Parameter identification for the decision model of uncertainty price competition in food delivery services

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Abstract. The sharing economy innovation has created a new service industry sector, the ride-hailing industry. Government regulations regarding minimum tariffs change the competition map and uncertainty in that industry. This has led to predatory pricing, switching costs and preemptive duopoly. This study aims to determine the parameters that can affect the decision model in the uncertainty of price competition through factorial experiments. This study was conducted on two ride-hailing companies, which currently lead market share, thus establishing a duopoly market. There are many services offered by these companies. This study focuses on investigating food delivery services, which are one of the stable services during the Covid-19 pandemic. The approach that will be used in this research is a factorial experiment to determine what parameters can affect price determination with several uncertainty cases. The result is the identification of the optimal decision model, both parameters and levels in pricing. The implication of this study is fair competition for the welfare of society and the country.

1. Introduction
In the 4.0 industrial revolutions, digitalization has been targeting all aspects of life, including the transportation sector, particularly the online ride-sharing or ride-hailing service industry [1-3]. Shifting interests of public transport users to transport conventional online increasingly open market opportunities for this industry [4, 5]. From a number of these service providers, two companies became the leader of the online transport market competition in Indonesia [6, 7]. Despite the new competition but they still dominate the market. As time goes by, the development of features in online ride-hailing is not only providing transportation services [8, 9]. Other features such as goods delivery service, food delivery service, and several other features make it easier and pamper for its users [10, 11]. However, the development of new features that led to increasingly fierce competition [12]. Both companies innovate and compete with each other to provide the best service strategy with various promos and services provided.

Previous studies stated that the main consideration for consumers using online services is earnings or price [13]. This indicates that the pricing strategy is very influential in supporting the existence of these two service providers in the online transport competition in Indonesia [14, 15]. Price competition continues even though the government has issued a policy for prices or minimum rates for all online transportation in Indonesia [16]. This designation is also used to reduce social tensions with the
conventional transportation industry [17]. However, the existence of a strategy, slashing prices or promotions, keeps them competitive by providing prices below the predetermined minimum rate [18].

On the other hand, consumers have full information about the advantages and disadvantages of each transport line, up any discounts and promotions provided by each [19, 20]. Swinger behaviour, rapid movement of brand use, is a phenomenon that cannot be avoided by the two companies [21]. In addition, the absence of switching costs allows consumers to find online ride-hailing services that are considered the cheapest and provide the most profitable discounts or promotions for them [22]. It also leads to uncertainty and sensitivity of the price of the higher bargaining power [23]. The question is whether the current pricing strategy can support their sustainability efforts in the future in the face of uncertainty or simply satisfy short-term goals.

The rapid development of the online transportation service business requires the companies to adapt to all the uncertainties, including during the current pandemic [24, 25]. From all features it has, food delivery is one that can survive a pandemic. This is due to government regulations regarding physical distancing and causing several service features to decrease in demand, including their main feature, transportation services. Food delivery service does not only involve the companies, driver-partners and consumers, but also involves the merchants or food producers [26-28]. Their sustainability and supply chains are also very dependent on the sustainability of the ride-healing industry [29]. With the current state and on-going price competition, the companies have to think about re-pricing strategy.

This study aims to identify and determine the parameters that can affect the price of food delivery services in the ride-hailing industry. Using a factorial experiment performs the determination of the parameters. Previous studies have disclosed that factorial experiments are very efficient in determining the parameters that can affect the conditions of a system [30-32]. Duopoly market must be kept to compete fairly [33]. In addition, this is also to avoid predatory pricing in which the company seeks to beat competitors by using promotional programs or minimum selling prices [34]. With the completion of this study, hopefully, it can be used as an input for the government in developing policies and regulations regarding service prices. In addition, the results of this study are expected to have implications for fair competition and consumer welfare. Although digital and sharing economy is very dynamic and full of uncertainty, the satisfaction and protection of the public must remain a key performance indicator in formulating government policy.

2. Research Methods

The initial stage is to identify the parameters in the form of factors that will be involved in the experiment. The data was collected through several approaches including observation, literature review, interviews and questionnaires. The questionnaire is a list of questions and is distributed to respondents related to the object of research [35]. In this study, respondents were users who used food delivery services from online transportation. This number is required to meet the minimum sample size in the study (Equation 1). Where n, z, p and e are sample size, degree of accuracy, probability and sampling error, respectively [36].

\[
    n = \frac{z^2 \times p(1-p)}{e^2}
\]  

After obtaining the factors to be studied, an experiment was performed [37]. An experiment objective is to understand how to reduce and control the variability of a process or product and to determine the parameters that affect the performance of the process or the product [38]. In this study, experiments are needed to determine the parameters that may affect the object of case studies to determine the price of their services. With so many involved parameters and their possible interactions, the experimental design conducted in this study is a factorial experiment [39].

With factorial experiments, every possibility of all factors is investigated, including the interactions between the factors. The effect of a factor is defined as the response resulting from changes in the level of that factor. This is often cited as the main effect of the experiment. In addition to the main factor effect, the influence of the interaction between factors on the experimental results is an important thing
to review [40]. This is due to the influence of a factor on the results. Sometimes it is also greatly influenced by the number or presence of other factors.

In general, there will be abc…n total observations if there are n replicates of the complete experiment. There are a levels for factor A, b levels of factor B, c levels of factor C, . . . so on. It must have at least two replicate to include all the possible interactions in the model. For example, the three-factor analysis of variance models shown in Equation 2.

$$y_{ijkl} = \mu + \tau_i + \beta_j + \gamma_k + (\tau\beta)_{ij} + (\tau\gamma)_{ik} + (\beta\gamma)_{jk} + (\tau\beta\gamma)_{ijk} + \epsilon_{ijkl}$$ (2)

Test statistics for each main effect and interaction may be constructed by dividing the corresponding mean square for the effect or interaction by the mean square error. The F tests on main effects and interactions follow directly from the expected mean squares[41]. Usually, the analysis of variance computations would be done using a statistics software package.

In summary, note that factorial designs have several advantages [42]. They are more efficient than one-factor-at-a-time experiments. Furthermore, a factorial design is necessary when interactions may be present to avoid misleading conclusions. Finally, factorial designs allow the effects of a factor to be estimated at several levels of the other factors, yielding conclusions that are valid over a range of experimental conditions.

3. Results and Discussion

3.1. Factors identification

Before the experiments were conducted, the first investigated the factors involved in this study. Questionnaires were distributed to the users of this service to determine what factors are to be used in experiments. The total respondents of the questionnaire were 320 respondents. With $\alpha = 5\%$, this number has exceeded the minimum sample size required according to Equation 1, i.e. 139 respondents.

The questionnaire results show that the number of respondents with male gender is the same as female, each of which is 160 respondents. Among a total of 320 respondents, the age range 18-22 years dominated the filling of the questionnaire with 50.9% or 163 respondents. The respondents' occupations also varied with students and company staff having the largest numbers of 158 and 114 respondents, respectively. The overall demographics are shown in Figure 1.

The distributed questionnaire was tested for validity and reliability. The validity test shows the degree of accuracy between the data that actually occurs on the object and the data collected. Meanwhile, the reliability test is a series of measurements that show consistency when the measurement is done repeatedly [43]. Based on the results of the validity test on the questionnaire, all values of each question item have a Sig> 0.01, so the questionnaire is valid. While in the reliability test, it is known that the Cronbach's Alphascore is 0.649> 0.60, so it can be concluded that all the question items in the questionnaire are reliable [44]. In addition, this study also examines the results of previous references to identify factors. There are several factors that are considered in the subsequent analysis, including type, weather, payment method, zone, time and distance.

3.2. Experiment analysis

Apart from identifying the factors, this study also identified the level for each factor as shown in Table 1. For example, the factor level for the type of company consists of two ride healing companies that have food delivery services and are currently leading the market. In each interaction of the six factors, there are 4 replications, so that the total data in this experiment is 864 data. The data is a response variable in the form of price or tariff for services according to predetermined factor and factor levels.
Figure 1. Respondent demographics: (a) gender; (b) age range; (c) occupation.

| Table1. Experimental factors and levels. |
|----------------------------------------|
| **Factor**                             | **Level Factor** |
| Type of company (A)                    | A1              |
|                                       | A2              |
| Weather (B)                            | Rain (B1)       |
|                                       | Fine/Sunny (B2) |
| Payment method (C)                     | Cash (C1)       |
|                                       | Non-cash (C2)   |
| Zone (D)                               | 1 (D1)          |
|                                       | 2 (D2)          |
|                                       | 3 (D3)          |
| Time (E)                               | Morning (E1)    |
|                                       | Evening (E2)    |
|                                       | Normal (E3)     |
| Distance (F)                           | Near (F1)       |
|                                       | Medium (F2)     |
|                                       | Far (F3)        |

The experimental results, price as the response variable, had descriptively the mean, maximum and minimum values were IDR 17,000, IDR 43,000 and IDR 4,000, respectively. Then analysis was performed using two-stage analysis of variance (ANOVA). The first stage examines all factors by considering the interaction between factors. The second stage examines the factors that from the preceding analysis are known to have a different effect, so that they affect the response variable, pricing. The factorial experimental model in this study is shown in Equation 3.

\[
y_{ijkln} = \mu + \alpha_i + \beta_j + \gamma_k + \delta_l + \tau_m + \varphi_n + (\alpha \gamma)_{ik} + (\alpha \delta)_{il} + (\alpha \tau)_{im} + (\alpha \varphi)_{in} + (\beta \gamma)_{jk} + (\beta \delta)_{jl} + (\beta \tau)_{jm} + (\beta \varphi)_{jn} + (\gamma \delta)_{kl} + (\gamma \tau)_{km} + (\gamma \varphi)_{kn} + (\delta \tau)_{lm} + (\delta \varphi)_{ln} + (\tau \varphi)_{mn} + (a \beta \gamma)_{ijk} + (a \beta \delta)_{ijl} + (a \beta \tau)_{ijm} + (a \beta \varphi)_{ijn} + (a \gamma \delta)_{ikl} + (a \gamma \tau)_{ikm} + (a \gamma \varphi)_{ikn} + (a \delta \tau)_{ilm} + (a \delta \varphi)_{iln} + (a \tau \varphi)_{imn} + (a \beta \gamma \delta)_{ijkl} + (a \beta \gamma \tau)_{ijkm} + (a \beta \gamma \varphi)_{ijkn} + (a \beta \delta \tau)_{ijlm} + (a \beta \delta \varphi)_{ijln} + (a \beta \tau \varphi)_{ijmn} + (a \gamma \delta \tau)_{iklm} + (a \gamma \delta \varphi)_{ikln} + (a \gamma \tau \varphi)_{ikmn} + (a \delta \tau \varphi)_{ilmn} + \epsilon_{ijkln}
\]  

(3)
where $\mu$, $\alpha$, $\beta$, $\gamma$, $\delta$, $\tau$ and $\varphi$ are the sum of the squares mean, type, weather, payment method, zone, time and distance, respectively. The hypothesis generates from six factors and their interactions. The general hypothesis of this study is formulated as follows:

$H_0$: There is no effect of difference in mean due to the factor

$H_1$: There is an effect of difference in mean due to the factor

By using a significance level of 5%, acceptance of $H_0$ occurs when the P-value is more than 0.05 and vice versa [45]. Figure 2 shows the comparison of the P-value that is the ANOVA output with 0.05.

**Figure 2.** P-value comparisons between experiment results and 0.05: (a) single factor; (b) 2-way interactions; (c) 3-way interactions; (d) 4-way interactions; (e) 5-way interactions.
Based on Figure 2 (a), the test for a single factor, there is a rejection of H0 on A, D, E and F are type, zone, time and distance, respectively. This is because the P-value of the experimental results is less than 0.05, so there is a difference in the average price based on these factors. Whereas in Figure 2(b), the interaction test for 2-way interactions, it is known that the experimental results for the interaction factors A * D (type * zone), A * F (type * distance), and D * F (zone * distance) have a P-value less than 0.05. The conclusion is that there are differences in the average price based on the interaction of these factors. As for testing 4-way interactions, 5-way interactions and 6-way interactions, there are no interaction factors that have a P-value of more than 0.05. Therefore, there is no difference in the average price based on the interaction of these factors.

Furthermore, the post-hoc ANOVA test was performed to test the factors having different effects in the preceding analysis [46]. There are four factors tested, i.e. type, zone, time and distance. Equation 4 and Table 2 are the factorial experimental models and analysis tables of variance, respectively.

\[ y_{ijklm} = \mu + \alpha_i + \beta_j + \gamma_k + \delta_l + (\alpha\beta)_{ik} + (\alpha\gamma)_{ik} + (\alpha\delta)_{il} + (\beta\gamma)_{jk} + (\beta\delta)_{jl} + (\gamma\delta)_{kl} + (\alpha\beta\gamma)_{ijkl} + (\alpha\beta\delta)_{ijkl} + (\alpha\gamma\delta)_{ikl} + (\beta\gamma\delta)_{jkl} + (\alpha\beta\gamma\delta)_{ijkl} + \epsilon_{ijklm} \]  

(4)

**Table 2. Analysis of variance.**

| Source       | DF  | Adj SS     | Adj MS     | F-Value | P-value |
|--------------|-----|------------|------------|---------|---------|
| Model        | 53  | 89,129,691,949 | 1,681,692,301 | 135.91  | 0.000   |
| Linear       | 7   | 81,647,881,069 | 11,663,983,010 | 942.64  | 0.000   |
| A            | 1   | 61,465,603   | 61,465,603  | 4.97    | 0.026   |
| D            | 2   | 19,112,109,798 | 9,556,054,899 | 772.28  | 0.000   |
| E            | 2   | 111,057,870 | 55,528,935  | 4.49    | 0.012   |
| F            | 2   | 62,363,247,798 | 31,181,623,899 | 2519.98 | 0.000   |
| 2-Way Interactions | 18 | 6,851,209,321 | 380,622,740  | 30.76   | 0.000   |
| A*D          | 2   | 822,166,316  | 411,083,158 | 33.22   | 0.000   |
| A*E          | 2   | 11,131,944   | 5,563,972   | 0.45    | 0.638   |
| A*F          | 4   | 782,312,983  | 391,156,492 | 31.61   | 0.000   |
| D*E          | 4   | 113,657,407  | 28,414,352  | 2.30    | 0.058   |
| D*F          | 4   | 4,980,658,263 | 1,245,164,566 | 100.63  | 0.000   |
| E*F          | 4   | 141,282,407  | 35,320,602  | 2.85    | 0.023   |
| 3-Way Interactions | 20 | 567,684,892  | 28,384,245  | 2.29    | 0.001   |
| A*D*E        | 4   | 38,944,444   | 9,736,111   | 0.79    | 0.534   |
| A*D*F        | 4   | 396,606,188  | 99,151,547  | 8.01    | 0.000   |
| A*E*F        | 4   | 23,902,778   | 5,975,694   | 0.48    | 0.748   |
| D*E*F        | 8   | 108,231,481  | 13,528,935  | 1.09    | 0.365   |
| 4-Way Interactions | 8   | 62,916,667   | 7,864,583   | 0.64    | 0.748   |
| A*D*E*F      | 8   | 62,916,667   | 7,864,583   | 0.64    | 0.748   |

**Total** 810 10,022,762,544 12,373,781

Based on Table 2, in single-factor testing, it is known that all factors get a rejection of H0. This result is in accordance with the results of the preceding analysis, there is an effect of differences in the average price based on factors A, D, E and F, which is type, zone, time and distance. In 2-way interactions, it is known that apart from A * E and D * E interactions, other interactions are rejected H0. On the other
hand, in 3-way and 4-way interactions, only A * D * F interactions are rejected H. This result is also the same as the preceding analysis.

The interaction results for 2-way, 3-way and 4-way show that E (time) does not have a significant difference effect, though a single testing shows otherwise. This is because the experimental results show that the variation of the experimental results grouped by time factor has small variance. This differs by type, zone and distance. They have a large variance between groups, so that it has a significant effect on prices.

4. Conclusions

The identification of factors that influence price determination on food delivery services is performed through literature studies, field surveys and discussions with related parties. The results of the identification of the factors indicate several factors. These factors include the type of company, weather, payment methods, zone, time and distance. There are two levels of factors for the type of company, weather and payment methods. While the remaining factors have 3 levels.

A total of 864 experiments were conducted and analyzed statistically by analysis of variance. The results of the analysis generate that 4 factors have a different effect on the price of food delivery services. These factors are the type of company, zone, time and distance. In addition, the interaction test for these factors also shows consistent results, although the time parameter does not give a different effect. Therefore, decision-makers, companies and governments should recognize these parameters in determining prices and other policies.

This study contributes to the enrichment of the references regarding price competition in duopoly market. By understanding what parameters can have an effect on pricing decisions, it is expected that this can become an input in policy making, especially in the online transportation industry, which is now a public need. Apart from creating a healthy competitive climate, the growth of innovation and business sustainability, satisfaction and protection of the community as consumers are also realized. Future studies should conduct more in-depth analysis of the parameters that have been identified to obtain optimal models in dealing with uncertainty. In addition, the implementation in industry and other market competitive conditions is also suggested for further study.

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