A Dynamic Strategy to Optimize Market Entry Timing and Process Improvement Decisions

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Abstract

Conventionally, manufacturing firms determine the time to introduce a new product to the market long before launching the product. As the rate of technological innovation increases, product life cycles become shorter, and the timing for introducing a new product becomes more important. As a result, firms need to dynamically determine the market entry timing depending on the evolution of uncertain market potential and the readiness of their production processes. This paper studies such a dynamic market entry strategy. We consider a manufacturer who employs a dynamic strategy to optimize the timing for introducing a new product and investment decisions for the new production process. Investments in production and learning processes often yield uncertain results. Uncertainties also reside in competitors’ market entry decisions. Hence, depending on the changes in the market potential and the readiness of his own production process, the manufacturer dynamically makes process improvement decisions in coordination with the market entry decision. After determining the market entry timing, the manufacturer also makes production and pricing decisions for the new product. We establish the optimality of threshold-type market entry policies and determine optimal joint production and pricing decisions in conjunction with the market timing decision. We show that compared to conventional static strategies, the dynamic strategy yields a higher and less variable profit. Our study also characterizes the industry conditions under which the dynamic strategy is most effective.

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1. Introduction
Manufacturing firms determine the timing for introducing a new product to the market in the presence of two major uncertainties. First, manufacturing firms are uncertain about competing firms’ market entry timing. Entering the market later than competitors results in a drastic reduction of profit in a highly competitive environment. For example, Kumar and McCaffrey (2003) estimate the penalty of being late to market by one quarter in the hard disk drive industry at $106 million. Second, manufacturing firms are also uncertain about whether they can complete the development of the new production process by the product launch time because the outcomes of manufacturing process development activities are often highly unpredictable. In 2005, Microsoft launched the Xbox360 with an ill-understood production process, which resulted in $1.15 billion of repair costs (Taub 2007). In the presence of such uncertainties, optimizing the market entry timing is a challenging problem. The market entry decision also involves considerable risk, because the decision is irreversible. As a solution for reducing such risk, we propose a dynamic strategy that determines the market entry timing in response to the evolution of uncertain factors.

For the dynamic market entry strategy to be effective, the coordination between the market entry timing and the development of the production process is important. For example, when competitors have introduced their products earlier than expected, the manufacturer needs to accelerate the market entry by investing more capital in process development activities in order to avoid a significant loss in the market share. In addition, the production and pricing decisions also need to be coordinated with the market entry decision. In this paper, we develop an integrated model that jointly optimizes (i) the timing for introducing a new product, (ii) process improvement decisions, (iii) production, and (iv) pricing decisions.

Our main contributions to the literature are three-fold. First, we study the decisions about market entry timing and process improvements under the dynamic evolution of the market potential and knowledge, whereas the existing literature (e.g., Kalish and Lilien 1986, Cohen et al. 1996) has studied optimal market entry decisions in static settings. Second, we provide a guideline for when to implement the dynamic strategy depending on specific industry characteristics. Because the employment of the dynamic strategy would require costly changes in firms’ decision processes, the result is important for manufacturing firms to make decisions about the adoption of the dynamic strategy. Third, we integrate the operational decisions (process improvements and production decisions) and marketing decisions (market entry timing and pricing decisions) in a single framework.

2. Model Description
We consider a manufacturer who dynamically determines the timing for introducing a new product to the market. Prior to introducing the product, the manufacturer can improve the production process for the new product by investing in learning activities such as adjustments of the process
recipe, development of faster inspection methods, and reduction of defect rates. After launching
the product, the manufacturer makes production and pricing decisions for the new product in the
presence of demand uncertainty. We model the manufacturer’s problem as a two-stage stochastic
decision process. The first stage is the process design stage during which the manufacturer dynam-
ically determines learning activities to improve the production process and the time to stop process
design and introduce the product. The second stage is the production and sales stage, during which
the manufacturer determines the production quantity and the sales prices for the new product.

At the beginning of each period of the process design stage, the manufacturer first updates
information about two states: the level of cumulative knowledge related to the production process,
and the expected size of the potential market for the new product. Based on this information, the
manufacturer next determines whether to stop process design or continue it. If the manufacturer
decides to continue process design, then he makes an investment decision to improve the production
process. Process improvement activities increase the manufacturer’s knowledge level. Because the
manufacturer often encounters failures of process development activities, we model the increase
in the knowledge level as a random variable. As the manufacturer continues process design, the
expected size of the potential market decreases for two reasons. First, the delay in market entry
increases the chance of competitors’ launching competing products earlier than the manufacturer,
which reduces the manufacturer’s market share. Second, the delay can shorten the lifespan of the
product when a new generation of the product makes the old product obsolete. We model the
dynamics of the market potential as a stochastic process to capture the uncertainties residing in
external factors such as competing firms’ market entry decisions. The stochastic process is general
and can model various scenarios arising in different environments.

When the manufacturer stops process design, the problem proceeds to the production and sales
stage, which consists of a regular sales period and a salvage period. Before the regular sales period,
the manufacturer determines the number of products to produce, and the regular sales price in the
presence of demand uncertainty. Demand during the regular sales period depends on the market
potential and the regular sales price. Unmet demand is lost, and the manufacturer can sell unsold
products during the salvage period. Demand during the salvage period also depends on the market
potential and the salvage price.

The unit production cost for the new product is determined by the manufacturer’s knowledge
level at the time when he stops process design. The unit production cost decreases in the knowledge
level, but the marginal benefit becomes smaller as the knowledge level becomes higher. Because
the learning activities we consider are not intended to improve the product but to improve the
production process, the attributes and quality of the new product are independent of the knowledge
level. Hence, the knowledge level does not directly affect demand for the new product. However,
it has an indirect impact on demand because the manufacturer’s pricing decision depends on the unit production cost, which in turn depends on the knowledge level.

3. Summary of Key Results
We formulate a two-stage dynamic programming to solve the manufacturer’s problem. The first stage problem is an optimal stopping problem that determines the optimal time to introduce the new product and optimal investment decisions. The second stage problem is a joint production and pricing problem. The solution for the second stage problem, i.e., the optimal production and pricing decision, depends on the size of the potential market and production costs, which are determined by the market entry timing and process improvement decisions.

Based on the formulation, we establish the optimality of threshold-type market entry policies. First, we prove the optimality of a knowledge-level-based policy under which the manufacturer stops process design if the current knowledge level exceeds a threshold. If the manufacturer’s knowledge level is very high, additional knowledge does not improve the manufacturer’s profit, and thus he needs to stop process design. Second, we prove the optimality of a market-potential-based policy under which the manufacturer stops process design if the current market potential is smaller than a threshold. However, we show that this structure is reversed when the reduction in the market potential is sensitive to the size of current market potential. We also characterize monotonicities of the optimal thresholds. Finally, we provide structural properties of the optimal production and pricing decisions.

The dynamic strategy that we propose has two benefits over the conventional static strategies. First, the dynamic strategy increases the manufacturer’s expected profit. Second, the dynamic strategy reduces the variability of the manufacturer’s profit. Using our modeling framework, we develop two measures that assess the two values of the dynamic strategy. The measures are based on comparisons of the dynamic strategy to an optimal static strategy. By examining the value of the dynamic strategy under various environments, we show that the dynamic strategy is effective when (i) the outcome of learning activities involve a great amount of uncertainties, (ii) the manufacturer can significantly reduce the production cost by improving the production process, (iii) flexible management of learning activities is possible, (iv) changes in the market potential are difficult to anticipate, (v) demand is highly uncertain, and (vi) the size of salvage market is small.

References