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OPTIMAL REPEATED PRODUCT MANAGEMENT WITH CUSTOMERS' PREFERENCES

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Abstract: *The study deals with the product management of repeated products such as smartphones, cars, and healthcare devices. They have limited lifecycles. The Galaxy S5 was marketed in 2014 and faded out as the Galaxy S6 launched in 2015. The study deals with when to stop selling a given product and initiate another repeated product, together with the R&D period and timing issues. The objective function is to maximize the discounted net cash flow or the equivalent annuity for a given period, e.g., a year, a decade, etc. We define the first-order conditions for optimality along with economic and management interpretation. The initiation of the following product functionally depends on the current product termination. We define the resulting rules in managerial terms. A numerical example illustrates the rules and the solution.*

Key words: *Repeated Product, Optimal Duration, Artificial Intelligence, Willingness for New Product*

1. INTRODUCTION

1.1 Rational and Background

The study deals with two aspects to stop a model of a product just because there is room for the following model or product. Typical examples come from the smartphone industry, where producers replace their products in the market almost once a year. Another example is the automobile industry. This phenomenon also involves products that serve organizations and not necessarily the private end user, like the healthcare device industry.

There are many aspects of this replacement, and this paper focuses on the technology and the motivation or even the eagerness of the consumers for a new product model.

The study deals with situations in which the market is ready for a new product, unlike cases in which a new product is based on new technology. However, it is challenging to implement the product in the market because the industry is still being prepared for such a change. A good example was the first E-Print by Indigo in the early 90's. Much research is about what should be handled first, building the market or developing a product [1].

This paper gives two sides: the aspects of production and technology over time and consumers' motivation for new products, on the other hand.

Table 1

Unit Sold of Samsung Galaxy (millions).

Series	Year	Unit Sold
S	2010	25
S II	2011	40
S III	2011	60
S 4	2013	80
S 5	2014	45
S6, S6 Edge	2015	45
S7 and S7 Edge	2016	55
S8 and S8+	2017	50
S9 and S9+	2018	35
S10, S10e and S10+	2019	36
S20, S20+ and S20 Ultra	2020	15
S21, S21+ and S21 Ultra	2021	13

In Table 1, there is the worldwide shipment of Samsung Galaxy smartphones. The numbers were collected from the internet sources. It is revealed from the data that the smartphone producer who is in a competitive market keeps the policy of launching a new model about every

year. The product answers the exact needs of customers over time. It is so emphasized that the market is ready or even eager to have new products so frequently.

1.2 Literature Review

The study by Ansof [2] is considered a baseline for product management concerning product cycles under various intensity levels of technology. A product has a relatively long lifespan in low-technology industries with few product cycles. The product is still relatively long-lived in mid-technology industries, yet many product cycles exist. In the high-tech sector, technologies have short lifecycles and many product cycles within each technological niche. Ansoff claims that organizational difficulties and the fit between the corporate culture and new technologies are some of the reasons for that.

The capital costs of cyclical patterns are explored by Grubbstorm [3] and Luciano and Peccati [4]. [5] use a dynamic programming method to confront the question of when to stop a product cycle.

The orientation of a producer toward developing a new product should be treated in all organizational aspects and should have organizational support, for example, in reducing risk [6]. This includes treating the contribution of organizational support to minimize the risk associated with developing a product.

2. MATHEMATICAL FORMULATION

2.1 The financial aspects of production.

The production of a product is modeled as the cash flow that a producer gets over time. In the early days of a product, there is negative cash flow because of research and development costs associated with the product. From the launching point of time of the product, the negative cash flow decreases and becomes positive cash flow. Then, the cash flow increases to a maturity point from which the cash flow decreases and could even be negative cash flow. The cash flow over the lifespan of a product is discounted to the starting point of a product's life. As in Equation 1, it refers to Net Present Value (NPV).

$$NPV(\boldsymbol{t_i}) = \int_0^{t_i} e^{-ru} f(u)du \qquad (1)$$

Where r is the annual continuous compounded interest rate, t is the stopping time of the ith product in a series of products. The function f(u) gives the instantaneous cash flow in point of time u. Yet, in cases of investment and revenues over time, primarily where the investment is repeatable, it is preferred to use the annuity of a project over time. This financial-mathematical act converts fluctuated cash flow over time to a uniform flow by multiplying the NPV by the annuity factor. The continuous version of an annuity factor is given in Equation 2 for the period span 0 to t, where r is the annual continuous compounded interest rate.

$$a(t) = \frac{r}{(1-e^{-r\cdot(t)})} \qquad (2)$$

It is claimed that a producer would like to maximize the annuity of its product over the time of the product's life. A naïve approach would be to optimize Equation 3 for t:

$$max\ (a(t)\cdot NPV(t), t) = \frac{r}{(1-e^{-r\cdot(t)})}\int_0^t e^{-ru} f(u)du \qquad (3)$$

Let us define the initiation point of time of product i+1 as a function of the termination time of product i

$$b(i+1) = s(t) \qquad (4)$$

Where b(i+1) is the beginning time of product i+1, and t is the stopping time of product i. s(t) is an increasing positive function of t. Say, s(t)=t, means that initiating product i+1 is when marketing of product i stops. Usually, this implies no overlapping, and if there is an R&D period, there will be no product in the market. Commonly s(t) is smaller than t.

The suggested optimization about t, the stopping time of product i that considers the resulting initiation of the following product, is to consider the period between the initiation of product i, which is zero, and the initiation of the next product, which is s(t). So, Equation 3 becomes Equation 5:

$$\max\big(a\big(s(t)\big)\cdot NPV(t), t\big) = max\ \frac{r}{(1-e^{-r\cdot s(t)})}\int_0^t e^{-ru} f(u)du \qquad (5)$$

In general, there are additional operational constraints to this optimization formulation. The

first-order conditions of Equation 5 can be summarized as:

$$\frac{NPV'(t)}{NPV(t)/t} = -\frac{a'(s(t))}{a(s(t)/t)} \qquad (6)$$

The optimal duration of a product is t* a positive number that satisfies Equation 6.

2.2 Economic Interpretation of the first order conditions

The left-hand side of Equation 6 is the marginal NPV on day t divided by the averaged NPV from time 0 to t. The marginal NPV is the change in the NPV if the duration is increased by one unit of time. The averaged NPV is the NPV of the cash flow from the product divided by the duration t.

The ratio of the left-hand side of Equation 6 is called the production elasticity to time. It means that a percent increase in time yields a percentage increase in NPV by the elasticity value. It should be noted that the value of the production elasticity is a function of t.

In many cases, it is common to equate marginal production with average production to achieve an optimal production level. This policy is valid for the problem in the study when the right-hand side is one.

The right-hand side of Equation 6 is interpreted as the elasticity of having a new product. This elasticity reflects the willingness of customers to have and to be able to implement more recent products. The role of the function s(t) is considerable on the right-hand side of Equation 6. The function s(t) as the starting of the following product as a function of the current product reflects how customers are ready for the new product.

3. NUMERICAL EXAMPLE

In Table 2, there is a scenario of the production side of a producer. The time step us a quarter of a year. The quarterly cash flow is the marginal cash flow, and the averaged cash flow is computed. In this illustration, the limit of r is zero. The interest rate's role diminished to emphasize the part of the other factors.

Consider a simple case that the elasticity of s(t) is 1. The stopping time of that product should be when the marginal cash flow equals the average cash flow, which is quarter 9. The total cash flow is 405, and the average is 405/9=45, like the cash flow in quarter 9.

Table 2

Illustration. Product's Cash Flow.

Quarter	Cash Flow	Accumulated Cash Flow	Averaged Cash Flow
0	0.00	0.00	---
1	-11.00	-11.00	-11.00
2	-4.00	-15.00	-7.50
3	15.00	0.00	0.00
4	40.00	40.00	10.00
5	65.00	105.00	21.00
6	84.00	189.00	31.50
7	91.00	280.00	40.00
8	80.00	360.00	45.00
9	45.00	405.00	45.00
10	-20.00	385.00	38.50
11	-121.00	264.00	24.00
12	-264.00	0.00	0.00
13	-455.00	-455.00	-35.00
14	-700.00	-1155.00	-82.50

Another example is where the elasticity value is 1.77, meaning customers are looking for a newer product. Then the optimal stopping time is quarter 8. In this quarter, the marginal cash flow is 80, while the average is 45. The suggested time reduction in the current product is to develop a new product sooner.

4. DISCUSSION

The producers can estimate their cash flow over time. The sales volume prediction has been done in the real world continuously. So even without knowing all parameters of the technological part of Equation 6, there are ways to measure the marginal and the averaged NPV.

The computation of the right-hand side of Equation 6; can be estimated by Artificial Intelligence (AI) and Machine Learning (ML) methods to explore customers' willingness for new products. The smartphone industry is an example of having a high willingness to more recent products, mainly by young customers.

The efforts from the producers' side should be in developing the production technology to be ready with new products or models. In a rapidly

driven technology yet the strategic point of view should concern the ability of the market to absorb or even to ask for newer products. Sadeh and Dvir (2021), among others, focused on the question of market first or product first for technology-oriented firms. Firms tend to need help with technology rather than with the market. Producers have to overcome risk-related issues in developing new products to be achievable. The uncertainty that the market has is much more difficult. This study shows efficiency and effectiveness in production side are very important; simultaneously, customer and market are crucial for better performance.

When we check the numbers in Table 1, they reflect the motivation that a giant smartphone producer observes. They come with a new model or a product almost every year because the market is ready for that, and the producers in the industry can handle the needed research and development.

5. CONCLUSIONS AND SUMMARY

The production theory side of repeated products has been widely covered in the literature, and optimal policies for production over time are well discussed. This study puts more light on the customers' attitude about the ability and willingness to have newer products. The study considers the optimal economic aspects of production and includes the perspective of customers. The suggested approach shows that producers should get customers' preferences about new products. It should be noted that such attitudes may vary between cultures and countries.

The AI concepts and tools can help producers get more relevant data to understand and use consumers' preferences in their industry.

The study gives the conditions for optimality along with economic interpretation. There is a numerical example to clarify the meaning of the optimality conditions.

Future research should explore the managerial rules and recommendations of the study. It is recommended to investigate the use of AI tools to define and compute the elasticities of willingness to get newer products.

6. REFERENCES

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GESTIUNEA OPTIMĂ REPETATĂ A PRODUSULUI CU PREFERENȚELE CLIENȚILOR

Studiul se ocupă de gestionarea produselor repetate, cum ar fi smartphone-uri, mașini și dispozitive de îngrijire a sănătății. Acestea au cicluri de viață limitate. Galaxy S5 a fost comercializat în 2014 și a dispărut odată cu lansarea Galaxy S6 în 2015. Studiul tratează când să nu mai vindeți un anumit produs și să inițiați un alt produs repetat, împreună cu perioada de cercetare și dezvoltare și aspectele de temporizare. Funcția obiectiv este de a maximiza fluxul de numerar net actualizat sau anuitatea echivalentă pentru o perioadă dată, de exemplu, un an, un deceniu etc. Definim condițiile de ordinul întâi pentru optimalitate împreună cu interpretarea economică și de management. Inițierea următorului produs depinde funcțional de terminarea produsului curent. Definim regulile rezultate în termeni manageriali. Un exemplu numeric ilustrează regulile și soluția.

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