Determining The Importance Factors of Financial Technology Adoption in Hospital Using Fuzzy Analytical Network Process (FANP)

M. Dachyar1*, E N Ilahiyyah1 and Farizal1
1Department of Industrial Engineering, Universitas Indonesia, Depok 16424, Indonesia
mdachyar@yahoo.com

Abstract. Electronic money transactions in Indonesia have grown rapidly with an average 66% from 2012 to 2018. Unfortunately, according to Jakpat Survey in 2018 said that until 2018, there’s still no adoption of financial technology in health services. This paper aimed to determine the important factors of financial technology adoption by hospital clustering with Fuzzy Analytical Network Process (FANP) method. This paper used the questionnaire from 35 hospital experts as the respondents from all around Indonesia. Scope data in this paper came from outpatient unit administration payment in Hospital. Fuzzy Analytical Network Process (ANP) were used to find the most significant factor from Technology, Organization, Environment, Human (TOEH) framework. This paper found that the most important factor and sub-factor for the hospitals in cluster 1 were technology and compatibility. Meanwhile, for the hospitals in the cluster 2, the most important factor was environment and the most important sub-factor was government pressure.

1. Introduction
Financial technology (commonly heard as FinTech), grew rapidly over past 10 years. Mostly, people knew FinTech as a tool for payment. Whereas, financial technology not only about payment, but also about lending, insurance pace, and wealth management. But it was true that one of core function of financial technology is a innovation of payment. The innovation exist because there were a hundred reason why payment process thru traditional bank was not effective. One of the reason was payment process relatively slow and expensive because people had to come to bank and there might a charge by the bank if payment process came from one bank into different bank company [1].

The example of financial technology company until 2017 were PayPal, AliPay, and Paytm. PayPal came as the preceding company who begin payment innovation from traditional payment into a web-based system and of course customer didn’t need to open a bank account. In 2017, PayPal already had a 210 million user/customer all around the world [1].

Financial Technology came from the emergence of technology. It could increase trust and transparency from the customer. It also asset-light and agile. Financial technology would bring a new customer experience and cost-effective impact for customer. Therefore, financial technology still had a challenge in front of it but there were an opportunity too for the company because of regulatory pressure made them free to offer anything for customer [2].

In Indonesia, according to 825 respondents who claim to use Financial Technology services in their devices, Go-Pay, Go-Jek’s digital wallet, is the most popular mobile payment provider (79%),
followed by Lippo’s OVO (58%) and Telkomsel’s Tcash (55%) [3]. Based on their survey, an understanding of Financial Technology in Indonesia increase every year since 2016 until 2018. In 2016 only 26.34% respondent familiar with Financial Technology, while in 2017, the number increase become 67.20%, then in 2018, 70.63% respondent already familiar with Financial Technology. In addition, survey about the reason of respondent use Financial Technology service commonly said that Financial Technology was easy to use (74.9%) and simple (71.03%) [3].

In 2018, from Jakpat Survey said that the example of electronic money that already used in Indonesia were Go-Pay, e-money Mandiri, T-cash, Flazz BCA, LinePay, Ovo, Brizzi, and Dana. Electronic money transaction grew rapidly from 2011 to 2018. According to Bank Indonesia data, electronic money transaction in Indonesia had an average 66% from 2012 to September 2018 [4].

The number of Indonesian population is increasing with 1.13% growth rate, which indicates the need for health and health facilities is increase too [5]. Meanwhile, the total hospital in Indonesia until 2017 was 2,831 with an average increase of 6% from 2012 to 2017. Whereas for hospitals in DKI Jakarta until 2017 there were 201 with an average increase 7% from 2012-2017 [6].

According to a survey conducted by Jakpat in 2016, 59% of respondents expected that in 2017 there would be digital payments to buy train tickets (71.11%), buy airplane tickets (64.65%), buy medicines and health services (63.03%), pay for a taxi (54%), Magazine/Newspaper Subscription (36%), and Salon Services (33%) [7]. Unfortunately, until 2018 in Indonesia there was still no adoption of Financial Technology in Health Service [8].

2. Literature Review

2.1. TOEH Framework

In previous research about the adoption of hospital information system, [9] quest to studied the new framework for technology adoption. They offered the new framework that they called TOEH, the TOEH framework built by combine two framework before, which is TOE and HOT-Fit models. The TOE framework is built by three aspects that directly influence its technological implementation and adoption. TOE consists of technological context, organizational context and the environmental context. While the HOT-Fit Framework emphasizes the importance of human factor in technological implementation and adoption. The HOT-Fit Framework is built by three factors of human, organization, and technology. By combining TOE Framework with HOT-Fit Framework, advantage from TOE framework that can provides details components that influence in technological implementation and adoption, increase with advantage from HOT-Fit Framework that emphasizes the importance of human factor in technological adoption.

![Figure 1. ANP problem structure](image)

As can be seen from the figure 1 that the node can be in different factor, and all sub factor always depend on other sub factor, sub factor in a factor can affect other sub factor in the same factor (inner dependence), and can also affect sub factor in other factor (outer dependence). Besides that, each
factor has a feedback for itself so that it will increase the prediction of ANP and make the results of these predictions more stable.

2.2. Fuzzy ANP

The Analytical Network Process offer the model that can connect upper and lower factor with two direction without restricted hierarchy. The ANP was built from a pairwise comparisons, which that pairwise was create from each criteria and alternative, ANP structures each criteria, (sub criteria if available) and alternative as a network where allows for loops and feedback connections. The eigenvectors of pairwise comparisons use for computing the super matrix where the eigenvectors use as column vectors in the super matrix [9].

In previous study, ANP method was combined with DEMATEL to solve a problem in human resource information system. They used 18 criteria and calculate the biggest weight of those criteria. The result shows that the most important criteria was quality information in human resource information system [10].

Meanwhile, the research conducted by Ramadhani et al. they used the same method (ANP and DEMATEL) to solve a problem in Food SMEs [11]. Unfortunately, from that previous study, ANP and DEMATEL couldn’t be used for this study because this study would solve a complicated decision problem with high uncertainty data.

In addition, there was a study from [12] who also used ANP to select the mechanism of subsidized diesel oil pricing policy in Indonesia. The result said that Price Smoothing Using Price Stabilization Fund had the highest priority in mechanism selection in Indonesia.

To solve problems that maybe complicated and hard to be parsed, an Analytical Network Process (ANP) was better than AHP. An Analytical Network Process can be used to solve some problem with two direction or loop or feedback between each factor better reflect the relationship between layers of the same measurement criteria from AHP [13].

In other version, the ANP can be mixed to the other method to get better result. Which is one of that is Fuzzy Analytical Network Process (FANP). This method combine the Fuzzy method that can process data with high uncertainty.

In this study, ANP method will be handled due to its help for well-structured group discussion with pairwise comparison. Fuzzy ANP is more popular compared to ANP method, since it provides a pairwise evaluation between alternatives by using fuzzy numbers, which gives more sensitive results. Therefore, fuzzy ANP is more suitable for this study based on a TOEH framework, since the location factors are determined based on human decisions. TOEH framework didn’t match with AHP (Analytical Hierarchy Process) because there was no hierarchy structure to find the relationship between factors or sub factors. Besides, Fuzzy ANP allows for complex interrelationships among decision levels and attributes. Because in this study it is necessary to consider the interrelationships among main factors, we had considered these interrelationships and developed the calculations with considering the inner dependence matrix of all main factors. So that’s the reason why this study used fuzzy ANP instead of fuzzy AHP.

2.3. K-means Clustering

Clustering is one method to classify data into groups that have similarity between each data. so many clustering method was developed before, one of the popular method to use is K-Means clustering. K-means clustering is a method that classify the data into some cluster which call "K". Amount of "K" is depend by Sum of Square Error (SSE). With analyze data based on amount of "K", each amount of "K" was represent as centroid which is the nearest point to surrounding data. Each data was calculated by Euclidean Distance to the nearest centroid. After calculated the distance between data and centroid, the next step is calculated the Sum of Square Error (SSE). The smaller the value Sum of Square Error (SSE) obtained that the best "K" should be choice [14].
This study used clustering to separate the hospital based on financial technology coverage and the hospital size. It was because the subsidiaries came from several region all around Indonesia. Every region had a different readiness in terms of financial technology adoption. So that in this study, the hospitals need to be clustered to identify which hospital include in cluster 1, and which hospital include in cluster 2. Type 1 insist of hospital that already had a resource and capability for Financial Technology adoption. Type 2 insist of hospital that had not enough resource and capability for Financial Technology adoption.

3. Methodology
This study used the primary data from selected Indonesian Healthcare Corporate (IHC) subsidiaries. The IHC had 14 hospitals all around Indonesia which possibly became the representative of Hospitals in Indonesia. This study gathered the data from questionnaire that distributed to 35 hospital experts as the respondents from all around Indonesia. All respondent were an expert in IT, finance, and director with more than 5 years of experience in their area. There are 4 factor and 12 sub-factors selected by experts, as follow: Technology factor (F1) consists of four criteria: relative advantage (S1), compatibility (S2), complexity (S3), and security concern (S4). Organizational factor (F2) consists of three sub-factors: Infrastructure (S5), top management support (S6), and financial resources (S7). Environment factor (F3) consists of three sub-factors: mimetic pressure (S8), coercive government pressure (S9), and vendor support (S10). Human factor (F4) consist of two sub-factors: perceived technical competence of staff (S11) and employer knowledge (S12). The second questionnaire of this research were distributed to 35 experts in same hospital and used Likert scale from 1 to 5. After the data gathered, this study used the Fuzzy Analytical Network Process (ANP) to examine the significant factors that should be prepared before financial technology adoption in Hospital.

We detect the proper framework that could be used in this study, using TOEH (Technology, Organization, Environment, and Human) framework. The reason why we chose that framework was we conclude the human category as one of the factor because without human, it would be hard to execute the adoption. The procedure for the method can be summarized as follow:

- Step 1. Identify the factor and sub-factor that will be used
- Step 2. Structured the decision model based on those identified factors and sub-factors in the framework
- Step 3. Design the 3 stage questionnaire. Questionnaire 1 to eliminate the unimportant factor, questionnaire 2 to identify the significance between one sub-factor to others based on a network sub-factors, and questionnaire 3 to perform the weighting of each selected network sub-factors.
- Step 4. Distributed the questionnaire
- Step 5. Use Fuzzy to determine the result of questionnaire 1 and clustering the result of fuzzy with K-Means Clustering based on each hospitals
- Step 6. Build the pairwise comparison of each factors and sub-factors based on questionnaire 2 for each cluster.
- Step 7. Compute the super matrix with eigenvector from step 6 and the result of questionnaire 3 for weighting each factors and sub-factors for each cluster.

4. Results and Discussion
In this research, we got the 35 respondents from selected Indonesian Healthcare Corporate (IHC) subsidiaries all around Indonesia. The largest total respondents were from Pertamina Cirebon Hospital (12 respondents) which located at West Java Indonesia. Respondent data could be used for hospital clustering.
The process of fuzzification and defuzzification are:

1) Make a fuzzy set
   - Turn a linguistic scales into mathematical scales so that the clustering process becomes easier. The linguistic scales 1 to 5 is turning into mathematic scale 0 or 1 to reduce the number of cluster. So to make this scale, it only requires a fuzzy triangle with a middle value of 2.5 as can be seen in figure 2.

![Figure 2. Fuzzy set number](image)

2) Fuzzyfication Data
   - After getting the fuzzy set, the next step is to calculate the membership function of each of the existing questionnaire results data. According to the previous fuzzy set, the membership will be calculated in the 2 fuzzy groups. The value of membership in a data will affect the defuzification process.

3) Defuzification
   - After knew the amount of membership value, in this process the membership value is changed to the fuzzy set identity, in this case the identity used is 0 and 1.

| Hospital                                    | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 |
|---------------------------------------------|----|----|----|----|----|----|----|----|----|-----|-----|-----|
| Pertamedika Holding Group                   | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 0  | 1  | 1   | 1   | 1   |
| Bintang Amin Lampung                        | 1  | 0  | 1  | 1  | 1  | 1  | 0  | 0  | 1  | 1   | 1   | 1   |
| Pertamina Balongan                          | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 0  | 1  | 1   | 1   | 1   |
| Pertamina Plaju (RSPPlj)                    | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 0  | 1  | 1   | 1   | 1   |
| Baiturrahim Jambi                           | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1   | 1   | 1   |
| Pertamina Balikpapan (RSPB)                 | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1   | 1   | 1   |
| Pertamina Cirebon (RSPC)                    | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1   | 1   | 1   |
| Pertamina Jaya (RSPJ)                       | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1   | 1   | 1   |
| Pertamina Pangkalan Brandan (RSPPB)         | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1   | 1   | 1   |
| Pertamina Sorong (RSPS)                     | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 0   | 0   | 1   |
| Pasat Pertamina (RSPP)                      | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1   | 1   | 1   |
| Pertamedika Ummi Rosnati                    | 1  | 1  | 1  | 1  | 1  | 0  | 1  | 1  | 1  | 1   | 1   | 1   |
| Pertamedika Tarakan (RSPTr)                 | 1  | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1   | 1   | 1   |
| Pertamina Rantau (RSPR)                     | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1   | 1   | 1   |

Table 1. Result of fuzzification and defuzzification of each sub-factor

From the result of questionnaire step 1, the next step of this study was we analyze with Fuzzy Algorithm to change the result from likert scale into agree and disagree scale as shown in Table 1. Table 1 shows the result of fuzzification and defuzzification of each hospital. As can be seen from table 1, there was a consistent answer from respondents which means the expert had a similar answer about adoption of financial technology. The next step after fuzzy is clustering with K means. K means algorithm need the determination of the number of groups (k) using total Sum of Square error as shown in figure 3. As can be seen from figure 3, the closest distance from centroid was 2 for the number of K.
After we knew the number of k, we input the result of fuzzy with Financial Technology coverage and hospital size class, then we calculate the data using SPSS and the result could be seen in table 2. Cluster 1 means the hospital already had a resource and capability for Financial Technology adoption and cluster 2 means the hospital had not enough resource and capability for Financial Technology adoption. Based on table 2, there were 2 hospital that became a part of cluster 2, RS Pertamina Sorong and RS Pertamina Rantau. Table 2 also shows the distance of hospitals from centroid after input the value of K. Pertamedika Tarakan Hospital had a longest distance from centroid with value of distance 1.843.

Table 2. Result of hospital clustering with K-Means with SPSS

| Case Number | Hospital                                | Cluster | Distance |
|-------------|-----------------------------------------|---------|----------|
| 1           | Pertamedika Holding Group               | 1       | .629     |
| 2           | Bintang Amin Lampung                    | 1       | 1.109    |
| 3           | Pertamina Balongan                      | 1       | 1.109    |
| 4           | Pertamina Plaju (RSPPlj)                | 1       | .629     |
| 5           | Baiturrahim Jambi                       | 1       | .479     |
| 6           | Pertamina Balikpapan (RSPB)             | 1       | .479     |
| 7           | Pertamina Cirebon (RSPC)                | 1       | .479     |
| 8           | Pertamina Jaya (RSPJ)                   | 1       | .479     |
| 9           | Pertamina Pangkalan Brandan (RSPPB)     | 1       | .479     |
| 10          | Pertamina Sorong (RSPS)                 | 2       | 1.000    |
| 11          | Pusat Pertamina (RSPP)                  | 1       | 1.181    |
| 12          | Pertamedika Ummi Rosnati               | 1       | 1.031    |
| 13          | Pertamedika Tarakan (RSPTtr)            | 1       | 1.843    |
| 14          | Pertamina Rantau (RSPR)                 | 2       | 1.000    |

After knew the cluster of each hospital, then the result of pairwise comparison of each cluster shown in Table 3 and Table 4.
Table 3. ANP priority result for cluster 1

| Factor          | Sub-factor                                      | Sub-factor Weight | Sub-factor Global Weight | Factor Weight | %       | % Cummulative |
|-----------------|-------------------------------------------------|-------------------|--------------------------|---------------|---------|--------------|
| Environment     | Coercive Government Pressure                   | 0.22878           | 0.00994                  | 0.04343       | 4%      | 4%           |
|                 | Mimetic Pressure                               | 0.06515           | 0.00283                  |               |         |              |
|                 | Vendor Support                                 | 0.70606           | 0.03066                  |               |         |              |
|                 | Employers Knowledge                            | 0.83899           | 0.07673                  |               |         |              |
| Human           | Perceived technical competence of payment administration | 0.16101               | 0.01472                  | 0.09145       | 9%      | 13%          |
|                 | Financial Resources                            | 0.68727           | 0.19293                  |               |         |              |
|                 | Top Management Support                         | 0.072             | 0.02021                  |               |         |              |
|                 | Compatibility                                  | 0.24072           | 0.06757                  |               |         |              |
|                 | Complexity                                     | 0.42022           | 0.24558                  |               |         |              |
|                 | Relative Advantage                             | 0.04654           | 0.02720                  |               |         |              |
|                 | Security Concern                               | 0.11339           | 0.06627                  |               |         |              |
|                 | Technology                                     | 0.41984           | 0.24555                  | 0.5844        | 58%     | 100%         |

As shown in table 3, for cluster 1, technology factor became the greatest weight in financial technology adoption. It indicates that hospitals in cluster 1 was already had enough resource and capability for financial technology adoption and they only need to consider about compatibility and security concern before adoption. Besides, another factor that need to be prepared was financial resource from organization factor. It indicates that hospital in cluster 1 also need to review the financial condition of hospital before financial technology adoption.

Table 4. ANP priority result for cluster 2

| Factor          | Sub-factor                                      | Sub-factor Weight | Sub-factor Global Weight | Factor Weight | %       | % Cummulative |
|-----------------|-------------------------------------------------|-------------------|--------------------------|---------------|---------|--------------|
| Environment     | Coercive Government Pressure                   | 0.47041           | 0.30039                  | 0.63858       | 64%     | 64%          |
|                 | Mimetic Pressure                               | 0.06957           | 0.04443                  |               |         |              |
|                 | Vendor Support                                 | 0.46002           | 0.29376                  |               |         |              |
|                 | Employers Knowledge                            | 0.87601           | 0.19002                  |               |         |              |
| Human           | Perceived technical competence of payment administration | 0.12399               | 0.02689                  | 0.21691       | 22%     | 86%          |
|                 | Financial Resources                            | 0.69543           | 0.03533                  |               |         |              |
|                 | Top Management Support                         | 0.06764           | 0.00344                  |               |         |              |
|                 | Compatibility                                  | 0.23693           | 0.01204                  |               |         |              |
|                 | Complexity                                     | 0.15476           | 0.01450                  |               |         |              |
|                 | Relative Advantage                             | 0.65075           | 0.06098                  |               |         |              |
|                 | Security Concern                               | 0.04336           | 0.00406                  | 0.0937        | 9%      | 100%         |
| Organization    | Financial Resources                            | 0.87601           | 0.19002                  |               |         |              |
|                 | Top Management Support                         | 0.23693           | 0.01204                  |               |         |              |
|                 | Compatibility                                  | 0.15476           | 0.01450                  |               |         |              |
|                 | Complexity                                     | 0.65075           | 0.06098                  |               |         |              |
|                 | Relative Advantage                             | 0.04336           | 0.00406                  |               |         |              |
|                 | Security Concern                               | 0.15113           | 0.01416                  |               |         |              |

As shown in table 4, for cluster 2, environment factor became the greatest weight in financial technology adoption. It shows that environment condition of hospital in cluster 2 still not support for financial technology adoption. There was a lag of government support and no financial technology coverage in their region so that financial technology adoption became harder than in cluster 1. Besides, another factor that need to be prepared was employer knowledge from human factor. It
indicates that hospital in cluster 2 also need to deploy the employee so they could understand how financial technology could works together with hospital integrated system.

5. Conclusions and future research

This aim to determine the important factors of financial technology adoption by hospital clustering with Fuzzy Analytical Network Process method. The result showed that from selected Indonesian Healthcare Corporate (IHC) subsidiaries which had 14 hospitals all around Indonesia, divide into two cluster. In cluster 1, the greatest weight was technology factor with compatibility sub-factor and hospital in cluster 2, the greatest weight was environment factor with coercive government pressure sub-factor. The next stage that should be done by hospital for cluster 1 was adjust the existing system with financial technology system and for cluster 2 give an advice to government to became faster in supporting the financial technology adoption so the financial technology provider could grows rapidly in their region.

This research had a limitation of lack of total respondent and still not focus on one region that could adopt financial technology and there was still no risk assessment if the hospital not succeed in financial technology adoption. Future research should consider about the total respondent or focus on one region for a better result. Beside, future research could make a risk assessment if the hospital not succeed in financial technology adoption.

References

[1] Amalia F. 2016 The Fintech Book: the Financial Technology Handbook for Investors, Entrepreneurs and Visionaries. Journal of Indonesian Economy and Business 31 345-8.
[2] Dalgleish T. 2007 Fintech the technology driving disruption in the financial services industry. (New York: CRC Press) 136:x-xi.
[3] DailySocial. 2018 Fintech Report 2018 [internet]. Available from : dailySocial.id.
[4] Bank Indonesia. 2018 Jumlah Transaksi Uang Elektronik Beredar. (Jakarta: Bank Indonesia).
[5] Dachyar M, Farizal, Minar IP. 2018 MATEC Web Conf. 248 03015.
[6] The Ministry of Health of the Republic of Indonesia. 2018 Jumlah Rumah Sakit di Indonesia. (Jakarta: Sirs Yanke The Ministry of Health of the Republic of Indonesia).
[7] Jakpat. 2016 JakPat Survey Report [internet]. Available From : Jakpat.net.
[8] Jakpat. 2018 JAKPAT Survey Report [ internet]. Available from : Jakpat.ne.
[9] Nilashi M, Ahmadi H, Ahani A, Ravangard R, OB Ibrahim. 2016 Technol Forecast Soc 111 244–64.
[10] Siregar E, Dachyar M. 2018 MATEC Web Conf 248 4.
[11] Ramadhani Y, Dachyar M, Farizal. 2018 MATEC Web Conf 248 4-5.
[12] Hardiati I, Dachyar M, Yadrifil 2015 Int. J. Appl. Eng. Res 10 38842–4.
[13] Wu T, Liu X 2016 Kybernetes 45 1486–500.
[14] Raval UR, Jani C. 2016 Int. J. Comput. Sci. Mob. Comput 55 191–203.