# Analyzing the Market Growth in API Economy using Time-evolving Model

Hiroki Yoshikai, Shin'ichi Arakawa, Tetsuya Takine, Masayuki Murata

***Abstract*—API (Application Programming Interface) economy is expected to create new value by converting corporate services such as information processing and data provision into APIs and using these APIs to connect services. Understanding dynamics of a market of API economy under strategies of participants is crucial to fully maximize the values of API economy. To capture the behavior of a market in which the number of participants changes over time, we present a time-evolving market model for a platform in which API providers who provide APIs to service providers participate in addition to service providers and consumers. Then, we use the market model to clarify the role API providers play in expanding market participants and forming ecosystems. The results show that the platform with API providers increased the number of market participants by 67% and decreased the cost to develop services by 25% compared to the platform without API providers. Furthermore, during the expansion phase of the market, it is found that the profits of participants are mostly same when 70% of the revenue from consumers is distributed to service providers and API providers. It is also found that, when the market is mature, the profits of the service provider and API provider will decrease significantly due to their competitions and the profit of the platform increases.**

***Index Terms*—API Economy, Ecosystem, Platform, API providers**

## I. Introduction

The API economy is attracting attention as a way to create new value by converting corporate services such as information processing and data provision into APIs and using these APIs to connect services [1]. In the API economy, service providers and consumers connect to the platform and supply and consume services via APIs.

A two-sided market is a model for analyzing the market economy. The model has two user groups that provide services each other via a platform and captures the most basic structure of the market. The two user groups activate the market through an interaction called the indirect network effect. In Refs. [2]–[4], studies have analyzed the behavior of the digital ecosystem using a two-sided market model. Modeling market behavior and seeking equilibrium points under a certain platform strategy will be important in understanding the qualitative behavior of the market. Sen et al. [4] has found that for an increase in the number of platform functions, the number of platform functions should be reduced under conditions of a gradual decrease in service development costs, and under conditions of a rapid decrease, the number of platform functions should be increased to maximize platform profits. However, seeking an equilibrium state in the market by maximizing profits does not reveal an appropriate market form. For example, even when indirect network effects cause an increase in the number of service providers and consumers, the effect is in turn increase in the price imposed on them to connect the platform. That is, the optimal strategy to increase the profits of platform providers will result in the shrink of the market [5]. Therefore, it is important to capture the behavior of the market as the number of market participants changes over time and identify the strategies that platforms should take rather than to capture equilibrium points under certain conditions.

In this paper, we present a time-evolving market model that aims to capture the behavior of a market in which the number of participants changes over time. Specifically, we present time-evolving market models for AWS-type platform [6] in which consumers and service providers participate, and Azure-type platform [7] in which API providers participate in addition to them. We then identify the sustainability conditions to expand the number of market participants in each market using these market models. Here, the sustainability conditions are the parameter region that forms the ecosystem by staying in the market and ensuring that each of the market participants' interests are properly served, not simply the parameter area that maximizes the profits of the platform. By clarifying the sustainability conditions, we can obtain some principles to form coexistence, cooperative platforms; for example, the strategies that should be adopted by each market participant, including platforms, during the early phase and/or maturity phase of the market.

The Azure-type platform targets the API economy, which is expected to leverage a combination of different APIs to drive innovation and improve value creation and time-to-market for new products using APIs [8]. However, when API costs increase excessively without proper competition among API providers, service providers are expected to leave the platform and the market may shrink. Therefore, by contrasting the behavior of an AWS-type platform without API providers, we will clarify the role of API providers in expanding market participants and forming an ecosystem.

## II. Platform Model

### A. AWS-type Platform

AWS-type platform is a platform involving consumers and service providers. The interaction model of the market partic-

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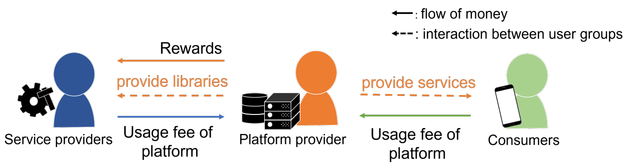


Fig. 1. Relationships among market participants in an AWS-type platform

ipants is shown in Fig. 1. By using the libraries provided by the platform, service providers develop services while reducing development costs and starting small. Consumers pay platform usage fees to the platform and use various services developed by service providers. The platform pays service providers a fee based on the frequency of use of individual services from the fees collected from consumers. The platform's profit will be the difference between fees from consumers and reward to service providers. In addition, platform profit is added by collecting platform usage fees from service providers.

Amazon Web Services (AWS) is a classic example of service providers developing and offering services to consumers. Service providers develop the functionality required for their services while controlling service development costs by using libraries provided by AWS, such as Amazon ECS and AWS Lambda, for example. Since service providers use only the libraries provided by the platform, the abundance of libraries is required to deploy a variety of services on the platform. However, since libraries are provided only by the platform, the cost of library development is structured to increase as the number of libraries increases.

### B. Azure-type Platform

Azure-type platform is a platform involving consumers, service providers and API providers. The interaction model of the market participants is shown in Fig. 2. The platform collects usage fees from consumers, service providers, and API providers. The platform gives a portion of its revenue to service providers and API providers. In this platform model, there are more functions available due to the presence of API providers. Furthermore, one API provider can lower development costs by using functions provided by other API providers in a complementary relationship. Service providers can further reduce development costs compared to AWS-type platforms because they can use APIs as well as libraries provided by the platform. Newly developed functions can also be provided as APIs, contributing to lower development costs for other market participants.

In Azure-type platform, the ease of developing diverse services depends on the number of APIs, and the more API providers participate in the market, the lower the cost of developing functions and developing services becomes.

## III. Time-evolving market model for an API Economy

This section presents a time-evolving market model for the AWS-type platform and the Azure-type platform. In the following, we describe the market model for the Azure-type platform since the market model for the AWS-type platform is obtained when the number of API providers is set to be zero in the market model for the Azure-type platform.

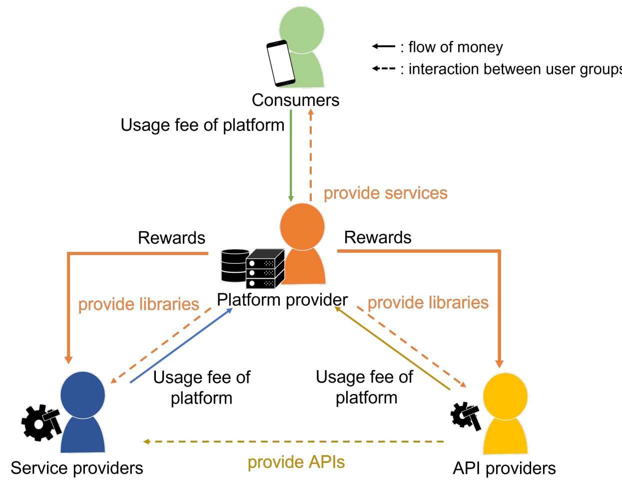


Fig. 2. Relationships among market participants in an Azure-type platform

### A. Market

The following are participating in market M.

- Platform $p$
- Consumers $u_i$: $u_1$, $u_2$, ...
- Service providers $s_i$: $s_1$, $s_2$, ...
- API providers $a_i$: $a_1$, $a_2$, ...

The market M is time evolving, and the state $\mathcal{M}_t$ of the number of market participants at time $t$ is represented as follows:

$$\mathcal{M}_t = \{\mathcal{P}_t, \mathcal{U}_t, \mathcal{S}_t, \mathcal{A}_t\}$$

Each variable is represented as follows:

$$\mathcal{P}_t = \{p\},$$
$$\mathcal{U}_t = \{u_1, u_2, \ldots, u_i, \ldots, u_{U(t)}\},$$
$$\mathcal{S}_t = \{s_1, s_2, \ldots, s_i, \ldots, s_{S(t)}\},$$
$$\mathcal{A}_t = \{a_1, a_2, \ldots, a_i, \ldots, a_{A(t)}\}$$

$\mathcal{P}_t$ is the only participant of the platform at time $t$ and is time independent. $U(t)$, $S(t)$, $A(t)$ are the number of persons who participated in market M by time $t$, respectively. Here, the number of participants is the total of those who are economically active and participating at time $t$ and those who have left the market without being economically active at time $t-1$.

### B. Time Evolution of the Market

In the market model in this paper, the number of participants changes as a result of their interactions, and profits and development costs change based on these changes. The details of the interactions are described in sections III. C through III.

F. We will simulate a time evolving market model using the following procedure.

1) Determine the initial number of market participants appropriately, and time t is set to $t = 0$.

$$\mathcal{M}_0 = \{\mathcal{P}_0, \mathcal{U}_0, \mathcal{S}_0, \mathcal{A}_0\}$$

2) Follow the established procedure to find $U(t)$, $S(t)$, $A(t)$.
3) Calculate $\mathcal{M}_{t+1}$ by applying the various equations described in Sections III. C through III. F.
4) Return to 2.

We repeat the calculation of $\mathcal{M}_{t+1}$ and observe the behavior of $\mathcal{M}_{t+1}$ until enough time has elapsed.

### C. Platform

The profit $U_p(t)$ of platform $p$ at time $t$ is

$$U_p(t) = p_s \cdot \hat{S}(t) + p_a \cdot \hat{A}(t) + P(t) \cdot (1 - \alpha_s - \alpha_a)$$

$\hat{S}(t)$ and $\hat{A}(t)$ are the number of service providers and API providers participating in market M at time $t$, respectively, and are defined in Section III. E and thereafter. $p_s$, $p_a$ are the platform usage fees of the service providers and API providers, respectively. In addition, $\alpha_s, \alpha_a$ are parameters that define the cost paid to the service providers and API providers, respectively. Furthermore, platform $p$ pays the service providers and API providers a fee based on the number of times the service is used or the API is used, and the source of the fee, $P(t)$, is

$$P(t) = p_c \cdot U(t) - I_p(t)$$

The $p_c$ is the platform fee for consumers. We assume that consumers enter into subscription-type contracts and interpret $P(t)$ as being financed by part of $p_c$. The $I_p(t)$ is the cost of capital investment in platform $p$ at time $t$, augmenting the library at a cost of $I_p(t) = \eta \cdot (p_c \cdot U(t))$. $\eta$ is a parameter that defines the investment ratio.

Although the number of libraries $F(t)$ held by the platform increases with investment, we interpret this as an increase in investment cost with the increase in the number of libraries. Therefore, the number of libraries is defined as follows:

$$F(t+1) = F(t) + e^{-\gamma \cdot F(t)/I_p(t)}$$

where $\gamma$ is a parameter for increasing investment cost.

### D. Consumers

The consumers consist of two elements: early adopters and majority.

$$U(t+1) = U^{early}(t) + U^{majo}(t)$$

Each element is given below based on the maximum number of early adopters, $K(t)$, and the number of early adopters participating in other markets that are not market M, $o^{early}(t)$, and its change.

$$\frac{d}{dt}U^{early}(t) = \zeta U^{early}(t)(1.0 - \frac{U^{early}(t)}{K(t)}) - \delta(t)\frac{d}{dt}o^{early}(t)$$

$$\frac{d}{dt}U^{majo}(t) = \omega U^{early}(t) - \delta(t)\frac{d}{dt}o^{early}(t)$$

$\zeta$ and $\omega$ are parameters that defines the behavior of the increase in early adopters and majority respectively, and $\delta(t)$ is a binary parameter that indicates whether market M and other markets are in a competitive environment. Let $\zeta$, $\omega$, $\delta(t)$, $o^{early}(t)$ be given in advance.

In this paper, we set parameters that there is no withdrawal of consumers and that the number of consumers increases monotonically with each incremental step, reaching a ceiling at a certain step.

### E. API Providers

The set of API providers participating in market M by time $t$, $\mathcal{A}_t$, is defined below.

$$\mathcal{A}_t = \{a_1, a_2, \dots, a_i, \dots, a_{A(t)}\}$$

In this section, we define the behavior of the API provider $a_i$. The profit $U_{a_i}(t)$ of $a_i$ is

$$U_{a_i}(t) = \alpha_a P(t) \frac{\mathcal{F}(a_i, \mathcal{S}_t, \mathcal{A}_t, \mathcal{R}_t)}{\sum_{a_k} \mathcal{F}(a_k, \mathcal{S}_t, \mathcal{A}_t, \mathcal{R}_t)} - p_a - K_a(F + J(T_i))$$

$\alpha_a$ is a parameter that defines the cost to be paid to the API providers. The function $\mathcal{F}(a_i, \mathcal{S}_t, \mathcal{A}_t, \mathcal{R}_t)$ represents the number of times the API provided by $a_i$ is used and is determined by the market participants at time $t$ and their frequency of use (popularity) $\mathcal{R}_t$. $\alpha_a P(t)$ is part of the revenue earned by the platform at time $t$. The ratio of the number of uses of the API provided by $a_i$, $\mathcal{F}(a_i, \mathcal{S}_t, \mathcal{A}_t, \mathcal{R}_t)$, to the total number of uses of the API existing in the market at time $t$ determines $a_i$'s revenue (income). $\mathcal{F}(a_i, \mathcal{S}_t, \mathcal{A}_t, \mathcal{R}_t)$ is given below:

$$\mathcal{F}(a_i, \mathcal{S}_t, \mathcal{A}_t, \mathcal{R}_t) = \frac{1}{\hat{A}(t)} \exp(-0.003 I(T_i))$$

where $T_i$ is a list of complementary and competitive relationships between $a_i$ and other API providers, and function $I$ counts the number of competitive relationships by taking a list containing competitive relationships as an argument. Therefore, the greater the number of APIs in a competitive relationship $I(T_i)$, the smaller the value of $\exp(-0.003 I(T_i))$, and the fewer times that API is used.

API provider $a_i$ decides whether to join or leave market M based on the positivity or negativity of the profit. In this paper, the leave condition is that the profit is negative. Assuming that participation and withdrawal are represented by binary variables with $\Delta_{i|u \geq 0}$, the number of participants in market M at time $t$, $\hat{A}(t)$, is

$$\hat{A}(t) = \sum_k \Delta_{k|u \geq 0}$$

The complementary and competitive relationship $T_i$ between an API provider $a_i$ and another API provider is represented as follows:

$$T_i = [1, -1, \dots, (a_i =)0, \dots, 1, 0] \quad (1)$$

In this example, $a_i$ and $a_1$ are complementary, $a_2$ is competitive, and $a_i$ (itself) is irrelevant (0).

When there is a complementary relationship, it can be interpreted as lower development costs for the API providers. Therefore, assuming that the sum of the number of libraries $F$ provided by the platform and the number of API providers in a complementary relationship $J(T_i)$ act on the development cost of $a_i$, the API development cost is represented as $K_a(F + J(T_i))$. Function $J$ counts the number of complementary relationships by taking a list containing complementary relationships as arguments. $K_a(F)$ is the development cost (monotonically decreasing with $F$) when the number of libraries provided by the platform is $F$. It expresses that the number of API providers $J(T_i)$, which is complementary, acts to reduce the development cost.

### *F. Service Providers*

Service providers compose and provide services to consumers using APIs provided by API providers.

The set of service providers participating in market M by time $t$, $\mathcal{S}_t$, is defined below.

$$\mathcal{S}_t = \{s_1, s_2, \ldots, s_i, \ldots, s_{S(t)}\}$$

The competitive relationship $V_i$ between one service provider $s_i$ and another service provider is represented as follows:

$$V_i = [0, -1, \ldots, 0, \ldots, -1, 0] \tag{2}$$

In this example, $s_i$ and $s_1$ are irrelevant, $s_2$ is a competitive relationship, and $s_i$ is irrelevant. Unlike the case of API providers, we do not consider complementary relationships among service providers.

The number of times the service is used is as follows:

$$\mathcal{G}(s_i, \mathcal{S}_t, \mathcal{A}_t, \mathcal{R}_t) = \frac{1}{\hat{S}(t)} \exp(-0.012 I(V_i))$$

Similar to the equation for the number of times the API is used, the greater the number of service providers in a competitive relationship $I(V_i)$, the smaller the value of $\exp(-0.012I(V_i))$, and the fewer times the service is used.

The profit $U_{s_i}(t)$ of $s_i$ is expressed as follows:

$$U_{s_i}(t) = \alpha_s P(t) \frac{\mathcal{G}(s_i, \mathcal{S}_t, \mathcal{A}_t, \mathcal{R}_t)}{\sum_{s_k} \mathcal{G}(s_k, \mathcal{S}_t, \mathcal{A}_t, \mathcal{R}_t)} - p_s - \{K_s(F + |\Phi_i(\mathcal{A}_t)|)\}$$

where $\Phi_i(\mathcal{A}_t)$ represents the set of APIs provided by the API providers that are used by the service provider $s_i$.

## IV. Analysis of Market Dynamics using a Time-evolving Market Model

This section analyzes the impact of the presence of API providers on the number of market participants and each participant's profit by comparing an AWS-type platform without API providers and an Azure-type platform with API providers. In addition, we will also analyze the impact on the market of changing the parameters that define platform usage fees and payment costs.

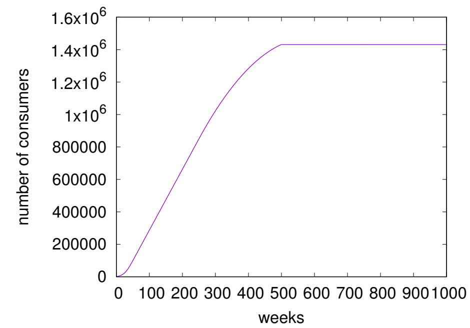


Fig. 3. Number of consumers

### *A. Model Settings*

In this section, we describe the model for increasing market participants and development cost models in the simulation.

*1) Increase of consumers:* We defined a model of consumers in Section III. D, and in this paper, we adopt a model based on the transition of consumers for existing services. For example, this could be the number of Spotify subscription subscribers [9], [10] or the number of premium members of Niconico service [11] which is one of popular streaming platform in Japan. In this paper, we use the model in which the number of consumers will reach about 1.5 million in about 10 years (500 weeks) and reach a peak, based on the number of Niconico premium members (Fig. 3). To fit this model, we use a value of $U(t)$ scaled by one-eighth. Specifically, we set $\zeta$, $\omega$, and $\delta(t)$ to 0.1, $o^{early}(t)$ to 10000, and $K(t)$ to 300000. $\omega$ is set to decrease by 0.0003 from 250 weeks. In addition, we set $U^{early}(0)$ to 10000 and $U^{majo}(0)$ to 0. This allows the analysis to observe the behavior of market participants during periods when the number of consumers continues to increase and during periods when the number of consumers remains constant, respectively.

*2) Increase of service providers:* An increasing model of service providers is shown below.

$$S(t+1) = S(t) + s_{birth} + \hat{S}(t) * 0.015$$

where $s_{birth}$ is a variable that is 1 at each step of the simulation with probability 0.1 and 0 otherwise. We also consider that 0.015 service providers are attracted to the market for every one service provider participating in the market.

With the case for the Azure-type platform, each service provider randomly selects APIs to use.

*3) Increase of API providers:* An increasing model of API providers is shown below.

$$A(t+1) = A(t) + a_{birth} + \hat{A}(t) * 0.01$$

where $a_{birth}$ is a variable that is 1 at each step of the simulation with probability 0.5 and 0 otherwise. We also consider that 0.01 API providers are attracted to the market for every one API provider participating in the market.

*4) Development Cost:* The greater the number of libraries and complementary APIs (x), the lower the development cost in the development cost model for API providers. Therefore, the development cost model for API providers is shown as $K_a(x) = 25\exp(-0.003x)$. In addition, we consider that service providers will incur more costs than API providers because they will need to manage customers and operate and maintain the service. Therefore, the development cost model for service providers is shown as $K_s(x) = 25\exp(-0.003x) + 20$.

*5) Complementary/Competitive Relationships:* $T_i$ in (1) is randomly determined with a probabilities of 0.4 for a complementary relationship, 0.1 for a competing relationship, and 0.5 for no relationship. Also, $V_i$ in (2) is randomly determined with a probability of 0.5 for a competing relationship and 0.5 for no relationship.

### *B. Parameter Settings*

The initial value of the number of platform libraries is 3, the initial value of the number of API providers is 4, and the initial value of the number of service providers is 1.

### *C. Business Strategy of Platform*

Platforms can set usage fees for consumers as well as for service providers and API providers, and a variety of business strategies are possible. In this section, we define the parameters in the market model that can be set by the platform and define them as the platform strategy.

First, we will describe the basic settings that will serve as the basic strategy for the platform. The basic settings are shown in Table I. Parameters related to fees such as platform usage fees are set to be in thousands of yen [/week].

In the basic settings, the platform pays 35% of the fees collected from consumers to the service providers and the API providers, respectively. Thus, 30% of the fees collected from consumers would be profit for the platform. We set this parameter with reference to the margins in the Google Play Store and the Apple Store [12]. Based on these parameter settings, we will introduce the following three platform strategies which the platforms can choose.

In high usage fee setting, we set higher fees for service providers and API providers to use the platform. This will lead to increase the platform revenue and to decrease the profits of service providers and API providers, which results in fewer market participants. We will observe how much the market shrinks when the platform sets the price selfishly.

In high margin setting, we set a low percentage of the revenue earned by the platform from consumers to pay service providers and API providers. Platform revenue will increase, but overall revenues of service providers and API providers will decrease, which will result in less market participants due to increased competition among market participants at an early stage. Then observe how much the market shrinks when the platform monopolizes profit.

In low margin setting, we set a higher percentage of the revenue earned by the platform from consumers to pay service providers and API providers. Platform revenue will decrease, but overall revenues for service providers and API providers will increase, which is expected to result in more market participants. Then, observe how much profit can be secured by the service provider and API provider.

TABLE I
PLATFORM STRATEGIES

| | basic | high usage fee | high margin | low margin |
|---|---|---|---|---|
| $\alpha_s$ | 0.35 | 0.35 | 0.10 | 0.50 |
| $\alpha_a$ | 0.35 | 0.35 | 0.10 | 0.50 |
| $p_a$ | 1.25 | 12.5 | 1.25 | 1.25 |
| $p_s$ | 12.5 | 125 | 12.5 | 12.5 |

The above parameter settings are shown in Table I. The common settings for the four platform strategies, including the basic settings, we set $p_c$ to 0.125, $\eta$ to 0.1, $\gamma$ to 10000.

In the platform strategy described above, in the case of an AWS-type platform with no API providers, the platform receives the fees that are paid to the API providers on the Azure-type platform. For example, in the basic setting, the platform pays 35% of the fees collected from consumers to the service providers. Thus, 65% of the fees collected from consumers will benefit the platform.

### *D. Numerical Results*

In this section, we present the results of our analysis of Azure-type platforms in four different platform strategies and the results of our comparison of Azure-type platforms and AWS-type platforms. In this paper, one step in the simulation is considered as one week, and the behavior is observed up to 1000 weeks.

*1) Market growth:* In this section, we evaluate the market model from the perspective of market growth, using the number of market participants as an indicator. The number of market participants is defined here as the number of service providers and API providers participating in the market as of 1000 weeks.

First, we compare Azure-type platforms. Fig. 4 and 5 show the number of service providers and API providers for the four platform strategies, respectively.

In the high usage fee platform strategy, the decrease in the number of service providers is lower than that of API providers. This could be due to the small number of service providers relative to the number of API providers and the lack of competition with a 90% reduction in the number of service providers. The fact that the high margin platform strategy has resulted in a similar rate of decrease in the number of service providers and API providers suggests that the number of market participants will continue to increase until appropriate competition is in place.

Next, compare with an AWS-type platform. In the basic setting platform strategy, the Azure-type platform has about 67% more service providers. In addition, about 15%, 70%, and 65% more are in the high usage fee, high margin, and low margin settings, respectively. Therefore, for all platform

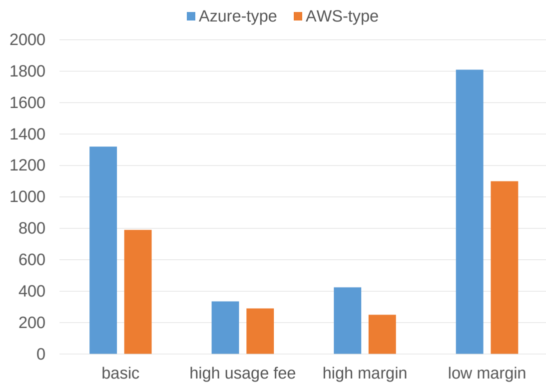


Fig. 4. Comparison of number of service providers

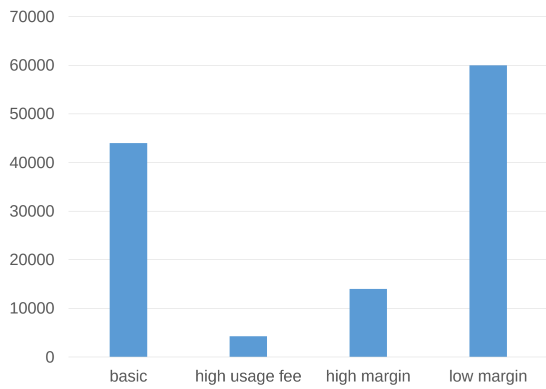


Fig. 5. Comparison of number of API providers

strategies, we found that Azure-type platforms have more service providers participating in the market.

In the basic setting platform strategy, the total development cost of the Azure-type platform was about 26700, which was lower than the total development cost of the AWS-type platform, about 35500, even though the Azure-type platform has more service providers participating in the market. The results show that service providers can lower development costs by using APIs on Azure-type platforms. Therefore, it was found that this has allowed more service providers to participate in the market because the Azure-type platform reduces the ratio of development costs to service provider revenues and allows them to make more profit compared to the AWS-type platform. The same is true for the high usage fee, high margin, and low margin platform strategies. However, the rate of increase in the number of service providers in the high usage fee setting platform strategy is small compared to the rate of increase in the basic setting, high margin setting, and low margin setting platform strategies. This suggests that when platform fees are set high, the effect of reduced development costs due to the presence of API providers will be small, and it may be difficult to benefit from the presence of API providers.

*2) Platform for coexistence:* In this section, we will evaluate the parameter areas that form a coexistent platform, using the profit of each participant as an indicator. The coexistent platform referred to here is a platform where not only the platform benefits, but also the service providers and API providers participating in the market benefit while contributing to the development of the market. The evaluation will also be conducted at two time points: at 500 weeks, after the number of consumers has continued to increase, and at 1000weeks, after the number of consumers has peaked.

First, we evaluate Azure-type platforms and AWS-type platforms at 500 weeks. The profits of each participant at 500 weeks are shown in Fig. 6. In the Azure-type platform, profit is divided into three equal parts in the basic setting platform strategy, indicating that a coexistence has been achieved. The high usage fee setting and high margin setting platform strategies show that platform profits are the majority of the profits. However, low margin setting platform strategies have not ensured platform profits.

Service provider profits on Azure-type platforms relative to AWS-type platforms increased for all four platform strategies. Specifically, they increased by 3% in the basic setting, 3% in the high usage fee setting, 10% in the high margin setting, and 2% in the low margin setting. Again, this is likely due to the lower development costs of Azure-type platforms compared to AWS-type platforms, resulting in increased profits for service providers on Azure-type platforms compared to AWS-type platforms.

Next, we evaluate Azure-type platforms and AWS-type platforms at 1000 weeks. The profits of each participant at 1000 weeks are shown in Fig. 7. For Azure-type platforms, platform profit account for the majority in all platform strategies. In addition, service providers and API providers profit more from a low margin platform strategy than from a basic setting that had achieved tripartite coexistence at the 500 weeks point. Therefore, after 500 weeks, when the number of consumers peaks, it is better to allocate more money to service providers and API providers to maintain the market. In addition, service providers profit on Azure-type platforms relative to AWS-type platforms increased on all four platform strategies. Furthermore, except for the high usage fee platform strategy, the results show a higher rate of increase than at 500 weeks. Specifically, they increased by 23% in the basic setting, 1% in the high usage fee setting, 22% in the high margin setting, and 19% in the low margin setting. Therefore, for a platform strategy with low usage fee, an Azure-type platform is more likely to maintain the market during market maturity than an AWS-type platform.

Based on the above evaluations, coexistence and cooperation of three participants can be achieved by the basic strategy during the period of market growth. However, as the market matures, the competitions among service providers and API providers suffers their profits even by the low margin strategy. We believe a fair competition regulated by the platform's strategy is required to achieve the sustainabe market growth and it is left for our future work.

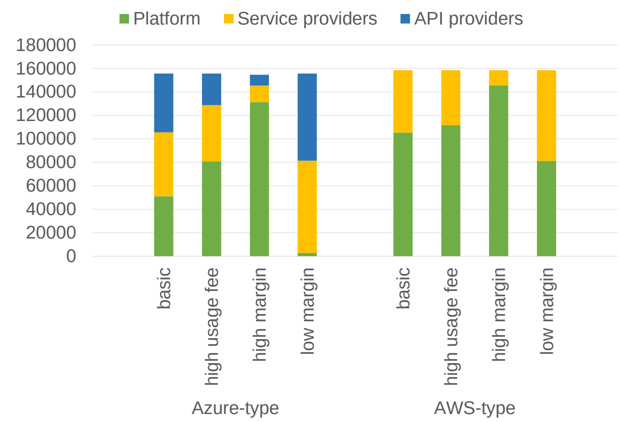


Fig. 6. Breakdown of market participants' profits (500 weeks)

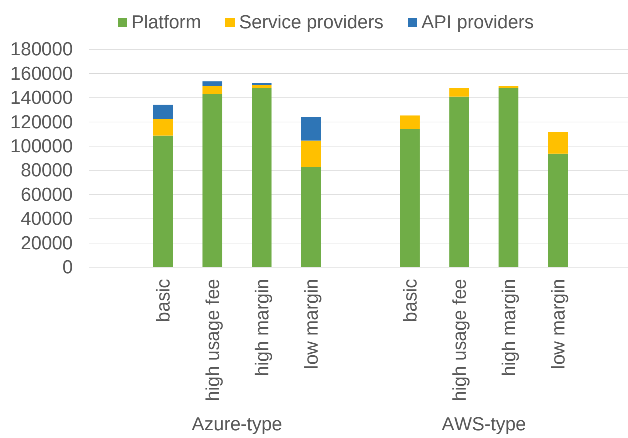


Fig. 7. Breakdown of market participants' profits (1000 weeks)

## V. Conclusion

In this paper, we presented a time-evolving market model to capture the behavior of a market in which the number of participants changes over time. We then analyzed the impact on the market of changing the parameters that define the platform usage fees and the costs paid by the platform to the service providers and API providers. Furthermore, we analyzed the impact of the presence of API providers on the number of market participants and their respective profits by comparing platforms without API providers with those with API providers. The results showed that the platform with API providers increased the number of market participants by 67% and decreased the cost of developing services by 25% compared to the platform without API providers in the parameter area closest to the coexistence. We also found that coexistence is feasible during periods of increasing consumers, when the platform allocates 70% of its revenue from consumers to service providers and API providers. On the other hand, it was also found that competition among service providers and competition among API providers decreases the profit of these two participants and increases platform profit after a period of constant revenue from consumers. At this time, it was found that the Azure-type platform was about 20% more profitable for service providers than the AWS-type platform for a low platform usage fee setting, making it easier to maintain the market during the market's maturity period. The analysis in this paper revealed the effectiveness of Azure-type platforms while changing the platform strategy.

However, in the real market, service providers, API providers, and consumers also have selection strategies. Particularly regarding consumers, since they may increase or decrease depending on the number of services and other market attractions, we will introduce a time-evolving market model that includes the selection strategies of each participant to clarify the behavior of the market.

## Acknowledgement

This work is supported in part by the KDDI Foundation.

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