Kyoto University,
Graduate School of Economics
Discussion Paper Series

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Discussion Paper No. E-21-002

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July, 2021

Delineating zero-price markets with network effects: An analysis of free messenger services

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Abstract: Billions of users worldwide use digital zero-price services every day. This study proposes a market definition method for digital zero-price services, using the messenger service as an example. We employ the small but significant non-transitory increase in cost (SSNIC) test, which is an improved version of the small but significant non-transitory increase in price (SSNIP) test, and conduct conjoint analysis while considering the network effect, a characteristic of digital services. Our results show that the price elasticity of demand is 0.628 and the critical markup ratio is 1.492–1.542 when only the price effect is considered. When the direct network effect is considered, the price elasticity of demand is 1.728 and the critical markup ratio is 0.479–0.529. Furthermore, when considering a two-sided market with indirect network effects, the price elasticity of demand is 2.162 and the critical markup ratio is 0.363–0.413. Thus, the price elasticity of demand for free messenger services is higher when the network effects and two-sided markets are considered.

Keywords: Freemium services, Market definition, Competitive policy, Conjoint analysis
JEL Classification: L13, L52, L41, L86, and L96

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1. Introduction

In the digital marketplace, free or zero-price services frequently use the business model called "freemium," in which basic services are provided for free and premium services are offered for a fee (Anderson, 2009). Google has been dominating the digital advertising market by offering its search engine and applications for free, with Facebook following its lead in providing social networking services. The rationale for offering free services is that the marginal cost of providing digital services is close to zero. However, because of fixed costs such as R&D and management, these companies will incur losses if the service is provided for free.

Why do companies offer zero-price services in the digital marketplace? First, humans have a behavioral tendency known as the "free bias" (Gal and Rubinfeld, 2015), meaning that consumers find special utility in free services. In return, companies offering zero-price services collect consumers' personal information. Second, the accumulating number of consumers who use a free service creates a network effect in which consumer utility increases with the size of the market. Platforms that provide a place for transactions in the digital marketplace utilize the network effect on the free-market side to charge the other market.[3] In addition, mega-platforms, such as Google and Facebook, have been acquiring new tech companies to strengthen their dominant position in the market. These mergers, often referred to as "killer acquisitions," have become a competition policy consideration.

Zero-price services represent a difficult problem for competition authorities. The traditional antitrust policy uses the small but significant non-transitory increase in price (SSNIP) test to define the market.[4] The SSNIP test assumes a 5% increase in price over a year; however, a 5% increase in price at zero is still zero. Therefore, we cannot use the SSNIP test to define a market for digital services that are provided for free.[5]

To define a zero-price market, several alternatives to the SSNIP test have been proposed. One approach is the small but significant non-transitory decrease in quality (SSNDQ) test, which uses a decrease in quality instead of an increase in price. Hartman et al. (1993) use small price substitutability but large quality substitutability between different types of diagnostic imaging equipment industries for market definition. However, the SSNDQ test has some limitations. For instance, it is difficult to conduct SSNDQ tests for all the different types of quality. Another option is the small but significant non-transitory increase in cost (SSNIC) test, which uses an objective or subjective increase in the cost borne by the consumer. Newman (2015, 2016) argues that consumers are willing to provide private data to platforms for free, and thus zero-price services are not truly free, given their real cost burden. Evans (2008) points

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[3] Rochet and Tirole (2003) and others have theorized such business models as "two-sided markets." For market delineation in a two-sided market, see Evans (2003), Filistrucchi et al. (2014), and Kawahama and Takeda (2017).

[4] The SSNIP test defines the narrowest market as one in which a single firm can sustainably raise prices or otherwise exercise market power (Werden, 2003).

[5] Not all economists are in favor of SSNIP testing. Among them is Kaplow (2010, 2015) who says that market definition is not based on economic theory and does not make sense for competition policy.

out that personal information, collected by such platforms, contains substantial value because it exposes the "attention" and "privacy" of consumers. If we regard the provision of such personal information and the risk of personal information leakage as the hidden cost burden of zero-price services, market definition by SSNIC test can be considered operationally feasible.[6]

In this study, we apply the SSNIC test to define a "messenger service" usually provided free of charge. Additionally, conjoint analysis, a stated preference method (SPM), is used to measure the price elasticity of demand for zero-price services.[7] For the analysis of price elasticity of demand, it is necessary to measure the change in the quantity demanded in response to a 5% increase in price, which requires current price information as reference. Here, we use the hidden cost that consumers pay for zero-price services as the reference price, and focus on the fact that consumers must provide personal information to use the services for free. Many zero-price services, including messenger services, bundle basic components such as messenger applications with ancillary services such as digital advertising and payment services to recover the overall cost. In summary, as the provision of personal information entails a substantial burden cost for users, we conduct a conjoint analysis to evaluate this cost in monetary terms.

As Hensher et al. (2005) explain, a conjoint analysis is a method of analyzing stated preference, and unlike revealed preference data obtained from market transactions, data collection is conducted by asking respondents to express their subjective evaluation of services that are not directly traded in the market, such as new products not yet released. Using stated preference data has many advantages over revealed preference data. In a virtual experiment based on the SPM, the analyst can ensure the diversity of attributes, including price, in the experimental design. In addition, multicollinearity between each attribute variable can be avoided by adopting an orthogonal experimental design. Thus, as suggested by Newman (2016), SPMs have become a powerful tool as a thought experiment for zero-price market delineation.

This study uses web survey data collected in February 2019. The survey results are obtained using conjoint analysis, where users of free messenger services are asked whether they will continue to use the service if it is to be paid for. As mentioned earlier, the SSNIC approach is applied to measure the price elasticity of demand for free messenger services. Since messenger services are affected by network effects, we first estimate the direct network effect, which means that if the number of users decreases due to pricing of service, the utility users receive from the service will also decrease. Furthermore, free messenger services are viable as a business model because they represent a two-sided market. The profitability of the paired services of the messenger service, such as advertising and payment services, depends on the number of users. In a two-sided market, if the number of users decreases due to price increase in one market, the value of the other market will decrease through indirect network effects.

[6] Kawaguchi et al.'s (2021) pioneering study uses the SSNIC test to propose a new model of imperfect competition for ad-sponsored media that can sell "free" products for merger analysis applicable to the mobile app industry.

[7] Prior studies dealing with market definition and mergers in two-sided markets include card payments (Emch and Thompson, 2006) the Google/DoubleClick case (Evans and Noel, 2008) newspapers (Filistrucchi et al., 2012; Affeldt et al., 2013; Cayseele and Vanormelingen, 2019) the radio (Jeziorski, 2014) and mobile apps (Kawaguchi et al., 2021).

Under certain assumptions, this study also attempts to simulate the repercussion on the free market caused by the decrease in revenues from the other market.

Evaluating the subjective cost of providing personal information to a free messenger service, we find that the real cost burden is JPY 706.7 (USD 7.07, assuming JPY 100 = USD 1). Using this amount as a starting point, we calculate the extent to which a 5% surcharge would reduce the probability of choice. First, we perform a one-sided market demand substitutability analysis, focusing only on the messenger service market. We obtain a price elasticity of demand of 0.628. Using this estimate, we calculate the critical markup ratio, which ranges from 1.492 (for profit maximization) to 1.542 (for constant revenue). Next, when calculating the price elasticity of demand, we take into account the direct network effect, where the value of a service increases as the number of users increases. As a result, the price elasticity of demand considering the direct network effect is 1.728. The critical markup ratio ranges from 0.479 (for the profit maximization case) to 0.529 (for the constant revenue case). Finally, in the case of a two-sided market, as we consider paired services on opposite sides, the calculation of price elasticity takes into account indirect network effects in addition to direct network effects. As a result, the price elasticity of demand considering the indirect network effect is 2.162. The critical markup ratio ranges from 0.363 (for profit maximization) to 0.413 (for constant revenue). Thus, in this study, we calculate the price elasticity of demand, owing to the actual cost borne by the user of a zero-price service and the 5% surcharge, by adding the direct and indirect network effects. Using zero-price messenger services as an example, this study is a pioneering attempt to define the market for digital zero-price services considering direct and indirect network effects and two-sided markets.

2. Data

2.1 Online survey

The survey was conducted in late February 2019. Before conducting the conjoint analysis, respondents were asked if they were using messenger services, and the subsequent conjoint analysis was limited to messenger users. The total number of respondents to the online survey was 1,225. The number of valid responses was 908 because respondents who did not use the messenger service daily, such as those who had installed the messenger service but not registered any friends, were excluded. For analysis, we focused on the 908 respondents who used the messenger service.

The survey was outsourced to an internet research company, and the respondents were randomly selected from among the company's respondent monitors. A summary of the sample is presented in Table 1. The survey questionnaire was developed to reflect the distribution of the population by gender and age in Japan. While respondents were selected based on their level of use of messenger services, there was enough variation for analysis by gender and age within the valid sample. However, while we were able to obtain a certain number of responses for both males and females up to the age of 59, there were fewer responses from the older age groups. Therefore, the model estimation that follows is weighted based on population distribution in Japan and messenger service usage rate by gender and age.[8] We also investigated usage trends in messenger services, with LINE being the most popular application, used by approximately 86% of respondents, followed by Facebook Messenger, used by only 4%. LINE is also the most popular application in terms of number of active users in a month, used by approximately 93% of the respondents, followed by Twitter DM, used by approximately 18%.

Table 1 shows the descriptive statistics of the variables used in the subsequent analysis. In terms of personal information provided by the respondents, e-mail address and phone number were the most common, at approximately 76% and 71%, respectively. More than 60% of the respondents provided their real names and ages. When asked about the subjective probability that their information would be leaked by their messenger service provider within a year, approximately 23% of respondents believed that there was a 50% chance, 46% believed that the probability was less than 10%, 19% believed that it was less than 1%, and 12% believed there would be no information leakage. Regarding the number of friends registered with messenger services, approximately 17% of the respondents had five or fewer friends, 34% had 10 or fewer friends, and 22% had between 10 and 25 friends. This means that more than half of the respondents had fewer than 25 friends.

Table 1 near here

The attributes of registered friends were considered next. Eight categories of friend attributes were selected: "family members living together," "family members or relatives living apart," "private friends currently in a relationship," "private friends who were in a relationship in the past but are not in a relationship now," "friends or acquaintances from work or school who are currently in a relationship," "friends or acquaintances from work or school who were in a relationship in the past but are not in a relationship now," "lovers," and "others." As seen from Table 1, the largest number of respondents (about 88%) registered "private friends currently in a relationship," followed by "family members living together" (about 70%). By examining the average social distance (the extreme right column of Table 1), we consider that the smaller the value, the more important is the friend attribute in each category to the respondent (closer social distance). The social distance to "family members living together," the second-largest share of registrants, is the smallest, and the social distance to "family members or relatives living apart," the fourth largest share of registrants, is the second smallest. The details of the definition of social distance are explained in subsection 3.1.

2.2 Conjoint analysis

[8] The weights used in the estimation were calculated from the population distribution data for Japan in FY2019 (Ministry of Internal Affairs and Communications, Statistics Bureau HP, http://www.stat.go.jp/data/jinsui/2019np/index.html). Messenger services' usage rates by gender and age were obtained from the screening of this survey.

The definition of a market requires information on the price elasticity of demand and the marginal cost of a hypothetical monopolist. As mentioned earlier, this study uses conjoint analysis to measure the price elasticity of demand for zero-price services. We consider the personal information that users provide to use a free messenger service as the real burden cost that they pay. Therefore, in our conjoint analysis, the provision of personal information and the risk of leakage are included as attributes.

In the conjoint analysis, we set a hypothetical question on whether the respondents will stop using the messenger service if a fixed monthly fee is imposed on the messenger service whose basic service is currently free. As shown in Figure 1, we present the respondents with two usage plans and ask them to choose either to continue using the messenger service under one of the plans or to stop using the messenger service altogether.

Figure 1 near here

The conjoint card has the attributes of "monthly fee," "need for personal information input," and "risk of information leakage within one year," as well as "circumstances under which other users stop using the service." The attributes of the necessity of personal information input and information leakage risk are set to determine the cost of the SSNIC test. The monetary evaluation of these two attributes represents the actual burden cost paid by the free messenger service users. The SSNIC test adopts the attribute of people who stop using the hypothetical messenger service for free or at a fee, after considering the direct network effect. In addition, we insert the monthly usage fee as an attribute to evaluate the inconvenience of entering personal information and the risk of information leakage as the numéraire in terms of monetary value.

The attributes and their levels are listed in Table 2. To ensure that the combination of attributes and their levels is appropriate for this study, two pre-test surveys were conducted: the first was conducted on 200 respondents in mid-January 2019, and the second on 150 respondents in mid-February 2019. Consequently, the attributes and levels employed in this survey were determined based on the results of the pre-test.

Table 2 near here

We pre-tested several conjoint questions on the fee level, including as high as JPY 3,000. The results of the pre-test showed that most respondents stopped using the service when the price exceeded JPY 1,000, yet they hardly responded to small price increases of approximately JPY 100. Therefore, for this survey, we decided to set the lower limit of the fee level at zero yen, which implies free service, the lower limit of the priced service at JPY 100, with an upper limit at JPY 1,000, and a level of JPY 500 in between.

Regarding the probability of information leakage, the following arrangements were made. In the pre-tests, respondents were asked to estimate the likelihood that their information would be leaked within one year, including the provision of information to third parties without their consent. In response to this question, more than 30% of the respondents thought that there was a 50% or greater probability that some kind of information leakage would occur. There were also four options below 50%: 0%, 1%, 10%, and 30%, and a certain number of respondents were distributed across each option. Based on these pre-test results, the conjoint analysis was set to four levels of 0%, 1%, 10%, and 30%, as shown in Table 2.

Next, we conducted a pre-test survey on personal information provided to application providers for service use, such as account information of social networking services (SNS) and personal information that may cause trouble if leaked. The same questions were used in this survey (see Table 1). Although there is a wide range of personal information provided, the variation in attribute levels for conjoint analysis should be considered so that respondents can easily recognize the differences. Therefore, in this analysis, we used three categories of personal information as attribute levels on the conjoint card, taking into account the pre-test responses. Specifically, we set "real name and address" as basic personal information, "e-mail address and phone number" as secondary personal information, and "credit card and bank account information" as personal information related to finance. Furthermore, assuming that the provision of "real name and address" information is included in personal information provision, we created the following four levels: "real name and address" only, "real name and address" + "e-mail address and phone number," "real name and address" + "credit card and bank account information," and “all three types of personal information.” The fifth level was "none" (ID and password settings only), or not requiring the provision of any other personal information.

The analysis considers the importance of the social relationship between those who stop using the service after it becomes fee-based and the respondents. On the one hand, even if those who rarely exchange messages stop using the service, the decrease in the utility of the service user is small. On the other hand, if those who frequently exchange messages with the respondents stop using the service, the decline in the users' utility will be large. Specifically, as shown in Table 1, there is a significant decrease in the utility of the service for "family members living together," "family members or relatives living apart," "private friends who currently exchange messages," "private friends who exchanged messages in the past, but not so much at present,” “friends or acquaintances at work or school who exchange messages at present,” and “friends at work or school who exchanged messages in the past, but not so much at present.” In addition to the seven categories in which users in each category stop using the messaging service, we added a category where no one stops using messaging, generating a total of eight levels. By specifying the attributes of the recipients of the messages, we measured the marginal decline in users' utility according to the corresponding categories.

Consequently, using the results of the pre-test as a reference, 20 cards were prepared by the orthogonal experimental design method, with each conjoint card considering only the main effect of each attribute. These 20 cards were randomly combined to prepare 10 multiple-choice questions as shown in Figure 1. All respondents answered the same 10 questions.

3. Estimation model and results

3.1 Model

Since the preferences of each consumer are considered to be heterogeneous, the random parameter logit (RPL) model is used to analyze the data.[9] Additionally, since the distribution of the parameters is unknown at the time of the RPL model estimation, certain parametric probability distributions are assumed for the estimation.

The stochastic utility function in this study is defined as a linear model using the following equation.

$$U_{ijt} = \alpha_{USE,i} + \beta_{Leak,i} LEAK_{jt} + \beta_{Name,i} NAME_{jt} + \beta_{Mail,i} MAIL_{jt} + \beta_{Fin,i} FIN_{jt} + \beta_{Drop,i} DROP_{jt} + \beta_{Price} PRICE_{jt} + \varepsilon_{ijt.}$$

In terms of the parameters of the stochastic utility function, α_i represents the utility of using the messenger services if consumer *i* chooses option *j* in question *t*. As for the other parameters β_i, all are expected to be negative, but the signs of the variables are transformed such that the parameters β_i become positive.

Each variable on the right side of the above equation corresponds to each attribute of the conjoint card shown in Table 2, where *LEAK* represents the risk of information leakage within one year (in 10% increments). *NAME* is a dummy variable that takes a value of 1 if the user needs to provide the app companies with the "real name and address" information and 0 otherwise; *MAIL* is a dummy variable that takes the value 1 if the "email address and phone number" is provided to the app companies and 0 otherwise; *FIN* is a dummy variable that takes the value of 1 if the user needs to provide credit card or bank account information to the app companies and 0 otherwise; and *PRICE* represents the monthly fee paid for using the messenger services.

A more detailed explanation is required for the variable *DROP*, which corresponds to the communication partner who has stopped using the service due to fees charged, one of the attributes of the conjoint card. The value of *DROP* relates to the subjective social distance assumed by the respondent for those who stop using the service. In our online survey, in addition to the conjoint-type questions, the subjective social distance of respondents corresponding to those who stopped using the service in each category was ascertained from their answers to the following question:

"It may not be a reality, but suppose you have 100 correspondents registered in your messenger app. If the person you want to communicate with the most in those apps is number 1, and the person who is registered but whose name and face do not match (and with whom you do not need to communicate) is number 100, please fill in the number of people who correspond to the following attributes."

The method of ascertaining the social distance between oneself and others was adopted from Rankin (2006). "People who stop using the service" cover seven categories, including private and business acquaintances, family members, and lovers, which appear in the conjoint cards.

[9] For more details on the RPL model, see, for example, Train (2009).

In the above question, the respondents were asked to identify the social distance of each of these categories. In addition, we define *DROP* corresponding to the category that appears in the attribute "people who will stop using messenger services" in option *j* in question *t* as (100-*SOC*), where *SOC* is the social distance for each category that respondents are asked to quantify by a number between 1 and 100. The average *SOC* for each category is shown in Table 1, where the smaller *the SOC* or the larger *the DROP*, the closer the person is to that respondent.[10]

3.2 Estimation results

For the estimation of the RPL model, a multivariate normal distribution is assumed for all parameters except *PRICE*, and 300 Halton draws are used to find the optimal value of the maximum simulated likelihood (MSL). The parameter β_i in the RPL model is assumed to be distributed as a population reflecting the preference heterogeneity among respondents. Since the respondents answered 10 conjoint-type questions at a time, the respondent's β_i is considered to be fixed for the data generated by the 10 questions answered by the same respondent. Therefore, the estimation is treated as for panel data.

The coefficient of *PRICE* is assumed to be fixed without assuming any probability distribution to avoid including zero or infinity in the definition of the *PRICE* coefficient, which is the denominator. This is because the coefficients of *PRICE* are used to divide the coefficients of other variables when converting the actual burden cost of inputting personal information into monetary terms, given that the monthly usage fee is the numéraire (Train, 2009).

Table 3 shows that all the parameters are statistically significant and different from zero at the 1% level with the expected sign. The standard deviations of all parameters, assuming a normal distribution, are also statistically significant and different from zero at the 1% level. The constant term α_i represents the benefit of using the messenger services, and the value obtained by dividing the parameter estimate by the parameter for the monthly usage fee, *PRICE*, which represents the willingness-to-pay (WTP) for the messenger service use. In Table 3, the WTP for the use of messenger services is estimated to be about JPY 781 (US$ 7.81) per month based on the average population distribution. As for the probability of information leakage, for every 10% increase in the probability of information leakage, the monthly WTP is estimated to decrease by JPY 167 per month. Similarly, the monthly benefit of using the messenger services is reduced by JPY 76, JPY 109, and JPY 323 per month, when providing real names and addresses (*NAME)*, phone numbers and email addresses (*MAIL*), and financial-related personal information (*FIN)*, respectively. In addition, the marginal utility loss is estimated to be JPY 38/month for each additional unit of social distance for those who have stopped using the messenger service.

Table 3 near here

[10] If no one stops using the service, the *SOC* is set to 100. In other words, the change in utility when the 100th partner stops using the service is equivalent to when no one stops using the service.

4. Demand elasticity analysis for a one-sided market

4.1 Change in choice probability with an additional 5% charge

We measured the price elasticity of demand for a 5% price increase based on the estimation results obtained using the RPL model. First, we estimated the price elasticity of demand in a one-sided market where there are no direct network effects. The reference price is defined as follows. To estimate the actual burden cost, we calculate a hypothetical price *X* such that *Pr* (use | price = 0, personal information provision rate = average provision rate of respondents, information leakage risk = average subjective probability of respondents) = *Pr* (use | price = *X*, personal information provision rate = none, information leakage risk = none). In other words, *X* represents the magnitude of the real cost to be borne, such that using the free service given the average personal information provision rate and information leakage risk (as obtained by answers to questions of the online survey) and using the paid service in the absence of personal information provision and information leakage risk are non-discriminatory.

The average values for the provision of personal information and the risk of information leakage were as follows. As mentioned earlier, the survey examined the types of personal information provided by respondents. The average values for the 908 respondents were 0.6784 for *NAME* (percentage of respondents who provided their names and addresses), 0.8447 for *MAIL* (percentage of respondents who provided their email addresses and phone numbers), 0.1486 for *FIN* (the percentage of respondents who provided their credit card or bank account information), and 0.3082 for *LEAK* (the average expected probability of information being leaked within a year). These values were multiplied by the average value of each β_i estimated by the RPL model and summed to calculate the decrease in utility. By dividing this value by the *PRICE* parameter, we calculated the actual burden cost for providing personal information and the information leakage risk, finding the actual average cost for this to the respondents to be JPY 706.7 (US$ 7.07) per month, which we employed as the hypothetical price *X* for the messenger service use.

We then calculated the price elasticity of demand. The actual cost burden of JPY 706.7 per month was the initial value used to apply the SSNIC test. The probability of using the service was 0.7151.[11] Next, we simulated the SSNIC test. When calculating the probability of using the service if we charge an additional JPY 35.34 per month, which is 5% of the subjective monthly cost of JPY 706.7, the choice probability changes to 0.6927. Therefore, the rate of decrease from the initial choice probability of 0.7151 becomes -0.0314 (= [0.6927 - 0.7151]/0.7151), indicating that a 5% increase in price will reduce the choice probability by about 3.1%. Therefore, the price elasticity of demand is calculated as -0.6280 (= -0.0314/0.05).

[11] In our study, the respondents who actively used the messenger services were included in the analysis. However, it should be noted that in the conjoint analysis, even if the variable is set to the current level, the probability of using the service does not necessarily integrates to 1. It can be interpreted that the ratio of respondents who have installed but intend to continue using the service is only 0.7151.

4.2 Change in choice probability considering direct network effects

Next, we measured the demand elasticity of a one-sided market considering the direct network effect. In the simulation described above, the decrease in the probability of choice due to an additional 5% charge was 3.1%. However, there should be a direct network effect at work in the messenger service, such that the more the users, the higher the utility of using the service. In this model, the *DROP* variable represents the extent to which the utility of using the messenger service decreases when others stop using it. As explained earlier, using the social distance *SOC*, the *DROP* variable is defined as (100-*SOC*). In other words, the more important a communication partner is, the smaller is the *SOC* when the partner stops using the application. Here, we assume that 3.1% of in-app communicators with average social distance would stop using the messenger service.

Note that the median number of people on the roster of correspondents in the application is 74, and the average social distance of people on the roster is 66.4. Therefore, we calculated the "median number of people registered in the communication roster (74) × service outage rate (0.0314) × social importance of dropouts (66.4/100)" and extrapolated that number to the *DROP* variable as a decrease in network size. As a result of calculating the selection probability using this method, its value changed to 0.6533. Therefore, the rate of change from the original selection probability was -0.08642 (= [0.6533 - 0.7151]/0.7151). Considering the above direct network effect, a 5% change in price decreases the choice probability by 8.6%, resulting in price elasticity of demand of -1.728 (= -0.08642/0.05).

5. Simulation analysis for a two-sided market

Here, we consider the indirect network effects to measure the price elasticity of demand in a two-sided market. The intuition behind the free business model is that companies can use free-service customers as a base to generate billing revenue on the other side of the market. In other words, as the number of users of a free service increases, the revenue gained from users in the paid market also increases due to the indirect network effects, and vice versa. In other words, if the number of free service users decreases, the revenue from the paid market shrinks. Considering messenger services as a two-sided market, the number of communicators exchanging messages is a variable that represents the size of the network. In the case of free messenger services, the advertising market and other application services form the other (paid) side of the market to monetize the two-sided market business. Naturally, the revenue generated by the paid market depends on the network size of the free market. Thus, if both the size of the free market and the profitability of the paid market decrease, the quality of the free service must be reduced or the free business must be abandoned.

Here, we attempt to simulate market delineation under simple assumptions that include both direct and indirect network effects. First, as when measuring the impact of direct network effects, we assume an initial monthly price increase of JPY 35.3 (5% of JPY 706.7) for personal information collection and information leakage risk. In this case, the price level after the increase is JPY 742.0 per month, and the decrease in the probability of choice due to the 5% price increase is the value measured in the case of the direct network effect (-8.6%). Furthermore, considering the indirect network effect, a decrease in the size of the network in one (free) market results in a decrease in revenue in the other (paid) market, which in turn rebounds to the original market. Here, if a decrease in network size due to a 5% price increase in the original market causes a decrease in revenue in the other market, the decrease in revenue must be compensated by increasing the real cost incurred in the original market. For example, assuming that the network size of a messenger service decreases by 10% due to a 5% price increase. In this case, due to the indirect network effect from the other market, the hypothetical price of the messenger service will additionally increase by JPY 74.20 (or, 10% of JPY 742.0) per month to compensate for the decrease in revenue. In this simulation, we need to incorporate this additional JPY 74.20 monthly price increase into the calculation of the price elasticity of demand.

In our previous calculations, we obtained the result that the first 5% price rise decreases the network size by 8.6% via the direct network effect. Therefore, we now simulate the indirect network effect by considering an additional monthly price increase of JPY 63.82, equivalent to 8.6% of the actual burden cost of the messenger service market. This additional fee reduces the user's utility, which further reduces the choice probability, resulting in a change in the choice probability by -0.6378 and a rate of change of 0.1081 (= [0.6378 - 0.7151]/0.7151). Therefore, when the simulation is performed considering the direct and indirect network effects, the probability of choice decreases by 10.8% for the first 5% price increase.

6. **Market delineation for zero-price services**

Based on the estimated price elasticity of demand, we now delineate one-sided markets without direct network effects, one-sided markets with direct network effects, and two-sided markets with indirect network effects. To delineate markets, the critical price elasticity of demand must be calculated (Werden, 1998; Werden, 2003). If the marginal price elasticity of demand is greater than the price elasticity of demand measured at the current price level, the increase in the maximum profit price will be greater than the SSNIC level. Therefore, this hypothetical monopolist will be able to increase its profit margin through SSNIC, and the competition authority will define this service as a relevant market. Conversely, if the critical price elasticity is less than the elasticity of demand measured at the current price level, the competition authority would not be able to define such a product as a relevant market.

Now, we briefly explain the critical price elasticity of demand in the case of linear demand. Let the linear demand curve for service *i* be $p = a - bq$, where *p* is price, *q* is demand, and *a* and *b* are the parameters. Let p^0 be the current price. Since $\frac{\partial p^0}{\partial q^0} = -b$, we calculate the price elasticity of demand at the current price of the linear demand line and obtain $\varepsilon_i(p^0) = p^0/(a - p^0)$. Next, let the profit maximization price be p^m and the marginal cost be c to calculate the profit maximization price of the hypothetical monopolist. Since the profit function is $\pi(p^m) = (p^m - c)q(p^m)$, we obtain $p^m = (a + c)/2$ by $\frac{\partial\pi(p^m)}{\partial p^m} = 0$. By transforming this profit maximization condition, we obtain $a = 2p^m - c$, and by substituting it in the definition equation of price elasticity of demand, we obtain $\bar{\varepsilon}(p^0) = p^0/(2p^m - c - p^0)$. This is the expression of the price elasticity of demand at the current price level p^0 using the profit maximization price p^m. Here, the current price-cost markup ratio is $m = (p^0 - c)/p^0$. In addition, since the rate of increase from the current level to the maximum profit price is $t = (p^m - p^0)/p^0$, we can rewrite the price elasticity of demand using *m* and *t* to obtain $\bar{\varepsilon}_i(p^0) = \frac{1}{m+2t}$. Furthermore, if we consider constant revenue instead of profit maximization, the critical elasticity is $\bar{\varepsilon}_i(p^0) = \frac{1}{m+t}$. Here, we do not make any specific assumptions about corporate behavior; thus, we calculate the critical elasticity values for both profit maximization and constant revenue.

We converted the zero price of the messenger service into JPY 706.7 (US$ 7.07) per month, which is the actual cost of providing personal information. Using this amount as a starting point, we calculated how much a 5% price increase would reduce the probability of choice. First, we conducted a demand substitutability analysis of the one-sided market, focusing only on the messenger service market, finding that the price elasticity of demand, defined as the decrease in the probability of choice due to a 5% surcharge, to be 0.628. Since we do not know the markup ratio of the hypothetical monopolist, if the actual markup ratio is less than this level, we calculate the critical markup ratio at which the relevant market can be defined as a relevant market. The critical markup ratio ranges from 1.492 (for profit maximization) to 1.542 (for constant revenues). Since the range of possible markup ratio is between 0 and 1, this service can always be defined as a relevant market.

Next, when calculating the price elasticity of demand, we considered the direct network effect, in which the value of a service increases when more people use it. Considering the direct network effects, we found the price elasticity of demand to be 1.728. Additionally, the critical markup ratio was found to range from 0.479 (for profit maximization) to 0.529 (for constant revenue). Therefore, if the markup ratio is smaller than 0.479 or 0.529, the service can be defined as a relevant market.

Finally, to calculate the price elasticity of demand, one service is considered a counterpart of the other service, and both indirect and direct network effects are considered, resulting in price elasticity of demand of 2.162. The critical markup ratio was computed to range from 0.363 (for profit maximization) to 0.413 (for constant sales). Therefore, if the markup ratio is smaller than 0.363 or 0.413, the service can be defined as a relevant market. Table 4 summarizes the results of this market definition for zero-price services.[12]

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[12] In this study, we assume that the repercussions of indirect network effects between the two markets are short-term and one time only as the market delineation of the SSNIC test is based on a short-term assumption of one year. However, in the long term, there could be a catastrophic scenario where multiple repercussions between the two markets will constantly reduce the network size in both markets.

Table 4 near here

7. Conclusions

Using messenger services as an example, this study proposes a market definition method for zero-price services. We employ the SSNIC test, which is an improved version of the SSNIP test, and conjoint analysis, while considering network effects, an important characteristic of digital services. In summary, in the case of a 5% price increase, we find a 3.1% change in the probability of choice, and the price elasticity of demand to be 0.628 when only the price effect is considered, while the decrease in the probability of choice is 8.6% when the direct network effect is considered. Additionally, the price elasticity of demand is1.728. Furthermore, when considering a two-sided market with indirect network effects, a decrease in the probability of choice of 10.8% is observed for a 5% price increase, resulting in price elasticity of demand of 2.162.

Thus, the results of the SSNIC-type market delineation test show that the price elasticity of demand for free messenger services is higher when network effects and two-sided markets are considered; thus, it is difficult to say that a free messenger service is a relevant market that is independent of the nearest other communication services. A free service is a typical business model of digital service provision, and the two-sided nature of the market makes it difficult for applying competition policy. Although it is difficult to directly apply the SSNIP-type market definition method, which uses the price elasticity of demand, to zero-price markets, it is possible to perform SSNIC-type market definition tests by calculating the actual burden costs and considering the effects of network effects. The method proposed in this study shows that a market definition for free markets is eminently possible.

Nevertheless, there are several limitations to this study. First, we only used the hypothetical stated preference method; future work should conduct analysis using the revealed preference method. Second, our model does not assume specific corporate behavior. Future studies can address this issue by conducting structural estimations assuming certain corporate behaviors. Third, this analysis was conducted for a short term, of approximately one year, and future research should conduct a long-term analysis to model the repercussions between markets.

References

Affeldt, P., Filistrucchi, L., Klein, T.J. 2013. Upward pricing pressure in two-sided markets. *Economic Journal* 123: 505–523.

Anderson, C. 2009. *Free: The future of a radical price*. Hyperion: New York.

Cayseele, PV., Vanormelingen, S. 2019. Merger analysis in two-sided markets: The Belgian newspaper industry. *Review of Industrial Organization* 54: 509–541.

Emch, E., Thompson, T.S. 2006. Market definition and market power in payment card networks. *Review of Network Economics* 5: 45–60.

Evans, D.S. 2003. The antitrust economics of multi-sided platform markets. *Yale Journal on Regulation* 20: 324–381.

Evans, D.S. 2008. *Antitrust issues raised by the emerging global internet economy*. Northwestern University Law Review 102: 285–306.

Evans, D.S. 2011. The antitrust economics of free. *Competition Policy International* 7: 1-26.

Evans, D.S., Noel, M.D. 2008. The analysis of mergers that involve multisided platform businesses. *Journal of Competition Law and Economics* 4: 663-695.

Filistrucchi, L., Geradin, D., Van Damme, E., Affeldt, P. 2014. Market definition in two-sided markets: theory and practice. *Journal of Competition, Law and Economics* 10: 300–306.

Filistrucchi, L., Klein, T.J., Michielsen, T.O. 2012. Assessing unilateral merger effects in a two-sided market: An application to the Dutch daily newspaper market. *Journal of Competition Law and Economics* 8: 297–329.

Gal, M.S., Rubinfeld, D.L. 2015. The hidden costs of free goods: Implications for antitrust enforcement. *Antitrust Law Journal* 80: 521–562.

Hartman, R., Teece, D., Mitchell, W., Jorde, T. 1993. Assessing market power in regimes of rapid technological change. *Industrial and Corporate Change* 2: 317–350.

Hensher D.A., Rose, J.M., Greene, W.H. 2005. *Applied choice analysis: A primer*. Cambridge University Press: New York..

Jeziorski, P. 2014. Law, effects of mergers in two-sided markets: The US radio industry. *American Economic Journal: Microeconomics* 6: 35–73.

Kaplow, L. 2010. Why (ever) define markets? *Harvard Law Review* 124: 437–517.

Kaplow, L. 2015. Market definition, market power. *International Journal of Industrial Organization* 43: 148–161.

Kawaguchi, K., Kuroda, T., Sato, S. 2021. *Merger analysis in the app economy: An empirical model of ad-sponsored media*. Conference paper. TPRC48: The 48th Research Conference on Communication, Information and Internet Policy.

Kawahama, N., Takeda, K. 2017. *Market definition in the platform industry*. RIETI Discussion Paper Series 17-J-032.

Newman, J.M. 2015. Antitrust in zero-priced markets: Foundations. *University of Pennsylvania Law Review* 164: 149–206.

Newman, J.M. 2016. Antitrust in zero-priced markets: Applications. *Washington University Law Review* 94: 49.

Rankin, F.W. 2006. Requests and social distance in dictator games. *Journal of Economic Behavior and Organization* 60: 27–36.

Rochet, J.C., Tirole, J. 2003. Platform competition in two-sided markets. *Journal of the European Economic Association* 1: 990–1029.

Statistics Bureau, Ministry of Internal Affairs and Communications, Japan. 2020. *Population Projection (Current as of October 1, 2019)*. http://www.stat.go.jp/data/jinsui/2019np/index.html

Train, K. 2009. *Discrete choice methods with simulation, 2nd ed*. Cambridge University Press: Cambridge.

Werden, G.J. 1998. Demand elasticities in antitrust analysis. *Antitrust Law Journal* 66: 363–414.

Werden, G.J. 2003. The 1982 merger guidelines and the ascent of the hypothetical monopolist paradigm. *Antitrust Law Journal* 71: 253–275.

Table 1. Descriptive statistics

Age	Male	Female	Name of app	Most used apps	Active user	Personal information actually provided	
10s	5.2%	12.0%	**LINE**	86.5%	93.3%	**Real name**	65.7%
20s	5.0%	10.5%	**Facebook Messenger**	3.7%	16.4%	**Age**	60.0%
30s	6.7%	10.7%	**Google Allo**	0.2%	0.9%	**Occupation**	33.0%
40s	8.1%	7.2%	**Skype**	2.6%	9.0%	**Mailing address**	33.9%
50s	6.3%	5.9%	**Twitter DM**	3.5%	17.8%	**Phone number**	70.9%
60's	10.6%	6.3%	**Instagram DM**	1.5%	14.3%	**E-mail**	75.8%
70s	4.3%	1.3%	**Snapchat**	0.0%	0.6%	**Account information for social networking sites other than that app**	13.8%
Over 80	0.0%	0.0%	**WhatsApp Messenger**	0.1%	1.3%	**Credit card information**	13.1%
			Others	1.8%	7.4%	**Bank account information**	8.0%
						Other information	11.8%
						Nothing	7.7%

Note：N=908

(continued)

Subjective probability that information will be leaked within a year		**Number of communication partners registered in the apps**		**Attributes of registered communication partners**		**Average value of social distance**
0%	12.2%	**Less than 5**	17.3%	**Family members living together**	70.0 %	7.56
1%	6.4%	**5 to 9**	16.9%	**Family members or relatives living apart**	55.0 %	11.06
5%	10.0%	**10 to 24**	21.6%	**Lovers**	16.2 %	22.71
10%	17.1%	**25 to 49**	16.4%	**Private friends with whom one has a current relationship**	87.8 %	13.76
30%	17.5%	**50 to 99**	13.2%	**Private friends with whom one had a relationship in the past but not anymore**	41.3 %	33.23
50%	23.0%	**100 to 299**	9.8%	**Friends or acquaintances from work or school with whom one has a current relationship**	59.1 %	26.69
70%	5.5%	**Over 300**	4.8%	**Friends or acquaintances from work or school with whom one had a relationship in the past but not anymore**	21.4 %	54.51
90%	3.3%			**Others**	2.1%	51.24
100%	5.0%					

Note：N=908

Table 2. Attributes and levels of the conjoint questions

Attributes	Levels
Price: 4 levels.	JPY 1,000/month JPY 500/month JPY 100/month JPY 0/month
Probability of information leaking from the app provider, including the content of messages exchanged, within one year: 4 levels.	0% 1% 10% 30%
Type of information you need to give to the app provider (information you enter when creating an account): 5 levels including 0. *: When entering information, it is assumed that "real name and address" are required, or "e-mail address and phone number" or "credit card or bank account information" are required in addition to "real name and address."	None (ID and password only) "Real name and address" only "Real name and address" + "E-mail address and phone number" "Real name and address" + "Credit card or bank account information" "Real name and address" + "E-mail address and phone number" + "Credit card or bank account information"
People who are expected to stop using the service due to changes in plan settings: 8 levels including 0. *: assuming that there is only one category for each card that will no longer be used.	"Nobody" "Family members living together" "Family members or relatives living apart" "Private friends with whom one has a current relationship" "Private friends with whom one had a relationship in the past but not so much anymore" "Friends or acquaintances from work or school with whom one has a current relationship" "Friends or acquaintances from work or school with whom one had a relationship in the past but not so much anymore" "Lovers"

Table 3. Estimation results

	Mean	S.E.	S.D.	S.E.	WTP
USE (α)	2.3803	0.0220	2.7845	0.0241	JPY 781.30
LEAK	0.5094	0.0047	0.4349	0.0058	JPY 167.20
NAME	0.2311	0.01090	0.3119	0.0191	JPY 75.84
MAIL	0.3315	0.0102	0.2301	0.0203	JPY 108.80
FIN	0.9844	0.0100	0.1488	0.0254	JPY 323.10
DROP	0.1164	0.0104	0.0966	0.0225	JPY 38.21
PRICE	0.3047	0.0014	-	-	-
McFadden Pseudo R2	0.3037				

Note: All parameter estimates are significantly different from zero at the 1% significance level.

Table 4. Market delineation for zero-price services

		Critical Markup Ratio	
	Price elasticity of demand	Profit maximization	Constant revenue
One-sided market without direct network effects	0.628	1.492	1.542
One-sided market with direct network effects	1.728	0.479	0.529
Two-sided market with indirect network effects	2.162	0.363	0.413

Figure 1. Examples of conjoint questions

- Please read the following instructions carefully and answer the questions.
- Assume that all messenger services have made changes, including fee-based services, and that all apps will collect fees and register personal information in one place.
- Suppose that from the next month, all the messenger services will be managed collectively, and you will be able to use only "Plan 1" or "Plan 2."
- Assume that the following changes will occur as a result of the plan change:
  - ✓ Setting a usage price (including the case of "free/0 yen")
  - ✓ Some people will stop using the app (assuming you know who will stop using it).
  - ✓ You will have to provide additional personal information.
- In addition, let us assume that the probability that personal information, including messages exchanged, will be leaked from one of the apps within the next year is the same for all app companies, and this probability is known.
- Please choose the more convenient of the following two plans, or the "stop using all messenger services" option.

<table>
<tr><th></th><th>Plan 1</th><th>Plan 2</th><th rowspan="5">Stop using all messenger apps.</th></tr>
<tr><td>Probability of information leaking from the app provider, including the content of messages exchanged, within one year</td><td>1%</td><td>0%
(It will never leak within a year).</td></tr>
<tr><td>Type of information you need to give to the app provider</td><td>Real name and address</td><td>Real name and address,
credit card or bank account information</td></tr>
<tr><td>People who are expected to stop using the service due to changes in plan settings</td><td></td><td>Family members living together</td></tr>
<tr><td>Monthly charge</td><td>Free (0 yen/month)</td><td>JPY 1,000/month</td></tr>
<tr><td>Please select one</td><td>○</td><td>○</td><td>○</td></tr>
</table>