Product Life Cycle and Competitive Strategies

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Abstract

In high-tech industries, technology is typically believed as a so-called key success factor. However, technology itself cannot secure incumbents' long-term survival; the more competitive industry's competition is, the smaller the contribution of technology on firm survival will be. This paper scrutinizes the impacts of product portfolio capability and marketing capability on long-term survival. For this purpose, a game-theoretic model is constructed. According to the model, both product portfolio capability and marketing capability can enhance firm survival but they can deteriorate profitability. Therefore, it is too much to say that the stronger the product portfolio and marketing capabilities are, firms are always better off. This prediction is supported empirically in the rigid disc drive industry; Surely, the stronger the portfolio and marketing capabilities firms own, they are more likely to stay longer in the HDD market. However, such effects are found to be marginally decreasing in the long-run.

Keywords: Survival, portfolio, marketing, behavior, and strategy

1. Introduction

1.1. Background

The HDD industry, technological evolution is solely measured by storage capacity and the smaller the size of disc drive is, the more advanced technology is associated (Christensen, 1993). Simply, the size of disc drive becomes to be smaller as technology evolves. Therefore, the generation of disc drive is characterized by the diameters of discs.

Subsequent to Christensen (1993)'s work, Lerner (1995 & 1997) show milestone researches concerning on the HDD industry. Differently from Lerner (1995 & 1997), Filson & Gretz (2004)

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focus on how leapfrogging can occur in the HDD industry. As Yim & Jung (2010) point out researches on the HDD industry are not furthered ex post Lerner's milestone study in 1995 and 1997. It is fundamentally because Lerner's dataset is a personally collected dataset which is available from 1982 to 1997 only. Actually, this time-period is the most revolutionary period in the evolution of the HDD industry.

1.2. Main issues

If product life cycles are long , then market participants are able to stay longer in currently available product life cycles. Actually, they have a room to enjoy current product segments longer in this case, which deters new innovations. Accordingly, it becomes incumbent's best response to devote their resources to current PLCs as longer the PLCs are. In contrast, market participants need to adapt to new innovation quickly if PLC changes rapidly. In this case, frequent market exit occurs in the beginning of the new PLC even if there are numerous market cohorts. In a short PLC, the generic competitive theme is to explore profitability shortly. Then a naturally intriguing strategic curiosity is how to make firms maximize profitability in a short time span.

Hence, it is no doubt that PLC can shape the strategic attitudes of market participants. In the pursuit of this paper, it should be noted that firms in the HDD industry had to create product portfolios because they could sell not only in newer segments but also in older product segments. Practically, incumbents would like to construct portfolios to secure market shares and, as a way to do so, they need to maintain a certain degree of production scale (Srinivasana, et al., 2008). Alternatively speaking, at least, firms can enhance their survival by mitigating risks when they can sell in overlapped product segments as long as they have enough resources (Stevenson & Gumpert, 1985).

In reality, like a curse to innovator, technology leaders in the HDD industry experienced frequent market exists. Product portfolio and marketing can be more useful to mitigate risks as they can adjust firm power to new trends in business (Kester, et al, 2011). Thus, the role of a product portfolio strategy should be importantly highlighted rather than technology itself. Also, in each product segment, firms are supposed to diversify for enhancing marketability of each produce. Actually, marketing decision is the most import decision and it has a positive impact on market success (Lodish, 2001; Salomo et al., 2008). Specifically, it enables the realization of the firm's strategies , which leads to increased market and financial performance.

A multi-model strategy is more desirable to reinforce profitability, which enable incumbents

to stay longer in the HDD market. In the paper, the former is defined to be product portfolio capability (PPC) and the latter is defined to be marketing capability (MC).

This paper constructs a game-theoretic model to understand the impacts of PPC and MC on the survival of hard disc manufacturers. In particular, it is scrutinized whether competitors in the HDD industry can benefit from both PPC and MC and, if so, how both capabilities can enhance their long-term survival is theoretically demonstrated. The predictions of the model is empirically examined using a time-series data from 1982 to 1997 for the HDD industry.

The paper is organized as the follows. Section 2 develops a Cournot type quantity competition model to analyze incumbent′s survival based on PPC and MC. Section 3 provides an empirical framework to verify the predictions of the game model in the section 2. Section 4 discusses main empirical findings and section 5 summarizes main strategic implications.

2. The Game Model

2.1. Profit Maximization

In a high tech industry, i and j are competitors and they competed in the PLC of $A^{'}$. As technology evolves, they start to compete in the current PLC of A. Both firms′ marginal cost is c in A. Surely, both firms are able to stay in $A^{'}$ as well

Because both firms can compete in A using c, the level of technologies of i and j are identical. The industry′s market demand is given to the inverse demand curve of $p = 1 - q$. Now, i constructs a product portfolio by maintaining their product lines-ups in $A^{'}$. As long as i owns c, it can produce at the same marginal cost in $A^{'}$. Compared to j that stays only in A, i in intended to sell in both A and $A^{'}$. So, i′s total production is defined as $Q_i = q_i + q_i^{'}$ and so i chooses q_i and $q_i^{'}$ simultaneously. But i′s total production cost increases and this can deteriorate the total product effect accordingly. The profit maximization problems of i and j are given to (1) and (2). i maximizes (1) w.r.t. q_i and $q_i^{'}$, which produce the F.O.C. of $1 - 2q_i - q_i^{'} - q_j - c = 0$ and $1 - q_i - 2q_i^{'} - q_j - c = 0$. The F.O.C. of j is given to $1 - q_i - q_i^{'} - 2q_j - c = 0$.

$$\pi_i = (1 - Q_i - q_j)Q_i - cQ_i \tag{1}$$

$$\pi_j = (1 - q_i - q_i^{'} - q_j)q_j - cq_j \tag{2}$$

2.2. Product Portfolio Capability

Proposition 1 opens a strategic pathway to compete in a highly competitive technology based industry. Even if i and j have a same technology level, i that can maintain a product portfolio can expand its production. Practically, constructing the product portfolio does not increase marginal production cost because portfolio contain not only the newest product generation but also the older production generation. However, maintaining more product segments can incur higher total production costs which should be paid incrementally according to the scale of production. This cost effect can be traded off by the portfolio effect, which is consistent to previous works.

Proposition 1. *Constructing a product portfolio in a high-tech industry provides a strategic advantage.*

Poof. Solving the F.O.C.'s, one can derive $1 - 3q_i - q_j - c = 0$ and so $q_i = q_i'$. Thus, the equilibrium productions of i and j when i constructs the product portfolio are determined as $Q_i^* = \dfrac{1-c}{2}$ and $q_j^* = \dfrac{1-c}{4}$. Therefore, $Q_i > q_i$.   Q.E.D.

An intriguing question out of Proposition 1 is what if i is required to pay a lump-sum payment to maintain A'. It can include all fixed costs to maintain production lines and value chains as well as an opportunity cost to maintain A'. Then, i's profit is redefined to be (3) where L is i's lump-sum payment.

$$\tilde{\pi}_i = (1 - Q_i - q_j) Q_i - cQ_i - L \tag{3}$$

Proposition 2 points out that i can take advantage of its product portfolio as long as the lump-sum payment satisfies $L \leq \dfrac{(1-c)^2}{16}$. Because i can earn positive profits for any L, i can be always better off pursuing the portfolio strategy as long as i's industry has short PLC's.

Proposition 2. *Even when i has to pay for a lump-sum payment to maintain the older generation, it still can benefit from the product portfolio strategy.*

Proof. Note that $\tilde{\pi}_i = \dfrac{(1-c)^2}{8} - L$ where $Q_i = \dfrac{1-c}{2}$ and $q_j = \dfrac{1-c}{4}$. Thus, $\tilde{\pi}_i \geq \pi_j$ if $L \leq \pi_j$. For any L, $\tilde{\pi}_i > 0$.
 Q.E.D.

Proposition 3 reveals why market participants in high-tech industries are supposed to make creative destructions; they gradually relinquish old product generations because maintaining too many old product generations discounts their average profitability. Although the product portfolio strategy can enhance i's profit, its average profitability becomes to be decreasing as the more product portfolios i maintains. This highlights i's portfolio construction guideline. Because too many product portfolios become to hurt i's profitability, i has to compare the opportunity cost to lose average profit and the gain from production effect. By this, it can find out the equilibrium number of product portfolios.

Proposition 3. *Product portfolio deteriorates i's average profitability.*

Proof. Note that $\dfrac{\tilde{\pi}_i}{Q_i} = \dfrac{(1-c)^2 - 2L}{4(1-c)}$ and $\dfrac{\pi_j}{Q_j} = \dfrac{(1-c)}{4}$. It is straightforward to see that

$$\frac{\tilde{\pi}_i}{Q_i} - \frac{\pi_j}{Q_j} = -\frac{\left[2L + 3(1-c)^2\right]}{4(1-c)} < 0$$

2.3. Marketing Capability

The marketing capability is a firm specific capability to maximize profitability through selling multi models in each product generation. Now, consider that i produces total n models in A while j does not. The inverse demand curve for i and j is redefined to be $p = 1 - \dfrac{q_i}{n} - q_j$. Then, i's profit is given to (4) under its multi-model strategy while j's profit is given to (5).

$$\hat{\pi}_i = (1 - \frac{q_i}{n} - q_j)\frac{q_i}{n} - cq_i \tag{4}$$

$$\hat{\pi}_j = (1 - \frac{q_i}{n} - q_j)q_j - cq_j \tag{5}$$

The equilibrium productions of i and j are derived as $\hat{q}_i^* = \dfrac{n(1-c)}{3}$ and $\hat{q}_j^* = \dfrac{(1-c)}{3}$. According to Proposition 4, i's production is enlarged by marketing capability. In a Cournot type quantity competition, this production effect is a key success factor. Nevertheless, multi-model does not guarantee profitability as well, which restricts i's the scope of the multi-model strategy. Simply, the multi-model strategy is useful for expanding i's production but the more the models i sells, the less its profitability will be due to transaction costs involved in marketing. Therefore, the multi-model strategy can be said to be necessary but selling too many models is not an efficient resource allocation. Thus, i has to find out the optimal number of models in each product portfolio, which is the core part of marketing activity.

Proposition 4. *Marketing capability enhances i's production but it can deteriorate its profitability.*

Proof. $\hat{q}_i^* > \hat{q}_j^*$ because $\hat{q}_i^* - \hat{q}_j^* = \dfrac{(1-c)(n-1)}{3}$ where $n \geq 2$; however, $\hat{\pi}_i^* < \hat{\pi}_j^*$ because $\hat{\pi}_i^* - \hat{\pi}_j^* = -(n-1)\dfrac{c(1-c)}{9} < 0$ where $n \geq 2$.

3. Empirical Framework

3.1 Data

In this paper, I use the dataset used in Yim & Jung (2010), Yim & Shin (2014), and Yim & Joo (2015). Unfortunately, only four information is available. First, the number of diameters of each firm owns represent product categories, which is a proxy for PLC. Second, the number of models in each product category is a proxy for marketing capability. Third, the storage capacity of each model in each category is used to measure the technological level of each firm.

According to Yim & Jung (2010), the smallest drive is 1.92 inch and the order of size is 2.6 inch, 3.80 inch, 3.84 inch, 5.20 inch, 5.32 inch, 7.5 inch, 9.5 inch, 14 inch. Combining '3.80 & 3.84' inches, '5.20 & 5.32' inches, '7.5 & 9.5' inches, total six product portfolios are classified. The maximum PPC and MC are six and seventeen along with the averages of 1.64 and 3.24, respectively.

3.2 Equations

This section constructs some empirical frameworks. In (6)-(8), $y_{i,t}$ is the natural logged longevity of i, which measures the survival of i. c is a constant and t is time dummies from 1982 to 1997. $tc_{i,t}$ represents the number of firms at t. It is worth testing if i's longevity is affected by the number of cohorts. According to Klepper (1996), in the initial growth stage of an industry, new market entries occur but market exits occur quickly as the industry grows. Therefore, one can expect that the more the $tc_{i,t}$ is, the lower the $y_{i,t}$ will be and vice versa.

$pn_{i,t}$ measures all the diameters of i at t and $pn_{i,t}^2$ is a square term. If the coefficient of $pn_{i,t}$ shows a positive sign while the coefficient of $pn_{i,t}^2$ turns out to be negative, one can say that the portfolio capability can enhance incumbents' longevity, which is partly consistent to Proposition 1. $mc_{i,t}$ measures the number of models, which measures the marketing capability. $mc_{i,t}^2$ is a square term of $mc_{i,t}$. According to Proposition 4, $mc_{i,t}$ is expected to show a positive sign while a negative sign for $mc_{i,t}^2$ is expected. As long as the square terms show negative signs, one can say that incumbents can stay longer, but with decreasing scales, as higher the PPC and MC are. $pm_{i,t}$ is the ratio of $mc_{i,t}$ over $pn_{i,t}$. So, (9) can examine if firms can stay longer in the HDD industry when their marketing capability compared to portfolio capability is higher.

$$y_{i,t} = c + t + tc_{i,t} + pn_{i,t} + pn_{i,t}^2 + \epsilon_{i,t} \qquad (6)$$

$$y_{i,t} = c + t + tc_{i,t} + mc_{i,t} + mc_{i,t}^2 + \epsilon_{i,t} \qquad (7)$$

$$y_{i,t} = c + t + tc_{i,t} + pn_{i,t} + pn_{i,t}^2 + mc_{i,t} + mc_{i,t}^2 + \epsilon_{i,t} \qquad (8)$$

$$y_{i,t} = c + t + tc_{i,t} + pm_{i,t} + \epsilon_{i,t} \qquad (9)$$

(10) is a probit estimation. $y_{i,d}$ is a dummy that is given the value of one when incumbents survive for the entire period. Therefore, $y_{i,d}$ represents full-time survivor. Because $y_{i,d}$ is a discrete variable, one can test the impacts of independent variables on $y_{i,d}$ using marginal effects derived by $\partial \mathrm{Prob}(y = 1)/\partial x = f(\beta' x)x$.

$$\mathrm{Pr}\{y_{i,d} = 1\} = f\{tc_{i,t}, pn_{i,t}, pn_{i,t}^2, mc_{i,t}, mc_{i,t}^2, pm_{i,t}\} \qquad (10)$$

4. Empirical Results

Table 1 summarizes the estimation results from (6) to (9). First of all, the more the cohorts are, incumbents are less likely to stay longer. This result clearly demonstrates that competition expedites market exits in a highly competitive HDD industry, which is consistent to Klepper(1996)'s prediction. Also, it is interesting to see that the technology level is negatively and significantly associated with market longevity. Thus, technology itself cannot secure firm survival. It is a typical phenomenon in high-tech industries; although firms are technologically advanced, they can experience market exits.

Actually, PPC shows positive and significant coefficients while its square term turns out to be negative. MC also shows positive and significant coefficients while its square term turns out to be insignificant. Between PPC and MC, PPC turns out to have a larger impact on firm survival than MC. The estimation result of (9) demonstrates that the ratio of MC over PPC is significant and positive, which indicates that firms are better off selling more models when they have product portfolios.

[Table 1] OLS: Portfolio Capability vs. Marketing Capability

Variables	Dependant Variable: The Natural Logged longevity			
	(6)	(7)	(8)	(9)
c	2.7363*** (.4895)	2.6284*** (.5037)	2.6301*** (.4817)	2.8255*** (.5513)
$tc_{i,t}$	-.3459*** (.1238)	-.2606** (0.1279)	-.3188*** (.1221)	-
$pn_{i,t}$	.4114*** (.0922)	-	.3365*** (.1011)	-
$pn_{i,t}^2$	-.0239 (.0184)	-	-.0256 (.0186)	-
$mc_{i,t}$	-	.1371*** (.0180)	.0439* (.0231)	-
$mc_{i,t}^2$	-	-.0039*** (.0011)	-.0004 (.0012)	-.2505* (.1395)
$pm_{i,t}$	-	-	-	.0612*** (.0164)
R^2	0.2096	0.1819	0.2211	0.0650
Obs.	840	840	840	840

(1) For correcting heterogeneity, White standard errors are reported
(2) *, **, *** are significant at 10%, 5%, and 1%, respectively.
(3) Time dummies are not reported.

Table 2 reports probit estimation results. Obviously, incumbents are less likely to survive longer if the number of cohorts increases. it is not significantly supported whether incumbents can secure their long-run survival through constructing product portfolios; however, PPC can

enhance their long-run survival with a increasing scale once it does. Marketing capability increases the chance for incumbents to survive longer. The ratio of marketing capability over portfolio capability shows a consistent result as well.

[Table 2] Probit: Portfolio Capability vs. Marketing Capability

Variables	Dependant Variable: The Long-term Survivor Dummy			
	(10)	Marginal Effects	(11)	Marginal Effects
c	1.7144* (.9017)	-	1.4232** (.6916)	-
$tc_{i,t}$	-1.0573*** (.2190)	-.1552*** (.0324)	-.7330*** (.1748)	-.1622*** (.0385)
$pn_{i,t}$	-.3217 (.3424)	-.0472 (.0511)	-	-
$pn_{i,t}^2$	.1699** (.0709)	.0249** (.0111)	-	-
$mc_{i,t}$	.4211*** (.0751)	.0618*** (.0101)	-	-
$mc_{i,t}^2$	-.0181*** (.0045)	-.0026*** (.0006)	-	-
$pm_{i,t}$	-	-	.2203*** (.0382)	.0487*** (.0087)
X^2	187.02		45.8	
Obs.	840		840	

(1) *, **, *** are significant at 10%, 5%, and 1%, respectively.

5. Conclusion

This paper scrutinized how firm specific portfolio capability and marketing capability can affect firm survival in the HDD industry. The theoretic model of the paper predicts three strategic implications. First, portfolio capability can enhance incumbents' total productions. However, their average profits can be deteriorated, which restrict incumbent's preference on portfolio construction. Practically, incumbents need to drop off old products from their product portfolios and, in fact, this drives creative destructions. Second, marketing capability can enhance firm production as well; however, this does not necessarily mean that they can earn more profits through active marketing activities.

Empirical results support these predictions. First, the stronger the portfolio capabilities firms own, they are more likely to stay longer in the HDD market. Second, the more products firms

sell, they are more likely to stay longer. However, such effects were found to be marginally decreasing in the long-run. The results of this paper are limited applicable because the empirical works in the paper endogenously assumes that incumbents in the HDD industry are less likely survive because the product portfolio and marketing capabilities can deteriorate profits. However, this endogeneity can be solved only when price effect can be scrutinized. Due to lack in price information, this endogeneity cannot be cleary demonstrated.

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