, local network effects may lead to market power also by creating switching costs. If consumers actually choose their operator to exploit local network effects, individual change of operator may be costly, thus

inducing consumer inertia. Furthermore, customers must usually communicate their habitual contacts that they changed operator, since this change affects the price of calls, and this constitute another source of switching costs (or other costs could exist if they do not do so). In that respect, local network effects resulting from firms strategies can provide an explanation for the fact that number portability has reduced, but not eliminated switching costs (see Grzybowski (2007) for the UK and Lee et al. (2006) for South Korea).

The link between local network effects and market power is of interest to policy makers as well. Although strategies creating artificial local network effects are not per se subject to sanctions, their consequences in terms of social welfare and competition should be of interest for policy makers, when they examine the competitiveness of the mobile communication sector and evaluate the desirability of welfare improving interventions.

4. Sample description and descriptive evidence on consumers' choices

The empirical analysis in this paper focuses on a sample of consumers in Italy. In particular, it is based upon a survey of 193 students with a mobile phone. Selecting students ensures a highly homogeneous respondent set and thus can accomplish the ideal theory falsification procedure (Calder et al., 1981). The survey was carried out among students in the fourth and fifth year of high school, and in the first year of university (undergraduate degree)[7]. We selected a young population, as we believe that the impact of social network on consumers' choices can be better captured within groups of young people who study together and are more likely to be affected by friends in their choice of mobile operators. Furthermore, young consumers of today will be the most important consumers of tomorrow and analysing their behaviour can provide important information on future trends. The questionnaire is made of 25 questions, which investigate the patterns of adoption of mobile phones and mobile operators, in terms of time of adoption, motivations behind adoption,

[7] The authors would like to thank Daniel Birke for his availability in sharing the main structure of his survey.

number of pre-paid cards and characteristics of the tariff plan, importance of factors behind the choice of operators (e.g. network coverage, network effects, services provided), intensity of usage of voice and non-voice services (minutes), and estimated expenditures in voice and non-voice services.

In terms of gender and age distribution, 29% of the sample is made of female students and 71% of male students. The average age is 18.4 years. A specific question in the survey asked respondents to report when they first bought (or were given) a mobile phone: 57% of respondents bought it before April 2001 and less than 10% after June 2002. In terms of mobile handset, Nokia is the most popular producer (37.6% of respondents), followed by Samsung (19.3%) and Motorola (15.3%). This means that in our sample the market for handsets appears to be quite concentrated, with three firms owning more than 70% of users.

An interesting insight on patterns of adoption comes from the investigation of the reasons behind the purchase of a mobile phone[8]. Indeed, 62.7% of respondents state that they bought a mobile phone to be called or tracked by friends and family, while 28% wanted a phone to call friends and family and 25.9% to send text messages. This means that social networks play an important role in affecting the adoption of a mobile phone. On the contrary there is a scarce evidence of pure "herd behaviour", since just 7% of respondents declare that they bought a phone because everyone else had it. Finally, if we look at the distribution of users across mobile operators, we note that 64.8% of respondents use Vodafone-Omnitel, 23.3% TIM, 6.2% Wind and 5.7% 3. This is somewhat surprising, considering that in 2004 TIM's market share was 43%, Vodafone's market share was 36%, Wind's market share was 17% and 3's market share was 4%. However, it is worth noticing that the market leader, who is also first mover in Italy, traditionally targets users with a high willingness to pay (such as business users), while the follower competes by concentrating on consumers with low willingness to pay – typically young people. As the survey was carried out among students, this might explain the bias in our sample. Quite interestingly, 26%

[8] The related question allowed multiple answers.

of respondents state that changed operator at some point in time. With reference to this issue, we do not observe more preferences towards one specific operator, i.e. the distribution of individuals who changed operator is even across operators. The most important reasons behind this change are "*The operator did not provide convenient tariff plans and/or promotions*" (28% of respondents) and "*My friends used a different operator*" (26% of respondents). This evidence is already pointing at the idea that network effects constitute an important factor in determining users' choices in the mobile communication sector.

5. Empirical analysis: demand patterns and network effects

In this section, we take a micro level perspective to study the importance of different factors in determining the choice of the specific mobile operator by adopters, and investigate how motivations vary across different across groups of adopters on the basis of individual characteristics and patterns of consumptions. One specific question in our survey asked respondents to rate on a five-point scale (1 being "not important", 5 being "very important") the importance of different factors when choosing the specific operator. These factors are: network coverage; special offers on phone calls, text messages, multimedia messages; bundling between operator and handset; tariff attractiveness[9]; friends using the same operator; family using the same operator; boyfriend/girlfriend using the same operator; available services (e.g. games); post-sale customer services. 36 respondents state that they did not choose the operator by themselves, because someone else did it for them. Therefore the reference sample for our empirical analysis is made of 157 users .Table I illustrates the distribution of respondents within each factor.

{Insert Table I approximately here}

[9] Second degree price discrimination is very common in the sector, making it virtually impossible for consumers to calculate the most convenient offering. However, among the factors driving the choice of a specific operator, we decided to include the fact that consumers might perceive tariff plans of specific operators particularly convenient for them and to base their choice on perceived prices.

Network coverage and tariffs appear to be the most important determinants affecting the choice of operators, but network effects are also relevant. We have three variables identifying network effects: friends, family and partner with the same operator. These variables play an important role in determining the adoption. 61.8% rate "friends' operator" as important or very important, while this percentage is 48.41% for "family's operator" and 48.75% for "partners' operator".

For the scope of our paper, we reduce the number of variables related to the importance of different factors for adoption, by way of factor analysis.[10] Results are reported in Table II.

{Insert Table II approximately here}

We can identify three underlying factors, which relate differently to network effects, tariffs and quality of services, and bundling opportunities. The first factor, labelled '*Tariff/quality of service*', is explained by network coverage, by the existence of special offers, by tariff attractiveness and by the availability of a wide range of services. Clearly, these variables are particularly important for users who are concerned mostly with service quality and costs when engaging in the process of adoption. The second factor, '*Network effects'*, is explained by family and friends with the same operator, and reflects the importance of network effects in choosing a specific operator. The third factor, '*Bundling*', is explained mostly by the existence of bundling between the handset and the specific tariff plan (operator) and, to a lesser extent, by the range of services offered.

The factor analysis provides an input for the cluster analysis, which aims at characterising the variety of attitudes towards adoption of mobile operators and, in particular, at identifying which individual characteristics mostly affect the relevance of network effects. The purpose of the clustering exercise is indeed to detect patterns of demand across different categories of users. Four clusters emerge out of the

[10] Within each component, we focus on the variables that display a factor loading greater than 0.50.

analysis (Table III) and statistical tests confirm that the factors are significantly different across clusters.

{Insert Table III approximately here}

Cluster 1 includes users who evaluate relatively more network effects, so that we label this pattern of adoption "*social network oriented"*. *Cluster 2* includes users who do not put much emphasis on any specific factor and therefore choose the mobile operator in a random way ("*random"*). *Cluster 3* includes users with a pattern of choice of operators focused on quality of service and tariff considerations, so that we label this pattern of adoption *tariff/quality oriented*. Finally, *Cluster 4* consists of users, who choose their operator because of bundling advantages deriving from their handset. All in all, this evidence suggests that there is a high degree of heterogeneity in demand patterns and different groups of consumers are characterised by highly idiosyncratic characteristics that require further investigation.

5.1 Explanatory variables

In order to compare different groups of users in terms of motivations for choosing a specific operator and, in particular, to investigate which factors determine the importance of network effects in affecting users' patterns of adoption, we have identified three groups of variables.

First, we argue that network effects are particularly significant for users who intensively use the mobile phone. This is because network effects bring about much more benefits the more contacts a user can exploit and the more time he/she spends on the phone. In order to capture the effect of intensity of usage on the importance of network effects, we asked respondents to evaluate how much time (minutes) they spend on the phone per week with different people (friends, family, partner, others) and how many text messages/multimedia messages they send per week to different people. We gave five ranges of possible answers, both for the intensity of phone calls (0; 1-20 minutes; 21-40 minutes; 41-60 minutes; more than 60 minutes) and for the

intensity of text messages/multimedia messages usage (0; 1-10; 11-20; 21-30; more than 30). These answers were coded as varying between 0 and 4 for each of the four categories of people. We then constructed two categorical variables – INTENSITYVOICE and INTENSITYSMS – by summing up all the values, so that these two variables range between 0 and 16. As said before, we expect more intensive users to rate network effects more than others, i.e. we expect INTENSITYVOICE and INTENSITYSMS to be higher for users in cluster 1.

Second, the importance of network effects might be also associated with the degree of users' sophistication. Users of mobile phones are extremely heterogeneous not only in terms of intensity of usage and willingness to pay, but also in terms of experience and information they collect on available services and tariff plans. In the first place, with the growing number of contracts provided by operators, consumers face an increasing range of offers and might find it difficult to identify the most suitable tariff plan for their specific needs. Most of them exploit the continuous development of innovative tariff plans and the provision of promotions, by switching to new contracts and sometimes to different operators, while others tend to be quite inertial. Furthermore, if we observe the type of services offered over the mobile network, we notice that firms offer a growing number of value added services such as ring tones/images, news, games, web surfing. We can argue that the use of value added services indicates users' sophistication. Third, we asked respondents to name the tariff plan and/or promotion they are using. Only half of our respondents (54.4%) know the type of contract they use and it is reasonable to assume that these users are more sophisticated than the others. In general, we expect more knowledgeable users to put more attention to network effects. Fourth, since the introduction of pre-paid cards, users in Italy have had the possibility of using different sim cards (different operators) on their handsets, i.e. there is no "sim lock-in". We could think that having two sim cards allows users to exploit tariffs of various operators discriminating according to different time zones or different "social networks", which in principle would permit them to spend less. Clearly, these users monitor the emergence of new tariff plans and are particularly careful in

choosing their contracts and operators. Given the availability of multiple sim cards, they do not need to conform to their social contacts' choices in order to save money.

In order to capture the effect of users' sophistication on the perception of network effects, we built four variables, PROMOTIONS, SERVICES, TARIFF PLAN, CHANGEOP and TWOSIM. PROMOTION takes value 1 if consumers use seasonal promotions (e.g. *Summer Card*, which allows sending free text messages during summertime) and 0 otherwise. SERVICES takes value 1 if users utilise value added services and 0 otherwise. TARIFF PLAN takes value 1 if users know their tariff plan and 0 otherwise. CHANGEOP takes value 1 if consumers have changed operator since their first adoption and 0 otherwise. TWOSIM takes value 1 if consumers have two or more sim cards and 0 otherwise. From the above considerations, we expect users who use promotions and value added services, and users who are aware of their tariff plan to put more attention to network effects when choosing the operator (i.e. to be relatively more numerous in cluster 1). Turning to CHANGEOP, we notice that users who have changed operator since their first choice might have done so precisely to exploit network effects (with friends and family) and might appear as sophisticated users, so that we can expect them to be relative more numerous in cluster 1. With reference to TWOSIM, it can be argued that users with two sim cards do not need to pay attention to local network effects, as they can easily switch from one operator to another one. However, these are also sophisticated users. Therefore, we do not have any a-priori expectation on the relationship between cluster membership and TWOSIM.

Third, when evaluating the importance of network effects in consumers' behaviour, we need to consider the role of expenditures. In order to capture the effect of expenditures on the relevance of network effects, we asked respondents to evaluate how much money they spend per month on phone calls and on text messages. We gave six possible ranges for phone calls (less than 10 €; 10-15 €; 16-20 €; 21-25 €; 26-35 €; more than 35 €) and five possible ranges for text messages/multimedia messages (less than 10 €; 10-15 €; 16-20 €; 21-25 €; more than 25 €). The answers were coded between 0 and 5 for phone calls, and between 0 and 4 for text messages. We then

built two variables, EXPENDVOICE, which varies between 0 and 5, and EXPENDSMS, which varies between 0 and 4. We do not have any a-priori hypothesis on the impact of expenditures on the importance of network effects. On the one hand, since one might think that expenditures are positively associated with the intensity of usage and we argue that intensity of usage is positively associated with the importance of network effects, then we might expect that expenditures and relevance of network effects are also positively correlated. On the other hand, consumers who are more interested in network effects are also more able to choose the "best" operators, given their social contacts' choices, and therefore should be able to reduce their expenditures, at least in relative terms.

Finally, we control for three additional determinants of the relative importance of network effects for consumers. First, we know from previous analysis (Corrocher and Zirulia, 2006) that over time there has been an evolution in firms' strategies towards the provision of contracts, which exploit the existence of local network effects. In particular, we observe an increase in the number of tariff plans that favour groups of users with the same mobile operator, i.e. firms have been introducing new contracts with on-net charges much lower than off-net charges. The percentage of new contracts of this type went from 10.71% in the period 1997-1998 to 48.15% in the period 2003-2005, with a peak in 1999-2000, when 73.81% of new contracts had this characteristic. Starting from this evidence, on the one hand we might think that, other things being equal, early adopters are more sophisticated than late adopters, as they had the opportunity of gathering experience and learning by using. On the other hand, early adopters tend to be users with high willingness to pay (as mentioned elsewhere), who are by definition less concerned about prices than late adopters. Indeed there exists a negative and statistically significant correlation between YEARPURCH and EXPENDVOICE, which partially confirms this intuition. Furthermore, we might expect that the perception of the importance of network effects in the choice of operators emerged when firms started offering tariff plans that discriminate between on-net and off-net calls, so that having friends and family with your same operator became a significant issue. Therefore, late adopters might be more concerned about network effects than early users. Given these considerations,

we do not make any a-priori hypothesis on the impact of YEARPURCH on NETWEXT.

Second, in the survey we ask respondents to identify whether they pay for mobile services or someone else is paying for them. In order to control for this effect, we created a dummy variable AUTOFIN, which takes value 2 if the user himself pays, 1 if he partially pays, and 0 otherwise. We expect this variable to be positively correlated to the importance of network effects, as long as the budget constraint is not tight when the user himself does not pay.

Third, we control for the operator. Empirical evidence on the Italian case shows that, beside the general trends in the market, some companies have been more active than others in introducing contracts based upon local network effects (see Table IV).

{Insert Table IV approximately here}

In order to control for the heterogeneity of operators, we created a dummy variable for each operator (TIM, VODAFONE, WIND and HG) which takes value 1 if the user uses the specific operator and 0 otherwise.

5.2 Results

The cluster analysis allowed use to identify four different clusters of patterns of adoption. Table IV summarises the differences across them in terms of the above-mentioned variables, in order to investigate, in particular, what are the characteristics of users who perceive network effects to be a crucial variable when choosing their mobile operator. For each variable, values greater than the sample average suggest a stronger correlation of the variable with cluster membership.

{Insert Table V approximately here}

We can first examine the impact of the intensity of usage on the perception of the importance of network effects in choosing the operator. As expected, intensive users consider network effects an important factor in determining their choices. The variable INTENSITYVOICE is greater than sample average for consumers in cluster 1 and this result is consistent with the idea that the benefits stemming from network effects are higher for users who use the phone intensively. Only 18.2% of users in cluster 1 have a value of INTENSITYVOICE lower than 4, while this percentage is 30% for users in cluster 2, 29.2% for users in cluster 3 and 26% for users in cluster 4. Furthermore, we find that more than 50% of very intensive users (i.e. users who talk on the phone for more than 40 minutes a week) belong to cluster 1. INTENSITY SMS is not significantly different across clusters.

As expected we find a significant relationship between users' sophistication and the perception of network effects as important factors. In particular, consumers in cluster 1 have higher values of TARIFFPLAN and TWOSIM as compared to the sample average and this confirms the idea that more sophisticated users are more sensitive to network effects. With reference to TWOSIM, in this case it seems that the "sophistication" effect is stronger than the effect related to the fact that users with more than one sim card do not pay attention to network effects, as they can easily switch to other operators. On the contrary, the variable SERVICES is not significantly different across clusters. With reference to this, it can be argued that, although the use of value added services generally indicates a high degree of sophistication, this sophistication concerns services whose tariffs are not affected by the existence of network effects, as they are not characterised by on-net/off-net discrimination. This is because these types of services do not involve communication between two users, but concern more the interaction between service providers and users.

An interesting result concerns the relationship between expenditures and the importance of network effects. Consumers in cluster 1 have a value of EXPENDVOICE which is greater than the sample average. However, it is worth noticing that consumers in this cluster are not the ones who spend most on voice services, since the average value of EXPENDVOICE is higher for consumers in

cluster 3. If we investigate more in depth the relationship between cluster membership and EXPENDVOICE, quite interestingly we observe that almost 30% of consumers in cluster 1 state that they spend less than 10€ per month, while this percentage is lower both for consumers in cluster 2 and for consumers in cluster 3. This result provides interesting insights on the relationship between expenditures and intensity of usage. From this analysis, it seems that there is no such a positive relationship between the time one spends over the phone and the money he/she spends. This might suggest that heavy users learn how to choose tariffs in order not to spend too much and this is done through the exploitation of network effects.

Finally, when we control for year of adoption, and operator, we find that consumers in cluster 1 have generally adopted earlier than consumers in other clusters and that a higher percentage than the sample average using the operator TIM. First, these results suggest that early adopters tend to pay more attention to network effects when choosing their operator as compared to other consumers. As underlined before, *a priori*, the relationship between the year of adoption and the relevance of network effects is not clear, as two opposite effects are at stake. With reference to this, our empirical evidence suggests that early adopters' sophistication is more important than their higher willingness to pay. Second, the evidence on operators shows that users in cluster 1 tend to use TIM more than sample average. This is in line with the evidence (table IV) illustrating that this operator has been particularly active in introducing tariff plans which exploit network effects. As far as the variable AUTOFIN is concerned, we do not find significant differences across clusters, which suggest the existence of a tight budget constraint.

6. Conclusions

The paper aimed at investigating the importance of different factors in the choice of mobile telephone operators and the emerging patterns of adoption. The attention was put on the role of local network effects and on the characteristics of consumers who take into account these effects when choosing their operator. To this scope, we carried out a survey among 193 high school and university students, by investigating

patterns of adoption and modes of usage of mobile phone services. Our analysis proceeded in two steps. First, using data from the questionnaire, we identified three determinants of adoption by means of a factor analysis: tariff/quality, network effects, bundling. Second, we clustered consumers around the factor loadings and examined differences across clusters along a series of variables describing consumers' innovativeness and mode of usage, with the aim of singling out in particular the peculiarities of consumers who attribute great importance to local network effects.

Empirical findings show that there is a high degree of heterogeneity in the market in terms of consumers' degree of innovativeness and sophistication, and patterns of mobile services usage. Of particular interest for our analysis, consumers who give importance to local network effects are intensive and sophisticated users of mobile phone services, as well as early adopters. In general, consumers that spend time and attention around the use of mobile phone services are also those who make their choices, taking into account the existence of local network effects. Interestingly, these users spend relatively little as compared to what could be expected and this partially reinforces the idea that consumers who do not take into account the choice of their social contacts when choosing their own operator pay an extra cost for this behaviour.

Our results have both policy and managerial implications. From a policy point of view, it has been argued that the lack of number portability was the main source of switching costs in the industry and that a policy intervention in this direction would have been beneficial for consumers. However, empirical evidence shows that the introduction of number portability has not eliminated switching costs. The fact that a significant part of consumers do care about local network effects reflects this evidence and suggests that, in presence of consumers heterogeneity and local network effects, firms have the opportunity to soften competition. Also we provide evidence on the existence of two types of consumers: *conscious* consumers, i.e. intensive users who carefully select their operator and try to minimize their expenditures, and *unconscious* consumers, who are less careful in selecting their

operators and pay an extra cost for it. From a firm's perspective, termination-based price discrimination can be seen as strategy to attract conscious consumers and exploit unconscious consumers.

References

Arthur, B. (1989), "Competing Technologies, Increasing Returns and Lock-in by Historical Events" *Economic Journal*, 99, 106-131.

Banerij, A. and Dutta, B. (2006) "Local network externalities and market segmentation", mimeo.

Berndt, E.R., Pindyck, R.S. and Azoulay, P. (2003), "Network effects and diffusion in pharmaceutical markets: Antiulcer drugs", *Journal of Industrial Economics*, 51(2), 243-270.

Birke, D. and Swann, G.M.P. (2005), "Social Networks and Choice of Mobile Phone Operator", available at SSRN: http://ssrn.com/abstract=944354

Birke, D. and Swann, G.M.P. (2006), "Network effects and the choice of mobile phone operator", *Journal of Evolutionary Economics*, 16(1), 65-84

Calder, B.J., Phillips, L.W. and Tybout, A.M. (1981), "Designing research for application", *Journal of Consumer Research*, 8(2), 197-207.

Church, J. and Gandal, N. (2004), "Platform competition in telecommunications" CEPR Discussion Paper No. 4659.

Corrocher, N. and Zirulia, L. (2006), "Innovation and Competition in the Mobile Communications Service Industry". Paper presented at the Innovation Pressure Conference, 15-17 March 2006, Tampere, Finland.

Cowan, R. and Miller, J.H. (1998), "Technological standards with local externalities and decentralized behaviour", *Journal of Evolutionary Economics*, 8(3), 285-296

Dranove, D. and Gandal, N. (2003), "The DVD vs. DIVX Standard War: Empirical Evidence of Vaporware", *Journal of Economics and Management Strategy*, 12(3), 363-386.

Farrell, J. and Saloner, G. (1985), "Standardization, compatibility, and innovation", *RAND Journal of Economics*, 16(1), 70-83.

Farrell, J. and Klemperer, P. (2007) "Coordination and lock-in: competition with switching costs and network effects", in M. Armstrong and R. Porter (eds.), *Handbook of Industrial Organization*, Volume 3, North-Holland, Amsterdam.

Grzybowski, L. (2007) "Estimating Switching Costs in Mobile Telephony in the UK". *Journal of Industry, Competition and Trade*, forthcoming.

Katz, M.L. and Shapiro, C. (1985), "Network externalities, competition and compatibility", *American Economic Review*, 75(3), 424-440.

Katz, M. and Shapiro, C. (1994), "Systems competition and network effects", *Journal of Economic Perspectives* 8 (2), 93-115.

Laffont, J.J., Rey, P. and Tirole, J. (1998) "Network competition II: Price Discrimination", *RAND Journal of Economics*, 29(1), 38-56.

Lee, J, Kim,Y., Lee, J. and Park, Y. "Estimating the extent of potential competition in the Korean mobile telecommunications market: switching costs and number portability", *International Journal of Industrial Organization,* 24 (1), 107-124

Rogers E.M. (2003), *Diffusion of Innovations*. New York, Free Press.

Rohlfs, J. (1974), "A Theory of Interdependent Demand for a Communication Service," *The Bell Journal of Economics and Management Science*, 5, 1, 16--37.

Sundadarajan, A. (2004), "Local network effects and network structure", mimeo.

Swann, G. M. P.(2002), "The Functional Form of Network Effects", *Information Economics and Policy*, Vol.14 (3), pp.417-429.

Valletti, T. (1999) "A model of competition in mobile communications", *Information Economics and Policy*, 11, 61-72.

Valletti, T. and Cave, M. (1998), "Competition in UK mobile communications", *Telecommunication Policy*, 22(2), pp.109-131.

von Hippel, E (1987) "Cooperation between rivals: informal know-how trading", *Research Policy,* vol 16: 291-302.

TABLE I – IMPORTANCE OF FACTORS FOR ADOPTION
(1 "NOT IMPORTANT", 5 "VERY IMPORTANT)

NETWORK COVERAGE	%	*CUM.*
1	10.83	10.83
2	5.10	15.92
3	12.10	28.03
4	41.40	69.43
5	30.57	100.00
SPECIAL OFFER	%	*CUM.*
1	8.28	8.28
2	5.10	13.38
3	13.38	26.75
4	30.57	57.32
5	42.68	100.00
BUNDLING	%	*CUM.*
1	52.23	52.23
2	5.10	57.32
3	15.29	72.61
4	16.56	89.17
5	10.83	100.00
TARIFFS	%	*CUM.*
1	12.10	12.10
2	6.37	18.47
3	12.74	31.21
4	47.77	78.98
5	21.02	100.00
FRIENDS WITH THE SAME OPERATOR	%	*CUM.*
1	17.83	17.83
2	5.73	23.57
3	14.65	38.22
4	36.94	75.16
5	24.84	100.00

FAMILY WITH THE SAME OPERATOR	%	*CUM.*
1	22.29	22.29
2	7.64	29.94
3	21.66	51.59
4	28.66	80.25
5	19.75	100.00
PARTNER WITH THE SAME OPERATOR	%	*CUM.*
1	30.00	30.00
2	3.75	33.75
3	17.50	51.25
4	26.25	77.50
5	22.50	100.00
AVAILABLE SERVICES	%	*CUM.*
1	37.58	37.58
2	11.46	49.04
3	27.39	76.43
4	13.38	89.81
5	10.19	100.00
POST-SALE CUSTOMER SERVICES	%	*CUM.*
1	15.92	15.92
2	11.46	27.39
3	28.03	55.41
4	36.31	91.72
5	8.28	100.00

TABLE II – DETERMINANTS OF ADOPTION

	TARIFF-QUALITY	*NETWORK EFFECTS*	*BUNDLING*
Network quality	**0,764**	0,028	-0,034
Special offers	**0,724**	0,160	-0,175
Tariffs	**0,670**	0,087	0,048
Post-sales services	**0,640**	0,153	0,193
Range of services	0,515	0,023	0,505
Family with the same operator	0,037	**0,902**	0,124
Friends with the same operator	0,238	**0,868**	-0,033
Bundling with handset	-0,095	0,069	**0,899**

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

TABLE III – PATTERNS OF ADOPTION

	SOCIAL NETWORK ORIENTED (44)	*RANDOM* (10)	*TARIFF-QUALITY ORIENTED* (48)	*HANDSET DRIVEN* (55)
Tariff-quality	-0,3076	-2,2821	**0,5444**	0,1859
Network effects	**0,8113**	-1,1369	-0,9435	0,3810
Bundling	-0,8976	0,7644	-0,5029	**1,0180**

TABLE IV – CONTRACTS WITH NETWORK EFFECTS

FIRM	*TIME PERIOD*			
	Duopoly	*Three firms (1999-2000)*	*Three firms (2001-2002)*	*Four firms*
TIM	1	82	11	3
VODAFONE	2	3	10	5
WIND		8	1	8
3				10

TABLE V – DIFFERENCES ACROSS CLUSTERS°

	Cluster 1	*Cluster 2*	*Cluster 3*	*Cluster 4*	*Whole sample*
yearpurch*	0,20	0,20	0,27	0,44	0,31
expendvoice*	2,32	2,10	2,75	1,76	2,24
intensityvoice*	6,68	4,80	5,75	5,24	5,77
promotion	0,80	0,60	0,81	0,87	0,82
tariffplan*	0,80	0,50	0,48	0,56	0,60
twosim*	0,50	0,40	0,58	0,31	0,45
changeop*	0,39	0,50	0,27	0,15	0,27
services*	0,11	0,60	0,29	0,47	0,32
expendsms*	1,64	1,30	1,71	1,49	1,59
autofin	1,45	1,40	1,35	1,24	1,34
intensitysms	7,16	5,60	6,77	6,89	6,85
TIM*	0,27	0,40	0,13	0,16	0,20
VODAFONE*	0,64	0,20	0,75	0,69	0,66
WIND	0,09	0,10	0,10	0,04	0,08
HG*	0,00	0,30	0,04	0,09	0,06

* Statistically significant at 99%. °Mean value for each cluster