**Problem Description**

The timing of a new product introduction is a critical decision for high technology firms. The timing decision depends on whether companies invest more time in product and process design and improvement or push the product to market before competitors. The decision involves several tradeoffs such as improved manufacturing yields versus higher market share. Market-timing decisions are even more challenging when product life cycles are shortened and firms are pressured to release new products more frequently. What has been the optimal timing for a new product may not be the best timing for the next new product. A collaborative project was initiated by Hitachi Global Storage Technologies (Hitachi GST) in the quest for defining minimum yield for launching a new product to improve financial performance. One critical consideration is the tradeoff between the loss of market share (due to product launch delay) and cost improvement as a result of better yield. Motivated by these challenges, we developed a framework for time-to-market optimization.

The timing of a new product introduction requires firms to consider various tradeoffs that impact profit. From the manufacturing perspective, the design and process improvement stage is the opportune time to improve yield and capacity. Delaying market entry often translates into lower production cost and higher capacity. Process improvement activities also improve the likelihood of getting qualified for the customer’s product, which means higher sales volume. However, a long delay may cause the firm to miss the qualification window altogether. From the marketing perspective, a late entrance to market translates to a potential loss of market share to competitors. In addition, rapid price erosion causes late entrants to miss the initial, steep profit margin. The complexity of the timing decision is increased further due to uncertainties in competitor market entry timing, the outcome of customer qualification tests, and sales volume projections. Yield improvements, likelihood of qualification, market share, and first-entry advantage are among the key factors that impact profit (see Figure 1).

Firms also need to consider the impact of market timing on their post-entry production decisions. For example, a relatively early entry may result in production that commences at a relatively lower yield than a later entry, resulting in higher production costs. A later entry may result in production that commences at a higher yield but with a lower profit margin. Decisions regarding production
volume must also be made. Accordingly, the timing of new product introduction and post-introduction production decisions should be linked.

Reaching a consensus is another major challenge in deciding when to introduce a new product. The market timing decision cuts across various functional areas within a firm and affects these areas very differently. For example, marketing and finance pay close attention to market share and prices and often push for early entry whereas the manufacturing pays close attention to the process design, yield, and capacity projections, and hence, they prefer late entry. So, it is not uncommon to have long discussions that may polarize the decision process to either extremes.

Solution Approach
To address the above challenges, we developed an integrated framework and an optimization tool that incorporates the aforementioned tradeoffs and profit drivers summarized in Figure 1. With the help of this tool, we determine an optimal time to enter the market as well as an optimal production schedule for the life cycle of the new product. The model explicitly considers the relationship between time-to-market and production yield. It also takes into consideration the impact of decision making under various uncertainties. Hitachi GST has also developed internal models to obtain some of the key inputs such as learning curves, and cost versus yield relationships. The following are the model’s input parameters:

- Market volume projections and forecast errors
- Market share projections according to market entry relative to competitors
- Price evolution over time
- Competitor behavior (e.g., probability of competitor entry)
- Interest rate and opportunity costs
- Yield and capacity projections
- Hard drive cost, inventory holding cost, and shortage costs
- Qualification time window, likelihood of qualification for customers

Based on this framework, we developed software that uses Microsoft Excel as an input and output interface. The software output includes optimal time-to-market decisions and the corresponding optimal profit and produce-up-to levels, which determine production volumes for the planning horizon.

Some Results
Our research shows that the optimal time-to-market decision should be revised in real time based on the number of competitors in the market. We illustrate this result with an example output shown in Figure 2. For this particular example, which is given without specifying the inputs, the optimal market timing is such that if there are no competitors in the market, it is optimal to enter in March 2005. However, if a competitor enters the market before March 2005, then it is optimal to delay market entry to May 2005. Intuitively, once the first competitor enters, the market share loss due to this competitor entry could be large enough that the benefit of delaying the entry decision to improve manufacturing processes and yield might surpass the cost of losing additional market share. We remark that this discussion is meant only as an example. Actual timing decisions vary, depending on the environment and the inputs considered.

The optimal timing decisions may need to be triggered by certain check points within a firm. For example, Hitachi GST’s manufacturing division monitors achieved yields during manufacturing process design prior to market entry. The software also provides the optimal minimum yield requirement as implied by the market entry timing. For example, Figure 3 illustrates optimum minimum yield requirements corresponding to the optimal market entry strategy in Figure 2. When the actual yield exceeds the minimum yield requirement, it is optimal to stop further process improvement and enter the market.

The software also calculates how much should be produced during each quarter after the product is launched. Figure 4 illustrates optimal produce-up-to levels as an output. The optimal policy is to produce enough to bring the inventory level up to these produce-up-to levels during each quarter.

This integrated framework also enables one to investigate the sensitivity of optimal profit with respect to the factors affecting the market-timing decision. For example,
Figure 5 illustrates how profit changes as a function of three problem parameters. Learning-by-experimentation refers to the changes in yield due to process improvements prior to product launch. Learning-by-doing refers to the improvement in yield during the actual production phase. Such a sensitivity analysis can illuminate key drivers and opportunities for profit improvements.

**Conclusions**

We conclude that:

1. The time-to-market decision simultaneously affects many profit drivers and functional areas within a firm. A dynamic and comprehensive model that integrates all profit drivers is needed.

2. Time-to-market and production decisions are inherently related with each other. This relation is an important consideration in NPI optimization models.

3. Optimal time-to-market strategy requires a real-time response to changing market conditions rather than a static framework.

4. Sensitivity analysis can augment the decision-making process by providing data-driven discussions based on quantitative analysis. Such discussions enable different functional areas within a firm to objectively communicate and identify opportunities.

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All numerical examples in this article are based on fictitious business cases that do not reflect Hitachi GST’s business case in any way.