ICT Development and Food Consumption: An Impact of Online Food Delivery Services

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Abstract: The online food delivery (OFD) service has grown globally. The growth of OFD depends on the ICT development where the online business could grow in a region. This study departs from the question, "does ICT development impact the food consumption of society?" The answer is likely to provide evidence for the ICT impact on a new issue: food consumption. In the Indonesian context, the study objectives are: (1) to investigate the pattern of ICT development among provinces in Indonesia; (2) to investigate the pattern of food consumption indicators among provinces; (3) to cluster provinces based on ICT development and food consumption; (4) to deploy a predictive model into another dataset. This study takes place in Indonesia, where the OFD revenue was projected about $800 million by 2021. This secondary and quantitative research adopted a data mining approach by analyzing data of ICT development and food consumption among Indonesian provinces. The clustering analysis indicated that provinces with higher ICT development have higher food consumption. The result is likely to explain the impact of the OFD growth. Managers of OFD platforms might use the finding to decide which provinces to focus on for their marketing strategy. As a prominent actor for ICT development, the government might use the result to formulate a better plan to improve ICT access. This study suggests that the government and OFD platforms promote healthy food eating to improve public health. The use of official statistics and data mining approach provides this research with generalized findings at the country level. Further studies are needed to obtain a generalization of the results beyond Indonesia.

1 INTRODUCTION

The online food delivery (OFD) service has grown globally, with a value of $126.91 billion at a compound annual growth rate of 10.3% in 2021, as reported by ReportLinker. OFD covers services that deliver prepared meals and food ordered online for direct consumption. Some OFD services in western countries are Just Eat, Uber Eats, and Deliveroo. In Asian countries, for example, GrabFood operates in six ASEAN countries: Indonesia, Singapore, Philippines, Malaysia, Vietnam, Thailand, and Myanmar, as presented in its site food.grab.com (accessed 19th Nov 2021). In addition, FoodPanda has been operated in 12 Asian countries, such as Japan, Hongkong, Pakistan, and Singapore, as shown on its site foodpanda.com (accessed 19th Nov 2021).

Online Food Delivery could be classified into two business models based on the ordering and delivery process. First, the Restaurant-to-Consumer model refers to the order made directly through a restaurant app/website (e.g., Domino's, McDonald's) or via a third-party platform (e.g., Just East). The delivery of meals is conducted directly by the restaurants. OFD offered by each restaurant or food outlet has been practiced for quite a long time. Second, the Platform-to-Consumer Delivery model refers to a third-party platform that typically intermediaries between customers and food vendors. Customers make orders through online applications. Their orders are sent to food vendors, where foods are prepared and then delivered to customers by agents/employees (delivery boys) associated with OFD service (Keeble et al., 2020). According to a report published by Statista (2021a), the global revenue in the Restaurant-to-Consumer Delivery segment was about $122 billion in 2021, with its annual growth rate of 11.16%, while the Platform-to-Consumer Delivery segment's revenue was $148 billion in 2021, with its annual growth rate of 9.74%.

During the Covid-19 pandemic, online food ordering has dropped in the early pandemic, as the closure of many businesses and the customer's fear. After some businesses resume their operation with

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some restrictions, the OFD platform becomes the solution for customers to buy food. Restaurants that offer online ordering during the pandemic benefit from enhancing customer experience, retaining its customer, and receiving revenue (Gavilan et al., 2021). OFD platform contains features such as online review, online rating, and online tracking, which influence customer satisfaction and the intention to reuse the application (Alalwan, 2020). A survey among OFD customers in Bandung found the direct effect of food quality on online loyalty, but not e-service quality (Suhartanto, Ali, et al., 2019).

The growth of OFD depends on the ICT availability and accessibility in the region. It is measured by ICT Development Index (IDI), published annually since 2009. IDI comprises three sub-index: ICT access, ICT use, and ICT skills. Until 2017, IDI was composed of 11 indicators and, starting from 2018, by 14. In addition, new indicators were added, such as the percent of individuals who own a mobile phone, and some were discarded, such as fixed broadband subscription per 100 inhabitants. The IDI framework specified that IDI leads the ICT impact (ITU, 2017).

The economic impact of ICT development in a country or region has been widely explored (e.g., Appiah-Otoo & Song, 2021). The relationship between ICT measures (e.g., ICT penetration) and economic indicators (e.g., GDP growth) has been summarized (Vu et al., 2020). Also, the impact of ICT on social life, such as leisure activities and traveling, was documented (Mokhtarian et al., 2006). Overall, the result of ICT development in a country or region is apparent, whether directly or indirectly.

This study departs from the question, "Does ICT development impact the food consumption of society?" This question arose from the emerging OFD in many countries, including Indonesia. The objectives are: (1) to investigate the pattern of ICT development among provinces in Indonesia; (2) to investigate the pattern of food consumption indicators among provinces; (3) to cluster provinces based on ICT development and food consumption; (4) to deploy a predictive model into other datasets. The unit of analysis is Indonesian provinces.

The remainder of the paper is designed as follows. Section 2 presents a literature review on ICT development and OFD. Section 3 describes methods, framework, and variables. Moreover, the results and discussions are presented in Section 4, with the conclusion and recommendation in Section 5.

2 RELATED WORK

This literature review section was aimed to lead the idea that ICT development relates to the consumption level through the emerging OFD segment. This short review subsequently presents the impact of OFD, ICT development, and an overview of OFD services in Indonesia.

2.1 Impact of OFD

The online food delivery (OFD) segment has been investigated its relation to various issues. A prior study discussed the impact of OFD on diet and diet-related health (Bates et al., 2020). An example of public health nutrition policy is mandatory to provide consumers with energy content information. As an OFD platform manage the partnership with many food vendors, it may have little control for the outlets to meet the policy. A good case in Australia, Deliveroo, as an OFD platform, is committed to presenting its food vendors' energy information (Bates et al., 2020).

The impact of OFD was investigated based on three aspects of sustainability: economic, social, and environment (Li et al., 2020). The study specified that the OFD provides transaction opportunities to food vendors and employment to independent riders/drivers as delivery people. However, the negative impact was also identified, such as the high charge fee to food vendors, the social impact on public health, and the environmental impact on the increasing waste and carbon footprint. The investigation of the OFD impact on the environment estimated that 86% of CO_2 equivalent came from the food package (Xie et al., 2021). OFD platform and food vendors could reduce a portion of the food package, for example, by rewarding consumers who do not require disposable spoons, forks, chopsticks, and napkins.

The relationship between OFD services and consumption was investigated based on the existing Theory of Consumption Value (Kaur et al., 2020). The paper tested whether the six dimensions of consumption values relate to the intention to use OFD applications. The study reported that price value and visibility were significant predictors to order food online through the OFD platform, but health-consciousness and food-safety concerns were not.

A previous survey among young people confirmed that the online service quality from the OFD platform and the food quality from the food vendor lead to customer satisfaction (Suhartanto, Dean, et al., 2019). Furthermore, the satisfied

consumers would repurchase, recommend to others, and pay more. Therefore, as OFD continuously improves its features, promotion programs, and more varieties of food offered, more people will order food online. (Suhartanto, Dean, et al., 2019). Consequently, food consumption increases.

The OFD platform regularly makes extensive advertisements to broaden its visibility and offer attractive prices or promotions. These are likely to lead more consumers to order food online. In addition, less concern about food health and food safety means more people order food online. As a result, the OFD segment becomes a new and emerging economic activity, replacing how people consume foods and increasing consumption. For example, a study in China indicated the escalating consumption from food delivery services (Maimaiti et al., 2018). Therefore, OFD platforms stimulate more consumption.

Literature indicated that some researchers used the term online-to-offline (O2O) food delivery for a similar meaning of OFD. The O2O service platform is defined as a marketing channel that facilitates customers to order local, daily services online via apps and deliver them directly offline (Zhang et al., 2019). There are four alternative modes for O2O food delivery: (1)the self-built platform and self-delivery, (2) the self-built platform and third-party delivery, (3) the third-party platform and self-delivery, and (4) the third-party platform and third-party delivery (Du et al., 2021). As described earlier, these four have the same classification as Restaurant-to-Consumer and Platform-to-Consumer.

2.2 ICT Development

ICT has entered many aspects of human life, the organization and business operations, public services, and international cooperation. As a result, countries pursue ICT development as a global performance measure. This global measure is named the ICT Development Index (IDI), published annually by the United Nations International Telecommunication Union (ITU, 2017). Overall, IDI consists of 11 measures such as the percentage of households with internet access, percentage of individuals using the internet, and mobile broadband subscription. ICT access refers to the availability of the mobile network and international bandwidth. ICT use contains measures such as the percentage of individuals using the internet or mobile broadband subscription. Finally, ICT skills relate to the education levels, such as year schooling.

Most of the literature indicates a positive impact of ICT on economic growth. For example, a prior study contended that ICT increased economic growth in rich and developing countries. However, developing countries are inclined to gain more from ICT development (Appiah-Otoo & Song, 2021). Similarly, the study among selected developing countries in the Middle East, North Africa, and Sub-Saharan Africa confirmed the impact of ICT development on ICT growth (Bahrini & Qaffas, 2019). Furthermore, the association between ICT development and economic (GDP) growth among OECD EU countries was also confirmed (Antonio Fernández-Portillo et al., 2020).

The availability of ICT infrastructure (e.g., mobile network) and adequate ICT skills enable entrepreneurs (e.g., food vendors) to enter online commerce. Entrepreneurs could develop their applications or join a third-party platform (e-marketplace). Moreover, access to the mobile network or fixed broadband enables customers to order online. The education level could be related to the person's ability to use an ICT device. Therefore, it is logical to link ICT with the increasing OFD services. The concluding concept from this short review is that ICT development enables the emerging OFD, which subsequently increases consumption.

2.3 OFD in Indonesia

The primary OFD Platform-to-Consumer services in Indonesia are GoFood and GrabFood, plus recently emerging Shopee Food. Based on a survey conducted by Rakuten Insight, around 78% of respondents in Indonesia selected GoFood as the OFD app they used. Similarly, 71% chosen GrabFood (Statista, 2021b). In Indonesia, the couriers are not OFD service's employees but independent partners. This new business model has generated millions of jobs in the informal sector. The Indonesian statistics agency (BPS) reported that 59.45% of employment would come from the informal sector by August 2021.

For the OFD Restaurant-to-Consumer services, the fast-food restaurant chains such as KFCs. McDonald, and Pizza Hut, provide their delivery services. However, these big chain restaurants also implement OFD Platform-to-Consumer services for customer preferences in actual practice.

OFD services have been available to all Indonesian provinces. Based on the data released by Statista, Figure 1 presents the bar chart of the total revenue from the Restaurant-to-Consumer and the Platform-to Consumer segments (Statista, 2021c). The revenue growth showed a logarithmic pattern

rather than linear. The projected total revenue from both segments was $803 million by 2021. In addition, revenue per segment for Restaurant-to-Consumer is higher ($52.51 in 2021) than Platform-to-Consumer ($32.06 in 2021), as reported by Statista.

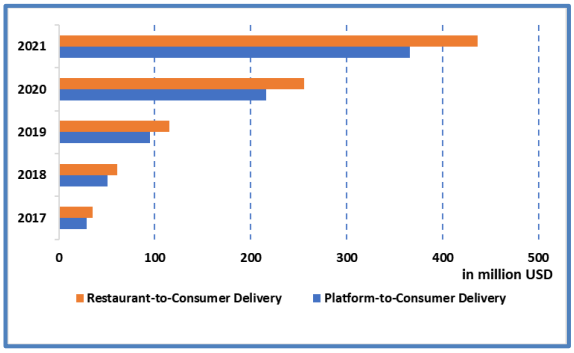

Figure 1: Revenue of online food delivery in Indonesia (Statista, 2021c).

3 METHODS

This research was categorized as secondary and quantitative research. Then, it adopted a data mining approach implemented using the CRISP-DM framework (Martinez-Plumed et al., 2019). The framework consists of six steps: Research (Business) understanding, Data understanding, Data preparation, Modelling, Evaluation, and Deployment. Moreover, Data mining was conducted using the Knime Analytics Platform, an open-source software.

This study used the official statistics published by the Indonesian Central Bureau of Statistics. Data were classified into two groups. First, the indicator of ICT development was taken from the ICT development index as the world composite measure of ICT development between countries. This index is composed of three sub-index ICT usage sub-index (40%), ICT access sub-index (40%), and ICT skill sub-index (20%). For example, the ICT usage index consists of (1) percentage of individuals using the internet, (2) fix broadband subscriptions per 100 inhabitants, and (3) active mobile broadband subscriptions per 100 inhabitants. Second, the indicator for food consumption consists of four indicators covering food expenditure in an urban area, food expenditure in a rural area, amount of protein consumed, and the number of calories consumed.

Based on section 2, a conceptual framework was developed by linking ICT development, online food delivery, and food consumption, as shown in Figure 2. However, data about OFD services in each province, such as the total sales or orders, was not available. Therefore, the working framework links the variables of ICT Development and food consumption variables, as shown in Figure 3.

Figure 2: Conceptual framework.

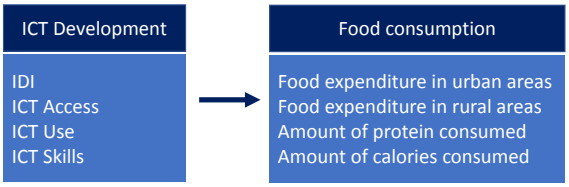

Figure 3: Working framework.

The unit of analysis is Indonesia province. From the total 34 provinces, Jakarta as a special capital city region was removed from the analysis because it has no rural data. The ICT development index and online food ordering service are higher than in other provinces. Therefore these 33 provinces entered in the analysis, in order of their location from west to east: 1.Aceh, 2.North Sumatra, 3.West Sumatra, 4.Riau, 5.Jambi, 6.South Sumatra, 7.Bengkulu, 8.Lampung, 9.Bangka Belitung Isl. , 10.Riau Islands, 12.West Java, 13.Central Java, 14.Yogyakarta, 15.East Java, 16.Banten, 17.Bali, 18.West Nusa Tenggara, 19.East Nusa Tenggara, 20.West Kalimantan, 21.Central Kalimantan, 22.South Kalimantan, 23.East Kalimantan, 24.North Kalimantan, 25.North Sulawesi, 26.Central Sulawesi, 27.South Sulawesi, 28.Southeast Sulawesi, 29.Gorontalo, 30.West Sulawesi, 31.Maluku, 32.North Maluku, 33.West Papua, 34.Papua.

Data analysis was performed using Knime's workflows. Figure 4 presents the basic workflow for plotting and clustering consisting of several nodes shown by colorful small boxes.

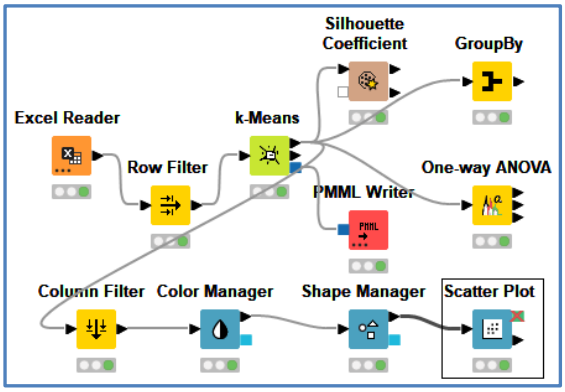

Figure 4: Knime's workflow.

4 RESULT AND DISCUSSION

This section was structured to answer each objective.

4.1 The Pattern of ICT Development

The overall ICT development index (IDI) was plotted against provinces, as shown in Figure 5. Provinces were ordered based on their official position from west to east of the Indonesian area—the four-line graphs representing the year 2017 to 2020 show a similar pattern. The highest IDI is Yogyakarta (YO), and the lowest is Papua (PA), as shown in Figure 5.

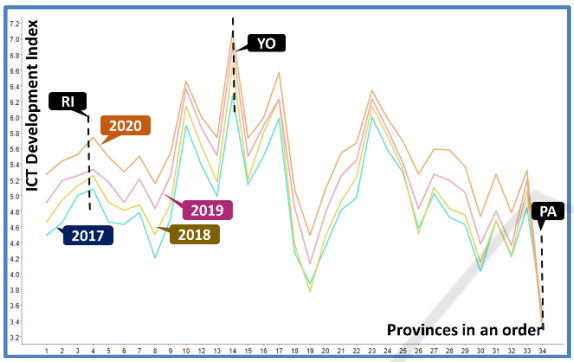

Figure 5: ICT Development Index among provinces.

The graph shows the increasing IDI from 2017 to 2020. Some provinces experience a high increase, led by a significant gap between years, such as Riau (RI). A high rise in IDI means a substantial improvement in the ICT access and infrastructure (e.g., percentage households with internet access) and ICT use (e.g., broadband subscribers).

4.2 The Pattern of Food Consumption

Figure 6 presents the line graph of food expenditure (thousand IDR) in the urban area among provinces for 2017-2020. It appears that the gap among provinces is considerably high. The highest expenditure took place in East Kalimantan (EK), and the lowest was West Sulawesi (WS) in 2020. The increase in spending over the period appears from the gap. Inflation also contributed to the rise that happened during the period. The Indonesian statistics agency released the data that the consumer price index for food in 2020 (2018 as a base year) indicated the inflation of 5.6% and food expenditure growth of 10.1%. The highest expenditure increase is observed for West Papua (WP).

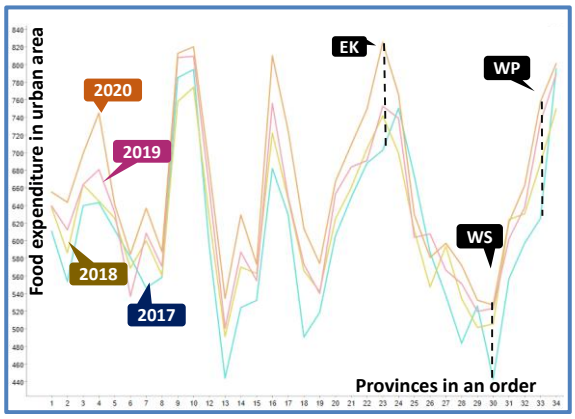

Figure 6: Food expenditure in the urban area.

As shown in Figure 7, the protein consumed per inhabitant varies among provinces. The highest is West Nusa Tenggara (WT), and the lowest is Papua (PA). The line graph indicates that some provinces experienced a decrease from 2017, such as South Sumatra (SS).

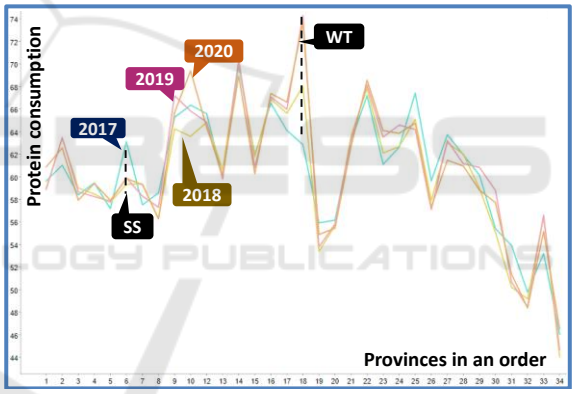

Figure 7: Protein consumption among provinces.

4.3 Clustering

4.3.1 Cluster Model

The modeling and evaluation phase of CRISP-DM was implemented. The objective of cluster modeling was to group provinces based on the ICT development and food consumption variables. The year 2020 was the pandemic period with the non-normal condition; therefore, the clustering used 2019 data. The k-means algorithm was adopted because of its simplicity and the reasonably small number of objects (33 provinces). The evaluation of the model was conducted based on two aspects. First was the number of clusters (k), which was determined as 2,3,4 by considering the number of objects, evaluated using

the Silhouette coefficient. The second was the variables significantly different between clusters.

Preliminary k-means clustering was performed with four variables of ICT and four of food consumption. The position of cluster members was investigated from scatter plots to detect any outliers. It was found that Papua province does not have closeness with others. For example, it has a high score in food expenditure in an urban area, but the lowest in the amount of protein consumed, as discussed earlier. Therefore, Papua was excluded for further clustering. The clustering result was examined with an ANOVA test to find which variables significantly differentiated between clusters. The test found two insignificant variables: ICT skill and the calories consumed. Thus, both were excluded for further analysis.

Clustering was performed with six variables. First, K-means clustering was performed for cluster size k=2, 3, or 4. Then, the optimum k was evaluated with the mean score of the Silhouette coefficient (range -1 to 1), as shown by Table 1. The highest mean score is 0.396 for k=2. The mean score +1 means clusters are well apart and distinguished, while 0 indicates the undistinguished clusters. The score of 0.396 implies that the two clusters are somewhat separated. The clustering result grouped the remaining 32 provinces into two (k=2), with 19 (cluster A) and 13 (cluster B).

- Cluster A: Aceh, North Sumatra, Jambi, South Sumatra, Bengkulu, Lampung, Central Java, East Java, West Nusa Tenggara, East Nusa Tenggara, West Kalimantan, North Sulawesi, Central Sulawesi, South Sulawesi, South-East Sulawesi, Gorontalo, West Sulawesi, Maluku, North Maluku
- Cluster B: West Sumatra, Riau, Bangka Belitung Isl., Riau Islands, West Java, Yogyakarta, Banten, Bali, Central Kalimantan, South Kalimantan, East Kalimantan, North Kalimantan, West Papua

Table 1: Cluster size and Silhouette coefficient.

k	cluster size	Silhouette coef. each cluster [-1 to 1]	Silhouette coef. overall
2	19,13	0.450, 0.317	0.396
3	11,12,9	0.328, 0.093, 0.355	0.247
4	12,4,8,8	0.251, 0.147, 0.038, 0.284	0.196

The characteristics of clusters A and B were investigated through their normalized mean scores of all six variables using Knime's Groupby node. Table 2 shows the mean scores and indicates that cluster A has higher mean scores for all six variables than cluster B. In addition, the p-value from the ANOVA test was presented in the table to show that the protein consumption variable is significant at $p<0.01$, while the other five are at $p<0.001$. These significances confirm that all variables' mean is different between the two clusters.

Table 2: Normalized mean value.

Variable	A	B	p-value
IDI	0.46	0.69	0.000
ICT access	0.44	0.63	0.000
ICT use	0.47	0.79	0.000
Food exp. rural area	0.25	0.67	0.000
Food exp. urban area	0.26	0.67	0.000
Protein consumption	0.49	0.66	0.009

4.3.2 Cluster Plotting

Figure 8 presents the cluster members based on the IDI and food expenditure in urban areas. Provinces in Cluster B are likely to have higher IDI and food expenditure in urban areas. For example, Riau (RI) Province has high IDI and food expenditure in an urban area. Conversely, East Nusa Tenggara (ET) has a relatively low score for both variables. Yogyakarta (YO) has the highest IDI among provinces but low food expenditure for rural areas.

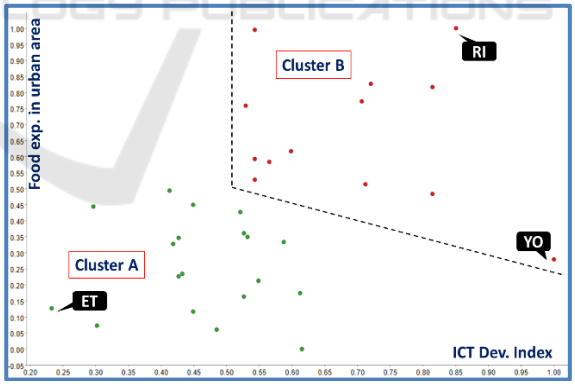

Figure 8: IDI vs. food expenditure in an urban area.

Figure 9 presents the cluster members based on the ICT use and food expenditure in rural areas. Provinces in cluster A tend to have lower ICT use and food expenditure in rural areas than in cluster B. The remote provinces, such as West Papua (WP) and North Kalimantan (NK), have relatively high ICT use and food expenditure in rural areas. In contrast, two provinces of cluster A are marked in Fig. 9. East Nusa Tenggara (ET) and Aceh (AC).

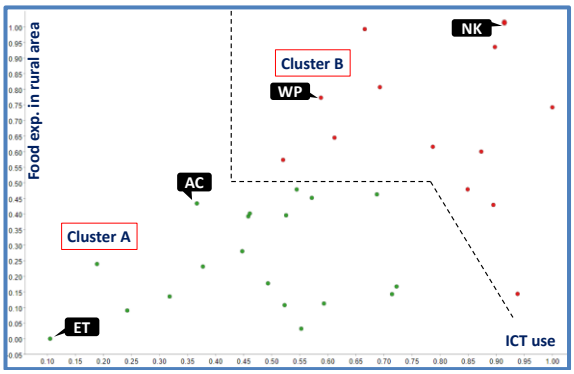

Figure 9: ICT use vs. food expenditure in a rural area.

Figure 10 displays the distribution of provinces based on the protein consumed and food expenditure in an urban area. It indicates that provinces with high food expenditure in urban areas have more protein consumption. Some provinces are shown in the figure. Bangka Belitung Island (BB) has high food expenditure and protein consumption. Contrary, East Nusa Tenggara (ET) has relatively low food expenditure and protein consumption. North Maluku (NM) with the lowest protein consumed but food expenditure around the median value among provinces.

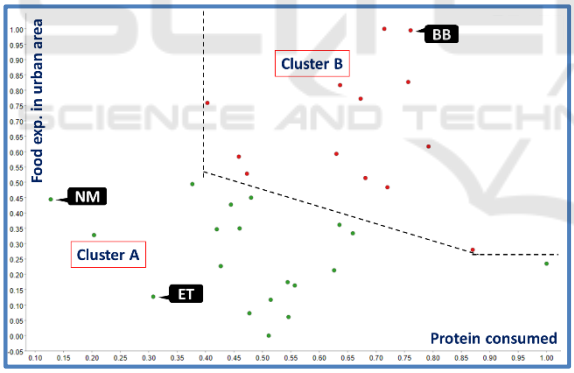

Figure 10: Protein consumption vs. food expenditure in an urban area.

4.3.3 Predictive Modeling

The clustering using dataset 2019 produces a predictive model in the PMML format. This model was applied (deployed) to datasets 2017, 2018, and 2020 to observe which provinces shift their cluster membership. The model deployment revealed that seven provinces experienced shifting their relative position between the two clusters. Table 3 presents the shift and the ICT use index. Provinces shift from A to B indicates the increasing ICT development and food consumption. West Papua and West Nusa Tenggara present their movement from A to B with the significant increase in ICT use.

Table 3: ICT use index and cluster membership shift.

Province	2017	2018	2019	2020
West Nusa Tenggara	3.01 A	3.09 A	3.87 A	4.28 B
West Papua	3.70 A	4.04 B	4.35 B	4.58 B
North Sumatra	3.38 A	3.72 B	4.19 A	4.72 A
Jambi	3.53 A	3.93 B	4.29 A	4.93 A
Bengkulu	3.55 A	3.61 B	4.12 A	4.58 A
North Sulawesi	4.62 B	4.55 B	4.72 A	5.15 B
Yogyakarta	5.01 B	5.44 B	5.65 B	5.91 A

4.4 Summarized Findings

The variation between provinces about the ICT development and the food consumption indicators is relatively high. Variations in geographic, demographic, economic, and cultural attributes will likely influence ICT development and food consumption. Furthermore, all provinces experienced an increase in ICT development. However, provinces with lower existing scores shared higher growth of ICT development scores. This fact shows that the government has made significant ICT development in those provinces. The analysis indicated that the ICT development was positively associated with food consumption among Indonesian provinces. Therefore, this growth of OFD services and increasing online consumers could be attributed to this association.

5 CONCLUSIONS

This study investigated the relationship between ICT development and food consumption based on growing OFD customers. The analysis of official statistics among Indonesian provinces indicates that provinces with higher ICT development have higher food consumption. This research gives the macro social-economic perspective to support other OFD related studies, mostly taking customers' views. The use of official statistics and data mining approach provides this research with generalized findings at the country level. However, this approach might imply some limitations. For example, the food expenditure

data do not differentiate the portion bought from online or conventional channels. Moreover, the generalization of the finding is limited to Indonesian provinces. Further studies for countries with growing online food delivery services could generalize.

Managers of OFD platforms might use the finding to decide which provinces to focus on for their marketing strategy. Similarly, as a prominent actor for ICT development, the government might use the result to formulate a better plan to improve ICT access. The growth of OFD, especially the Platform-to-Consumer segment, will give a big multiplier economic impact, at least for food vendors and delivery people. In addition, increasing food consumption could heighten obesity or diet-related disease in society. Therefore, the government and OFD platforms should promote healthy food eating to improve public health.

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