Games and Economic Behavior 80 (2013) 243–261

Contents lists available at SciVerse ScienceDirect

Games and Economic Behavior

www.elsevier.com/locate/geb

Pricing in social networks ☆

Francis Bloch [a,*], Nicolas Quérou [b]

[a] Department of Economics, Ecole Polytechnique, 91128 Palaiseau, France
[b] CNRS, UMR 5474 LAMETA, F-34000 Montpellier, France

ARTICLE INFO

Article history:
Received 11 October 2011
Available online 22 April 2013

JEL classification:
D85
D43
C69

Keywords:
Social networks
Monopoly pricing
Network externalities
Reference price
Centrality measures

ABSTRACT

We analyze the problem of optimal monopoly pricing in social networks where agents care about consumption or prices of their neighbors. We characterize the relation between optimal prices and consumers' centrality in the social network. This relation depends on the market structure (monopoly vs. oligopoly) and on the type of externalities (consumption versus price). We identify two situations where the monopolist does not discriminate across nodes in the network (linear monopoly with consumption externalities and local monopolies with price externalities). We also analyze the robustness of the analysis with respect to changes in demand, and the introduction of bargaining between the monopolist and the consumer.

1. Introduction

This paper analyzes the optimal pricing strategy of a monopoly in a social network. Our objective is to understand how discriminatory prices reflect (or not) the centrality of consumers in the social network. Marketing techniques to discriminate among consumers based on their social connections have long been in use. When selling new products or creating an installed base for products with network externalities, it is not uncommon for firms to offer "referral bonuses" – discounts or cash to consumers who bring new friends into the network. In doing so, the firm rewards agents with a large number of friends, and price discriminates according to the consumer's number of neighbors, or degree centrality. In a more systematic fashion, following MCI in 1990, telecommunication companies have introduced "friends and family plans" as a way to discriminate among consumers based on their number of friends and pattern of calls (Shi, 2003).

With the spectacular emergence of online social networks like Facebook, Orkut and MySpace, new possibilities for large scale social-network based discriminatory pricing have emerged. Due to a combination of privacy and technical reasons, this possibility has not yet been exploited, and most of the monetization of online social networks stems from targeted advertising using data on consumer characteristics rather than their social connections. However, the discrepancy between the current revenue of Facebook (between 1.2$ and 2$ billion in 2010) and its value (82.9$ billion reported as of January 29, 2011) (Levy, 2011) suggests that new marketing opportunities based on social network data will likely be exploited in the near future. In fact, the agreement between Facebook and the group buying platform Groupon which allows consumers to

☆ We dedicate this paper to the memory of Toni Calvó-Armengol, a gifted network theorist and a wonderful friend. We thank Coralio Ballester, Sebastian Bervoets, Yann Bramoullé, Geoffroy de Clippel, Jan Eeckhout, Matt Elliott, Sanjeev Goyal, Matt Jackson, Michael König, the advisory editor and two anonymous referees for their helpful comments.

* Corresponding author.
E-mail addresses: francis.bloch@polytechnique.edu (F. Bloch), querou@supagro.inra.fr (N. Quérou).

0899-8256/$ – see front matter
http://dx.doi.org/10.1016/j.geb.2013.03.006

sign up on Groupon on their Facebook page points in that direction. Groupon may exploit the social network of Facebook to attract new customers, offering deals and coupons to consumers who bring in new friends, thereby discriminating in favor of consumers with higher degree centrality in the network.[1]

While the current social-network based price discrimination strategies only make use of the consumer's number of neighbors, it is very likely that more detailed data on social networks will soon be used in pricing and marketing strategies (Arthur et al., 2009; Hartline et al., 2008). An important issue is to understand whether the number of neighbors is always the relevant measure of centrality that should be used for price discrimination. Even in case where this characteristic is relevant, it is necessary to assess its actual influence (positive or negative) on the prices that should be offered. In this paper, we consider price discrimination based on the entire social network, where each agent receives a price associated to her nodal characteristic. We consider two channels through which social networks influence a consumer's demand. In the first model of *local network externalities*, consumers benefit from the consumption of the same good by their direct neighbors. This model captures situations where agents receive discounts if they call friends who subscribe to the same network, share a common software with their colleagues or co-authors, or need to reach a critical mass of consumers to obtain a deal or launch a project. In the second model of *aspiration-based reference price*, consumers construct a reference price for the good based on the price charged to their direct neighbors, and experience a positive utility if the price they receive is below their reference price. This model is applicable to situations where firms use discriminatory pricing that lacks transparency, like airline pricing and negotiated pricing.

In both models, our objective is to understand which measure of centrality is relevant to rank prices charged at different nodes. Are prices increasing or decreasing in the number of neighbors that a consumer has? Is the structure of the network at distance two (the number of neighbors of neighbors) a relevant information for optimal monopoly pricing? When does the monopoly charge uniform prices across nodes? To answer these questions, we consider a linear model, where consumers pick a random valuation for the object according to a uniform distribution. In the model of local network externalities, a consumer's utility is positively affected by the consumption of her direct neighbors; in the model of aspiration-based price reference, a consumer's utility is positively affected by the average price charged to her direct neighbors. Using the analysis pioneered by Ballester et al. (2006), we characterize the demand of every consumer as a function of her centrality in the network. We then consider two different market structures: one where a single monopoly serves all the consumers in the network and one where oligopolistic firms control a fraction of the nodes in the network.[2]

In the local network externalities model, we first obtain a *network irrelevance result*: in the linear model, the monopoly optimally chooses a uniform price in the network. This striking result can be explained as follows. There are two countervailing effects of the centrality of a node on the optimal price. On the one hand, a more central node generates more positive externalities on its neighbors and hence should be subsidized (the classical effect by which more central agents receive lower prices); on the other hand, more central agents benefit more from the object, and have a higher valuation which can be captured by the monopolist. In the linear model, these two effects are exactly balanced, giving rise to a uniform pricing strategy. However, this exact balance disappears as soon as one moves away from the linear model. When costs are quadratic, the price at each node is proportional to the Katz–Bonacich centrality. When influence is directed, so that the social network is represented by a directed graph, prices are higher for nodes which receive more influence than they provide. Finally, in an oligopolistic model, the optimal price depends both on the node centrality and on the competition structure in the node's neighborhood. Higher prices are charged to more central nodes whose neighbors are controlled by competitors.

In the aspiration-based price reference model, we obtain a second *network irrelevance result*, this time when every node is served by a different firm. This irrelevance result, which is robust to changes in the model, stems from the following observation. If all other firms charge the optimal monopoly price, a local monopoly cannot benefit from charging a different price. When all nodes are served by a single monopolist, this reasoning fails as the monopolist may want to increase the price at some node in order to increase demand at the neighboring nodes. For example, in a star, the monopoly has an obvious incentive to charge a high price at the hub in order to increase demand at peripheral nodes.

We finally discuss two extensions of the model. In the first extension, we consider general demand schedules and analyze the robustness of our results. In the second extension, we compute the consumer surplus accruing at each node. This enables us to analyze the agent's incentives to form links in the social network and the formation of prices as a result of a bargaining process between the monopoly and the consumer.

We now discuss briefly the related literature. The model of local network externalities finds its origin in the seminal work of Farrell and Saloner (1985) and Katz and Shapiro (1985) on network externalities. These early papers eschew the "network" dimension of network externalities and implicitly assume that consumers are affected by the global consumption of all other consumers. Models of local network externalities which explicitly take into account the graph theoretic structure of social networks have been proposed by Jullien (2011), Sundarajan (2006), Saaskilahti (2007) and Banerji and Dutta (2009). Jullien (2011) and Banerji and Dutta (2009) analyze competition between two price-setting firms. While Banerji and Dutta

[1] The drop in Facebook's share prices following the initial public offering on May 18, 2012 casts a shadow on the future profitability of Facebook and suggests that the exploitation of social networks in marketing may take longer than initially thought.

[2] An example of an oligopoly where firms control a fraction of the nodes in the social network is given by Apple and Microsoft. Both firms compete to establish exclusive partnerships with universities. Researchers from two different universities may be forced to use two different operating systems even though they interact and share files repeatedly.