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Local network externalities and market segmentation

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ABSTRACT

This paper models interaction between groups of agents by means of a graph where each node represents a group of agents and an arc represents bilateral interaction. It departs from the standard Katz–Shapiro framework by assuming that network benefits are restricted only amongst groups of linked agents. It shows that even if rival firms engage in Bertrand competition, this form of network externalities permits strong market segmentation in which firms divide up the market and earn positive profits. The analysis also shows that some graphs or network structures do not permit such segmentation, while for others, there are easy to interpret conditions under which market segmentation obtains in equilibrium.

1. Introduction

It has long been known that some goods and services (for example, telecommunications, computer software and hardware) generate network effects or externalities. The seminal paper by Katz and Shapiro (1985) defines a network effect to exist when the utility that a user derives from consuming a product depends on the number of other agents who consume either the same brand of the product, or another brand which is compatible. This way of modelling the network effect is found throughout the large theoretical and empirical literature that has developed.[1] While this is reasonable in many contexts, in other instances it overlooks the fact that such positive externalities arise from the *specific* patterns of interaction between groups of users.

For instance, consider software packages with specific functions such as word processing, accounting, data analysis and so on. The use of such packages has *local* network effects. Thus the utility to a user (say, a researcher in a University) of a word processing or data analysis package depends at least partly on the number of her research *collaborators* who use the same package, rather than on the total number of users of the package. A main advantage to two collaborators using the same package is sharing files. For many of these products, there is a degree of incompatibility between brands. Two users using incompatible brands find it difficult if not impossible to share files; a program written on one software package cannot be read, or worked on, using a competing brand.

These two elements — a user's utility from a product depending on the number of other users who *interact* with her, and of some degree of incompatibility between competing brands, are present in other contexts as well. Thus many people using instant messaging typically communicate only with their friends or coworkers; and there are incompatibilities between the leading competing brands provided by AOL, MSN and Yahoo.[2] In interactions between businesses, it helps if software systems are compatible.

We use the formal network structure proposed in the important recent paper of Jackson and Wolinsky (1996) to model the interaction between groups of users. In particular, the set of all consumers is partitioned into different groups or *nodes*, and two nodes are connected to each other if they "interact".[3] Our main interest is in analysing whether the precise pattern of interactions – that is, the

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[1] There is by now a large literature analyzing important issues in markets subject to network effects. See, for instance Katz and Shapiro (1985, 1986), Farrell and Saloner (1985, 1986), Economides and Salop (1992), Farrell and Katz (2000), Matutes and Regibeau (1992), Choi (1994), Ellison and Fudenberg (2000), Waldman (1993). Economides (1996) provides an insightful overview. Gandal, Kende and Rob (2000) and Saloner and Shepard (1994) are two interesting papers from the empirical literature.

[2] There is software available, such as Trillian, that provides interfaces between these products, but it involves costs (all the competing brands have to be installed in one's computer, for instance), and firms such as AOL constantly change their software to maintain incompatibility.

[3] Although this kind of modelling has only very recently been used in the literature on network externalities, the use of such network structures in other areas of economics is becoming increasingly popular. Dutta and Jackson (2003) contains several interesting papers in this genre. See also Goyal (2007), Jackson (2008).

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specific network structure – has any influence on market outcomes. For instance, suppose the overall "market" is the academic market for software. Does the fact that economists typically do not collaborate with physicists (that is, economists are not "linked" to physicists) matter in this market?

A typical feature of information goods such as software is that firms incur possibly high fixed costs to develop essentially unlimited capacity, and their marginal costs are negligible. As a first step towards understanding competition in markets with local network effects, we maintain the assumption of unlimited capacity and study price competition. The issue of pricing and competition is interesting when we study information goods for a variety of reasons. Local network interactions is one of them, for which price competition has not been analyzed so far. If firms produce competing, incompatible brands of the same *intrinsic* quality, and have the same constant marginal cost of production, existing models of network externalities would yield the Bertrand zero profit outcome. This is so for the Katz and Shapiro (1985) model as well, if it is modified to analyze price, rather than quantity competition.[4] A main result in this paper is that if network effects are generated from patterns of interaction among users, then there exist outcomes in which firms do make *positive* profits, and there is *market segmentation* in the sense that rival firms divide or partition the overall market into separate segments, with each firm selling to different segments.

Market segmentation accords well with casual observation, which suggests (a) positive profit outcomes arise even when firms compete in prices and capacity is essentially unlimited; and (b) a group of users often uses a single brand overwhelmingly, when several similar brands are available. For example, law firms in the U.S. continued to use WordPerfect when the rest of the world was switching over to Microsoft Word in the 1990s (Porter, 2000). The positive *local* network benefits to lawyers from using the same word processor other lawyers (and some clients) used explains this pattern.

Perhaps the most interesting contribution of the paper is that the specific interaction structure *matters*; for some networks, market segmentation can be ruled out in equilibrium, while other networks permit market segmentation. Thus, one way of interpreting our results is to say that there are interaction structures which convert the industry into a differentiated goods industry. However, there are other interaction structures – for instance, the complete graph where all users are linked to each other – where the goods remain homogeneous, and so firms do not earn positive profits. The discussion also shows that when positive profit equilibria exist, if firms could choose whether or not to make their brands mutually compatible, they would choose not to do so.

1.1. Related work

Very recently, work has begun on understanding markets for products that exhibit local network effects, using an explicit model of the network structure (Jullien (2003), Sundararajan (2007), Tucker (2006)). In an interesting paper, Jullien (2003)[5] develops a model of oligopoly in an industry in which network effects can be local or group-specific, while the other two papers analyze the adoption of a single good in the presence of local network effects. The present paper analyzes competition and is therefore closer to Jullien (2003). Jullien analyzes a setting in which price discrimination across different groups of consumers is possible.[6] In his model, one firm (the Strong firm) has a reputational advantage. However, the ability of the Weak firm to price discriminate (by cross subsidizing some groups of consumers, inducing them to buy, thereby creating a strong network-effect inducement for other groups of customers) creates strong competition for the Strong firm. This keeps equilibrium profits low. In contrast with Jullien (2003), the present paper studies competition in situations where price discrimination is not possible; a major difference in emphasis is also the attempt to study how the structure of interactions affects market segmentation.

Sundararajan (2007) studies a model (with incomplete information) in which agents must simultaneously and independently decide whether or not to adopt such a product. Each agent is located at a node of a graph, knows the nodes that he/she is connected with, but is not informed about the rest of the network structure. Sundararajan finds that the symmetric Bayesian equilibria can be Pareto-ranked, and that the greatest of these is the unique coalition-proof equilibrium. Tucker (2006) analyzes a rich data set describing the adoption of a video-messaging technology by employees of a financial firm. Among other interesting findings, the data strongly support the hypothesis that the network effect to an employee of adopting the technology is limited to people that she communicates with. While these two papers study the adoption of a single good, the present paper analyzes an oligopoly model in which firms compete for customers who are linked over a network whose structure is common knowledge.

There is a recent interesting literature on two-sided markets (e.g. Armstrong (2006), Caillaud and Jullien (2003), Rochet and Tirole (2003)) such as markets for payment cards, intermediation services, and mobile telephony; Jullien (2003, 2008) provides more general, multi-sided market analyses. Ambrus and Argenziano (2009) show that endogenous market segmentation can result in a two-sided market if consumers differ in their valuation of the network externality. Gabrielsen and Vagstad (2008) explain observed differences in on- and off-network call termination charges between mobile telecommunication service providers in terms of switching costs and local network externalities that operate within 'calling clubs' of friends. The specific patterns of interactions between agents in two-sided markets provide further motivation for looking at models with local network effects; however as noted earlier, price discrimination is a key element in these markets and the models above differ from ours in this respect.[7]

2. A model of network externalities

Our model of network externalities in the context of a partial equilibrium duopoly is very similar to that of Katz and Shapiro (1985). A major difference is in the way in which we model network externalities. Another difference is that in our model firms compete in prices, in contrast to Katz and Shapiro (1985) who assumed that firms behaved a la Cournot.

Our model has the following components and structure. There are two profit-maximizing firms 1 and 2, firm j producing network good j. To bring out the main points simply, the two goods are assumed to be functionally identical. The two firms simultaneously announce prices p_1, p_2. Given these prices, consumers simultaneously decide which good to buy. A consumer buys one unit from either firm 1 or firm 2, or abstains from consumption. Consumers benefit from own consumption, as well as from interaction with others who consume the same good.[8] The presence of network externalities generates a coordination problem for the consumers. We assume that for each vector of prices, consumers coordinate on a rational expectations equilibrium allocation. Both firms correctly anticipate which allocation will be chosen by the consumers. So, an overall equilibrium is a vector of prices which

[4] The zero profit outcome obtains under a restriction (Assumption 1 below) on consumers' expectations that requires the demand for a brand to be non-increasing in its price. See the discussion following Theorem 1.

[5] We became aware of this paper after writing a draft of the present paper. We thank Bruno Jullien for pointing us to this paper.

[6] This is especially reasonable in the context of two-sided markets and competition among intermediaries. See Caillaud and Jullien (2003).

[7] Patterns of price discrimination in these models share some similarity with price discrimination over time in dynamic models of network competition (Cabral (2008)).

[8] If the goods are partially compatible, then consumers also derive some benefit from interaction with other consumers who consume the *other* good.