Journal of Economic Dynamics & Control 35 (2011) 462–478

Contents lists available at ScienceDirect

Journal of Economic Dynamics & Control

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

Two state capital accumulation with heterogenous products: Disruptive vs. non-disruptive goods

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ARTICLE INFO

Article history:
Received 15 April 2009
Accepted 14 September 2010
Available online 22 September 2010

JEL classification:
C61
D24
D92
L10

Keywords:
Investment
Product innovation
Maximum principle
Skiba curve

ABSTRACT

The paper considers the problem of a firm that, while producing a standard product, has the option to introduce an innovative product. The innovative product competes with the standard product and will therefore reduce revenues of the standard product. A distinction is made between innovative products that do or do not become even more relatively appealing as their market share grows (e.g., because of network externalities). It is shown that in the former case, which we call a "disruptive" good, history dependent long run equilibria can occur, which are in line with recent real life economic examples.

1. Introduction

This paper considers the problem of a firm having the option to produce different products for the same market. One product is an old fashioned "standard" that is already established. The other product is a recent innovation, which is qualitatively better and thus brings strong competition to the older product. At the same time, producing this innovative product is more complicated for the firm, because it requires skilled labor, advanced technology, or other inputs that are in limited supply. An example is Philips, which had produced the "standard" CRT television sets for decades, when in 1999 it started a joint venture with its Korean partner LG to produce LCD (flatscreen) television sets. Another example (The Economist, May 20th, 2006, p. 75) is Neumann, a traditional microphone producer that is investing 1.4 m Euro to develop digital microphones. In a similar fashion, Motorola is developing WiMax, an emerging wireless standard that will link mobile devices to the internet at broadband speeds. In a way this is surprising, since WiMax is widely seen as a challenger to existing mobile phone technologies (The Economist, October 7th, 2006, p. 74).

Microsoft faces an analogous problem (see, e.g., The Economist, April 1st, 2006, pp. 55–56). Currently, Microsoft dominates the PC market, but it knows that its position is under threat from online applications, which are changing how

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doi:10.1016/j.jedc.2010.09.008

people use these computers. Rather than relying on an operating system, and its associated application software—bought in a box from Microsoft and then loaded onto a PC—computer users are increasingly able to call up the software they need over the internet. Software companies are now selling software as a subscription service that can be accessed via a web-browser. Salesforce.com, an example of this trend, offers salesforce management tools; other firms offer accounting and other back-office functions.

Since Microsoft's two main products—Windows and Office—remain fabulously profitable quasi-monopolies, Microsoft is still in a position that most firms would kill for. However, these online applications clearly threaten the way Microsoft makes money. For that reason Microsoft is reorienting itself by adding an online component into virtually all its products. The first steps in that direction are "Windows Live" and "Office Live". The difficulty will be getting the timing right, so that new products do not undermine existing cash cows.

The aim of this paper is to establish the optimal speed at which the firm should start bringing the new product to market, given that it is already actively producing a standard good. In other words, we try to answer the question of how quickly to introduce an upgraded product that will cannibalize part of an existing product's market. The paper is original in that it looks at the question in continuous time and with state variables for two capital stocks, each of them governing the production processes of the two products.

We are interested in understanding not only whether a firm should introduce the new product but also what is the ideal rate at which to introduce it and how that affects sales of the standard product. Hence, we need to employ an optimal control model to focus on "dynamics". This inevitably raises complexities relative to a discrete, two period model, so we focus on the case of a monopolist or someone for whom pricing drives innovation but not competition. This approach yields an extra benefit. As the examples in this introduction reflect, competition is often invoked as the reason for introducing a new product, but we will see that even a monopolist can benefit from product innovation and, hence, face structurally similar choices.

In this paper we make a distinction between two types of goods. One type behaves according to a usual linear demand structure. The second, which we call a disruptive good, has the characteristic that small volumes have negligible influence but the consumer utility of using the standard product significantly decreases when the disruptive good is dominantly present in the market. A typical example would involve network externalities. When VHS became common, films stopped being released on Betamax so the utility of having a Betamax VCR declined once the suppliers of complementary products focused efforts on serving people using the new technology. A contemporary example is the use of a mobile phone as a way to pay. The Economist (February 17th, 2007, pp. 67–70), notes that this "new system could prove to be a 'disruptive technology'. Banks could be 'disintermediated' if, say, the payments for the train ticket, newspaper and coffee made every day by a commuter with his mobile phone appear not on their monthly credit-card statements, but on those of a mobile-phone service provider." The basic punchline will be that non-disruptive goods can coexist or not, depending smoothly on the parameter values, but that with disruptive goods this coexistence can also depend on the size of the firm's existing investment in the standard product. It turns out that the presence of non-disruptive goods leads to saddle point behavior, while disruptive goods can generate a history dependent (Skiba) solution.

Our inquiry is motivated by the case of product innovation, where the initial stock of capital dedicated to producing the new product is zero. However, we will also provide solutions for other initial values of this capital stock. This generality is relevant if, for example, a firm producing two different products that are imperfect substitutes experiences unanticipated process innovation that alters one or more relevant problem parameters and needs to know how optimally to steer to a new equilibrium.

The analysis rests on two streams of literature. First we have the static heterogeneous product market games as in Dixit (1979), Singh and Vives (1984), Vives (1985) and Qiu (1997). These papers consider two firms competing either in a Cournot or Bertrand fashion, and use the same linear demand structure as we adopt in our model for non-disruptive goods. However, our paper differs in that we have a dynamic framework where one firm produces two different goods. In other words, whereas the just described literature focuses on competition in a static context, we study a monopolist in a dynamic framework.

Second, we have the literature on capital accumulation, e.g., Lucas (1967), Davidson and Harris (1981), Dechert (1983) and Barucci (1998). In these models the firm is the decision maker. This firm owns one capital stock, which can be increased by investment. The capital stock, which is the only state variable in the model, is employed to produce a single homogeneous good. Due to a non-concavity in the revenue function, Davidson and Harris (1981) and Dechert (1983) obtain history dependent equilibria, i.e., two different long run steady states are derived, and the initial capital stock level determines which steady state is optimal in the long run. The two domains of attraction are separated by a Skiba (1978) point. Haunschmied et al. (2003) extend this literature by considering a two state model, where the second state is the amount of investment. Now, since the state space has two dimensions, the non-concavity in the revenue function adopted in that paper leads to the existence of a Skiba curve separating the domains of attraction of initial levels of investment and capital stock. While all these contributions have firms producing identical goods, our paper considers a firm producing two different goods. For each good a different capital stock is needed. The paper shows that the resulting two state model, with the two capital stocks being the two states, also can lead to the existence of a Skiba curve, as in Haunschmied et al. (2003). However, instead of being caused by non-concave revenue, in the present paper history dependence results from the interaction terms in the two demand functions.

The paper is organized as follows. Section 2 presents our general framework. This framework is directed towards non-disruptive goods in Section 3 and towards disruptive goods in Section 4. Section 5 concludes. Proofs of propositions can be found in Appendix A.