Optimal Capital Accumulation and Durable Goods Production

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Introduction

In this paper we analyze a monopolist’s production of a durable good under the supposition that capital investment is irreversible. Situations characterized include production of a durable with specialized capital equipment, durables for which advertising expenditures constitute a large share of marketing costs, and production of new information through investment in human capital; see Arrow [1, pp. 40-41].

Irreversibility of investment constitutes one source (the other being adjustment costs) of what Jorgenson [6] terms a recursive production technology — one for which production possibilities at any time depend on the accumulated stock of capital. Consequences of adjustment costs on investment behavior have been investigated by Gould [5] and Rothschild [17] among others while irreversibility has been explored by Arrow [2] and Nickell [12, 13]. In all these analyses it is assumed that current revenue derives from contemporaneous production rather than from the accumulated stock of the good, suggesting that it is nondurable. Recent investigations of durable goods production, including Feldstein and Rothschild [4], Kleiman and Ophir [8], Levhari and Srinivasan [10], Levhari and Peles [9], Schmalensee [18], Parks [14], Ramm [15], and Swan [21, 22], have been based, at least tacitly, on the supposition that the production technology is decomposable — one for which production possibilities are independent of the current capital stock. Only Sieper and Swan [20], and Kamien and Schwartz [7] addressed the question of durable goods production with a recursive production technology. In both analyses a single
irreversible investment in an infinitely durable capital input was posited. Sieper and Swan concluded that irreversibility might influence the relationship between market structure and product durability while Kamien and Schwartz found that it did.

Analysis of durable goods production in the presence of irreversible capital investment appears neither to be a trivial extension of previous work in regard to economic content nor does it involve straightforward application of earlier methodology. Our present study focuses on the optimal factor employment policies and output profile of a long run profit maximizing producer of a durable good.

We employ the common assumption that the firm retains ownership of its product and collects a rental fee for the good’s services. This assumption is applicable to durable goods such as housing, computers, copying machines, communications equipment and certain transportation modes. If all agents in the market had perfect foresight regarding the future price of the durable and if there were a perfect second-hand market for the good, then the firm (and its customers) would be indifferent between sale and rental. The analytic advantage of the rental assumption is that we thereby avoid the complication of potential purchasers having to correctly assess the good’s future price movements. The rental price of the durable is inversely related to its stock. We further assume that the durable is produced with a variable factor, labor, and a fixed factor, capital. It decays at a constant proportionate rate. Productive capacity of the capital stock also deteriorates at a fixed proportionate rate and may be replenished by investment. The purchase price of capital is independent of the level of purchase.

We conclude that in a stationary environment the stock of the consumer durable accumulates to a peak value above the steady state level, towards which it then declines. Correspondingly, the rental price of the durable begins high, declines to a trough below its steady state value and then rises toward its stationary value. By contrast, if capital is infinitely durable, the stock of the consumer durable approaches its steady state value monotonically, see [7].

Our investigation begins within a nonstationary environment in which factor prices and the demand for the durable may vary through time. We then specialize our study to a stationary environment and require the production function to be homogeneous of degree one. This specialization enables us to carry out a phase diagram analysis to deduce the temporal profile of the stock of durable good. The results are then contrasted with those of the polar cases