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Price competition in a differentiated products duopoly under network effects

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ABSTRACT

We examine price competition under product-specific network effects, in a duopoly where the products are differentiated both horizontally and vertically. We emphasize the role of consumers' expectations formation. When expectations are not influenced by prices, the market may be shared but shares must be equal unless product qualities differ or one firm, possibly even the low-quality one, may capture the entire market. When expectations are influenced by prices, which would be the case when there is commitment, competition becomes more intense and the high-quality firm tends to capture a larger market share. Under strong network effects there is a continuum of equilibria and the higher the prices, the smaller the difference between those prices can be. Requiring continuity of expectations, however, delivers a unique equilibrium where one firm captures the entire market.

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1. Introduction

Motivation and overview. In telecommunications and other information systems, network effects play a crucial role as, by their nature, the value these systems generate depends on the number of users. At the same time, in a given market there may be competing products (or services) and hence strategic pricing becomes important. These products (or services) will typically be viewed by the market as differentiated along a horizontal dimension (that is, some users prefer one product and some the other) or a vertical (that is, all users view a product as superior) dimension. In fact, we argue that whenever network effects are product-specific, product differentiation be-

comes important.¹ In this paper, we provide an analysis of price competition between horizontally and vertically

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¹ In addition to communications and information systems, several other cases come to mind. In the "classic" Beta vs. VHS case, consumers cared both about the inherent characteristics that differentiated one product from the other and also about their market shares (see, e.g., Cusumano et al., 1992; Liebowitz and Margolis, 2002). Likewise with many more recent cases. Credit cards are viewed by users as differentiated with respect to their stand-alone characteristics (different varieties or qualities) but also with respect to the network size of each card (as more popular cards are more widely accepted). Perhaps the most important recent example comes from the DVDs market. When the time came to replace the standard DVD with a high-definition DVD, two formats appeared, Blu-ray and HD DVD, the first supported by Toshiba, Intel, and Microsoft (and also with Universal and Paramount Pictures on its side), and the second by Samsung, Pioneer, and Sony (with Disney and Fox on its side). The products had elements of horizontal and vertical differentiation but network effects were also very strong. Thus, when Blu-ray attracted Warner Brothers in January 2008 and the top two US DVD retailers in the United States, Wal-Mart and Best Buy in February 2008, Toshiba stopped producing the HD DVD (<http://www.news.bbc.co.uk/2/hi/business/7252172.stm>).

differentiated duopoly products when there are network effects. In addition to comparing the prices set by the firms, consumers may choose a product because it has higher quality, because they prefer its particular variety (location), or because they expect that a larger number of other users will choose the same product (and hence they expect its value to increase via the network effect).

Relation to the key literature references. The paper is related to two distinct literatures, one on network effects² and the other on product differentiation. A seminal analysis of network effects in oligopoly is provided by Katz and Shapiro (1985). They study competition in quantities (not prices, which is what we do), and in their model, consumers' expectations about these quantities are formed before the firms make their choices (whereas we also consider the case where the firms' choices influence the consumers' expectations).³ Our work is closely related to Grilo et al. (2001) who, as far as we know, are the first to study network effects when product differentiated duopolists compete in prices.⁴ Besides some specific modeling differences, our analysis can be viewed as complementing theirs and providing some important further results. First, unlike Grilo et al. (2001), we also consider the case where expectations are not influenced by prices and we contrast how the equilibria differ from the case where they are influenced by the prices. Thus, we emphasize the role that expectations play for the market outcome. Second, we allow for horizontal and vertical differentiation to both exist at the same time; we focus on circumstances in which the low-quality product can survive (or even dominate) in the market and the crucial role that the process of expectations formation plays for that to happen. Third, we provide a (continuity) refinement that leads to a unique equilibrium in the case where expectations can be influenced by prices and network effects are strong.⁵

² See, e.g., Economides (1996) and Shy (2001) for a review. A growing empirical literature also analyzes the importance of network effects (for a review see Birke, 2009).

³ Katz and Shapiro (1985), in their Appendix, also briefly discuss the possibility that expectations can be influenced by the quantities chosen.

⁴ In their paper (which partly builds on the analysis in Navon et al., 1995) network effects take the form of a "conformity or vanity" factor.

⁵ Hurkens and López (2010) show that whether expectations about network externalities are assumed to be affected by prices or simply to be fulfilled in equilibrium makes a difference for the appropriate policy recommendations in the mobile termination market. Other work that examines competition under possibly differentiated network effects and/or the role of buyers' expectations includes (without being limited to) Farrell and Saloner (1986), Bental and Spiegel (1995), Baake and Boom (2001), Jullien (2000), Kim (2002), Caillaud and Jullien (2003), Andreozzi (2004), Mitchell and Skrzypacz (2006), Laussel et al. (2004), Gabszewicz and Wauthy (2004), Doganoglu and Wright (2006), Valletti and Cambini (2005) and Argenziano (2008). Other recent papers are also broadly related to our analysis, dealing with issues of compatibility and welfare. Chen et al. (2009) examine if compatibility in markets with network effects is a stable choice in the long run. Cabral (2010) considers a dynamic model of competition between two proprietary networks. Alexandrov (2008) finds that, under certain conditions, firms may decide to make their products compatible, even when this is welfare decreasing. Fjeldstad et al. (2010) analyze a market where network effects work not only through the size of the customer base, but also through its composition by introducing a two-dimensional spatial model. They find an inefficient allocation of consumers and excessive compatibility. In Serfes and Zacharias (2009) two horizontally differentiated platforms that exhibit network effects, choose locations before prices. Depending on the strength of network effects, firms may have maximum differentiation, or one firm may dominate the market.

Model description and main results. We set up the simplest model that allows us to explore the issue at hand: a static duopoly where suppliers of differentiated products compete in prices. To capture horizontal differentiation, we employ the standard modification by d'Aspermont et al. (1979) of Hotelling's (1929) "linear-city" with quadratic transportation costs. In addition, we introduce the possibility of quality differences; thus, in addition to horizontal differentiation, there may be an independent dimension of vertical product differentiation, such that all consumers view quality in the same way (see e.g. Vettas, 1999). Finally, we enrich the model by adding a network effect, so that given each product's characteristics and price, each consumer would prefer the product more widely used. We take as given the differentiation between the products and we examine how price competition takes place under network effects. A number of important questions arise, not only from a theory but also from a business strategy and a policy viewpoint: When is it that equilibria have to be symmetric and when can they be asymmetric (in prices or market shares)? When will both firms be active in the market and when can we expect one of the two to be excluded? Is it possible that products of lower quality obtain a higher market share? How is the equilibrium affected if firms can influence consumers' expectations? Does the ability of firms to commit to the prices they set contribute to an equal or an unequal sharing of the market and does such a commitment tend to favor high- or low-quality firms? Are there conditions that give rise to a multiplicity of equilibria and what is the role of the formation of expectations for distinguishing among such equilibria?

In this paper, we emphasize the role of consumers' expectations formation. Throughout the analysis, consumers' expectations about firms' market shares are required to be fulfilled in equilibrium, to be "rational". However, we distinguish between two alternatives. First, we examine the case where these expectations cannot be influenced by the prices set by the firms. In this case, expectations are formed before the prices are set (or equivalently, even if expectations are formed after some prices are set, that does not matter because firms do not commit to these prices). Second, we examine the case where consumers' expectations can be influenced by the prices set by the firms; this should be the case when firms commit to the prices.

When expectations are not influenced by the prices, our main results are as follows. If the products have equal quality and for relatively weak network effects, the only equilibrium is that the firms share the market equally. In contrast, for stronger network effects, there can also be asymmetric equilibrium configurations, with one of the two firms capturing the entire market. The threshold, above which asymmetric equilibria with only one active firm arise, is determined by comparing the strength of the network effect to the transportation cost (or, equivalently, to the importance of product differentiation). The two possible asymmetric equilibria are extreme (in the sense that one firm captures the entire market) and no other asymmetric equilibria (with the market shared unequally) exist. However, when, in addition to horizontal

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