International Journal of Industrial Organization 41 (2015) 84–96

Contents lists available at ScienceDirect

International Journal of Industrial Organization

journal homepage: www.elsevier.com/locate/ijio

Network effects, aftermarkets and the Coase conjecture: A dynamic Markovian approach

Didier Laussel [a], Ngo Van Long [b], Joana Resende [c]

[a] Aix-Marseille University, Aix-Marseille School of Economics, CNRS, EHESS, France
[b] Department of Economics, McGill University, Montreal H3A 2T7, Canada
[c] Cef.up, Economics Department, University of Porto, Portugal

ARTICLE INFO

Article history:
Received 22 June 2013
Received in revised form 27 May 2015
Accepted 2 June 2015
Available online 9 June 2015

JEL classifications:
L12
L14

Keywords:
Durable good
Network externalities
Aftermarkets
Coase conjecture

ABSTRACT

This paper investigates the expansion of the network of a monopolist firm that produces a durable good and is also involved in the corresponding aftermarket. We characterize the Markov Perfect Equilibrium of the continuous time dynamic game played by the monopolist and the forward-looking consumers, under the assumption that consumers benefit from the subsequent expansion of the network. The paper contributes to the theoretical discussion on the validity of the Coase conjecture, analyzing whether Coase's prediction that the monopolist serves the market in a "twinkling of an eye" remains valid in our setup. We conclude that the equilibrium network development may actually be gradual, contradicting Coase's conjecture. We find that a necessary condition for such a result is the existence of aftermarket network effects that accrue (at least partly) to the monopolist firm.

1. Introduction

In a seminal work, Coase (1972) argued that, in continuous time, under rational expectations, a monopolist who produces and sells a durable good will lose all her monopoly power, given her inability to commit to future prices and outputs. In equilibrium, the price is equal to the constant marginal cost, and the monopolist serves all her customers in one go. Subsequent literature (Bulow, 1982; Gul et al., 1986; Stokey, 1981) has confirmed this conjecture, showing that all trade takes place instantaneously at a price equal to marginal cost (in the "no gap case") or a price depending on the utility of the lowest-valuation consumer (in the "gap case").

Coase (1972) considered neither the possibility of network effects,[1] nor the fact that the value of durable goods may be enhanced by the subsequent consumption of complementary goods and services (CGS). Yet, there are markets in which the durable good producers are increasingly involved both in a primary market (in which the production and sale of the durable good take place) and an aftermarket (where CGS are provided by the firm, possibly in the presence of some rival CGS producers). Examples of such markets include tablets/smartphones and applications, hardware and software, wireless services and phone calls, and so on (see e.g. Shapiro, 1995).

Another important feature of these markets is the existence of network effects, both in the primary market and in the aftermarket. Consider, for instance, tablets with integrated video-call apps (e.g. Facetime is integrated in the iPad) and other applications purchased after buying the tablet (e.g. iWork or Pages). The bundle iPad & Facetime would be the durable good sold in the primary market, whereas applications such as iWork or Pages would be CGS. In this example, there are primary market network effects (PMNE) since the utility of a given Facetime user (owning an iPad device) increases with the number of other Facetime users with whom she can communicate. There are also aftermarket network effects (AMNE) since the utility of applications such as iWork or Pages depends on the number of individuals with whom the consumers may exchange files.[2]

The present paper provides a theoretical investigation into the speed of expansion of the network of a monopolist firm that produces a

E-mail addresses: didier.laussel@univ-amu.fr (D. Laussel), ngo.long@mcgill.ca (N. Van Long), jresende@fep.up.pt (J. Resende).

[1] These effects arise when the benefits derived from a good are increasing in the total number of individuals consuming that good. See the seminal papers by Rohlfs (1974), Katz and Shapiro (1985), Grilo et al. (2001), or, more recently, Amir and Lazzati (2011) and Griva and Vettas (2011).

[2] Page and Jopatka (2000) point out that "the value to an individual of a particular word processing program, say WordPerfect, will likely depend in part on the number of others who select WordPerfect and with whom the individual expects to exchange files. This effect is diminished to the extent that conversion between programs is possible, but, so long as conversion is imperfect or costly, the effect persists".

http://dx.doi.org/10.1016/j.ijindorg.2015.06.001
0167-7187/

durable good and is also involved in the corresponding aftermarket, under the assumption that buyers benefit from the subsequent expansion of the network. Does Coase's prediction that the monopolist must serve the whole market immediately remain valid? The paper yields a theoretical contribution to this debate.[3] In the context of our model, the network development may be gradual, contradicting Coase's prediction. The existence of AMNE that (at least partly) accrue to the monopolist firm is a necessary condition for this outcome.

We analyze a continuous time dynamic game played by the monopolist and forward-looking consumers with heterogeneous valuations. Each consumer, correctly forecasting the future prices and the evolution of the network, determines whether, given her type, it is advantageous to buy the durable good and, if so, when to buy it. We assume a continuum of infinitely lived consumers, ranked in order of their stand-alone valuation of the durable good. Each consumer demands at most one unit of the durable good, whose value depends on its intrinsic characteristics, the PMNE, and the value of the subsequent CGS purchases (which is influenced by AMNE). We make an assumption in favor of the Coase Conjecture by considering non-stationary network effects. These effects arise when the buyer who purchases the good at time t benefits from the network expansion after time t. In the iPad & apps example, we may have non-stationary network effects. For example, consumers may benefit from the expansion of opportunities to communicate with future adopters using Facetime, iWork or other apps.

The monopolist's problem involves choosing a time path for the durable good's output and its price so as to maximize the present value of the discounted stream of total profits (both in the primary market and in the CGS market). We assume that the monopolist cannot make any commitment as to future prices and output. Following Laussel and Long (2012) and Hilli et al. (2013), we focus on the Markov Perfect Equilibrium (MPE) of the game.

Our analysis of the speed of expansion of the network reveals that, under non-stationary positive network effects, Coase's prediction that the market is served in one go remains valid if and only if the monopolist derives sufficiently large benefits from positive AMNE.[4] In this situation there is a "large gap" between the lowest consumer valuation and the monopolist's "effective marginal cost" of supplying her.[5] Thus, it is in the interest of the firm to reap all these benefits at once, serving all consumers immediately.

In contrast, if the AMNE accruing to the monopolist are positive but not too strong, the equilibrium development of the network may be gradual, contradicting Coase's conjecture. Such a result arises because in this case the equilibrium expected price of the durable good equals the monopolist's effective marginal cost of supplying an additional consumer, which is a decreasing function of the network size when the monopolist derives profits from the existence of positive AMNE. Thus, when AMNE are positive but not too strong the monopolist prefers to slow down the adoption rate of the durable good.[6] It is worth noting that, this gradual expansion of the network can take place both in the "No Gap" case and in the "Gap" case. However, in the latter, such outcomes can only occur when AMNE accruing to the monopolist firm are neither too weak nor too strong, implying a "Small Gap" between the lowest consumer valuation and the monopolist's effective marginal cost of supplying her.[7] To be more precise, in the Small Gap case, the network expands gradually until a critical mass of users is reached. Afterwards, all the remaining consumers are served instantaneously with a given positive probability, or remain unserved with the complementary probability.

Our model relates to two strands of literature: the literature on durable good monopolies, with the Coasian Conjecture as a main theme, and the literature on dynamic monopoly pricing in network industries,[8] which also touches on the Coasian Conjecture.

Starting with the seminal work of Coase (1972), a vast literature has studied the optimal monopoly pricing of durable goods. See, for example, Stokey (1981), Bond and Samuelson (1984), Kahn (1986), Gul et al. (1986), Ausubel and Deneckere (1989), Karp (1996a,b) and Driskill (1997) among others.

Kuhn and Padilla (1996) considered a monopolist selling both a durable and a non-durable good to a representative consumer with linear-quadratic preferences over the two goods (that may be complements or substitutes). There are no network effects and the monopolist cannot commit to future prices of the goods. They showed that the firm does not sell the stock of durables in one go. At the formal level, the non-durable good market in their model plays a similar role to the aftermarket in our paper. The violation of the Coase Conjecture rests on a formally identical feature: the convexity of instantaneous equilibrium profits in the non-durable good market with respect to the stock of the durable good. However, beyond the formal similarities, there are substantial differences between the two papers. In our paper, there is a continuum of consumers' types instead of a representative consumer; buying one unit of the durable good is a necessary condition for consuming CGS in the aftermarket; and the stock of durables enters the instantaneous equilibrium aftermarket payoff functions via network effects rather than complementarity/substitutability in consumption.

In the literature on monopoly pricing in network industries, it has often been argued that the Coase Conjecture may fail when network effects are stationary, in the sense that consumers do not benefit from further developments of the network after they have bought the durable good. Examples of stationary network effects include the case where earlier purchasers of a software package do not benefit from the release of a new version unless they buy it (Bensaid and Lesne, 1996). Under such stationary network effects, the value of the durable good to later consumers increases as the network expands through time, and several authors have shown that access-pricing strategies may be time-consistent in network industries with these features. In some circumstances (see Cabral et al., 1999), a low introductory price is necessary to reach a critical mass of users and launch the market. However, almost all of these papers (Fudenberg and Tirole, 2000; Gabszewicz and Garcia, 2007, 2008; Xie and Sirbu, 1995) avoid significant issues of Coasian dynamics by assuming that consumers buy the good only when they are young, i.e., consumers do not optimize the date of purchase. An exception is Bensaid and Lesne (1996) who allow consumers to choose the date of purchase, in a discrete time model. Considering only the "Gap case", they show that (i) the price of the good may increase through time, and (ii) prices and profits are bounded below.

Mason (2000) comes closest to the issues addressed in the present paper. He analyses a continuous-time model of a monopolist selling a durable good to a continuum of consumers. The firm only participates

[3] The Coase Conjecture has spurred a lot of theoretical research, leading to many interesting contributions. However, as argued by Waldman (2003), the practical applicability of many models addressing the Coase conjecture may be limited since in real-world markets, firms often find strategies to partially overcome the commitment problem raised by Coase.

[4] When we allow for negative network effects, Coasian dynamics may also arise in the no-gap case since, here, the value of the good diminishes with the size of the network. While under positive network effects, the monopolist has incentives to slow down the speed of sales in the No-Gap case (cf. the discussion following Proposition 1), that will no longer be the case under negative network effects.

[5] The effective marginal cost is the marginal production cost minus the per period marginal profitability (in the aftermarket) of supplying one additional unit of the durable good. In Subsection 3.2, we present a detailed analysis of this concept.

[6] The existence of positive AMNE is a necessary condition for this result. Under negative AMNE, the Coasian dynamics would always arise (both in the Gap and the No Gap cases). In particular, under negative AMNE the monopolist's effective marginal cost of supplying an additional consumer increases with the network size. Therefore, under this source of network effects, the monopolist prefers to serve all consumers immediately, even in the No Gap case.

[7] The existence of positive AMNE is a necessary condition for the occurrence of the Small Gap case. Cf. Sub-section 3.2 for a more detailed analysis of this result.

[8] More recently, there was a boost to the literature studying dynamic pricing in oligopoly network industries. See, for example, Doganoglu (2003), Laussel et al. (2004), Mitchell and Skrzypacz (2006), Driskill (2007), Markovich (2008), Markovich and Moenius (2009), Chen et al. (2009), Cabral (2011), Laussel and Resende (2014), among others.