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RESEARCH ARTICLE

Examining the Fintech Ecosystem of ASEAN-6 Countries

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Abstract: Fintech is the driving force behind the digital economy, with the goal of improving cross-national interaction. However, the future development of Fintech in ASEAN-6 remains ambiguous, with little attention paid to an investigation. This study, therefore, aims to examine the Fintech ecosystem in ASEAN-6 countries by constructing a Fintech Index over the period of 2017 to 2019. This index consists of the readiness and capacity to participate in Fintech activity, the level of demand for Fintech services, and the possible future growth of Fintech. To achieve this objective, this study employs the averaging methods, that is, arithmetic mean, geometric mean, and entropy form. The results show that Singapore has the strongest Fintech ecosystem, followed by Thailand, Malaysia, Vietnam, Indonesia, and the Philippines. The findings imply that there is no single nation dominating the index by overlapping all aspects; ASEAN-6 countries are advised to resolve the major obstacles to enhance the Fintech development.

Keywords: fintech index, fintech ecosystem, ASEAN-6, arithmetic mean, geometric mean, entropy form

Fintech is the result of the merger between finance and technology involving an extensive range of financial services from mobile payments, transfers, peer-to-peer lending and crowdfunding, dispersal into the new blockchain world, cryptocurrencies, and Robo investing. John Reed, Citicorp's president, was probably the first person who coined the word Fintech (Nicoletti, 2017).

Technology has impacted various sectors, as there is no exception to the financial industry. It transforms the financial market into a more digitalized industry with the invention of new innovative financial services and products, which has been regarded as Fintech. The Fintech revolution (2015) stated that Fintech redeploys the role of traditional financial institutions through the introduction of cost-efficient financial services and products to underserved consumers. PricewaterhouseCoopers' (2016) survey revealed that 83% of financial firms thought their businesses were endangered by Fintech.

Overall, Fintech has evolved from phase 1.0 to 3.5, as suggested by Arner et al. (2015). It evolved from analog to digital and later the improvement of digital technology for communication and business during phase 2.0. Further, the emergence of new start-up and technology companies in developed countries, which offer Fintech products and services, happened in phase 3. Latest, the emerging and developing countries

in Asia and Africa are trying to improve their economic growth through the introduction of Fintech. In this vein, the development of Fintech is taking place with no exception to the ASEAN countries (Muhn, 2020).

According to the United Overseas Bank et al. (2019), Fintech in ASEAN countries is still in its nascent stages. Based on the statistics from United Overseas Bank et al. (2019), there are only 7% of the Fintech firm with more than 10 years incorporation and the majority of Fintech firms are only within 2–5 years incorporation in ASEAN countries.

Soriano et al. (2019) reported about the distribution of Fintech firms was found highest in Singapore, accounting for 29%, then in Indonesia (17 %), Malaysia (11%), Thailand (10%), Philippines (7%), Cambodia (4%), Vietnam (3%), and Myanmar (1%) in the year 2019. Hence, it is interesting to investigate how the uneven distribution of Fintech firms in ASEAN countries differs within the same geographical region.

In addition, the total investment in Fintech in ASEAN countries is booming significantly from $35 million in 2014 to $1148 million in 2019 (United Overseas Bank et al., 2019). This phenomenon signifies that investors are very assured of the future development of Fintech in ASEAN countries. Yet, a deficiency in the detailed examination of the Fintech ecosystem may hurt the projection of viable competitiveness of Fintech in ASEAN countries.

Moreover, past studies on the Fintech ecosystem in ASEAN are quite limited. The weaknesses and strengths of the Fintech ecosystem in each ASEAN country remain ambiguous. Therefore, this study seeks to fill these gaps by constructing a Fintech ecosystem index for ASEAN countries by fitting in the most important components as key indicators to support policymakers in decision-making. Thereby, each country is able to seek opportunities from their strength and resolve their deficiency to foster their Fintech growth.

Most importantly, a detailed examination of the component of Fintech's growth helps to boost their economic growth by drawing up an effective policy that supports Fintech's development in ASEAN-6. Apart from that, a true understanding of the Fintech readiness in ASEAN-6 will guide the investment decisions of investors and industry players. In short, the assessment of such valuable findings enables the successful development of Fintech in ASEAN-6 and forms the basis for effective policymaking.

Also, Fintech is a complex phenomenon that has many consequences (Iman, 2020). The development of Fintech is hampered by several factors. It may not be possible to draw up an effective policy by looking only at a single indicator. The combination of various indicators into one figure can contribute a diverse finding that is useful for developing a sound policy. Thus, a composite index is constructed in this study to provide valuable insights into Fintech's growth in ASEAN-6.

The remainder of the study is organized as follows. Section 2 explains the conceptual framework and related past literature on the Fintech ecosystem. Section 3 deliberates the data and methodology involved in constructing the index. Next, Section 4 shows the results attained. Finally, Section 5 concludes the study.

Past Studies

According to Castro et al. (2020), the socio-technical system theory was found to be fitting in defining the roles and connections between the actors such as Fintech start-ups, government, traditional financial institutions, technology developers, customers, and investors within a Fintech ecosystem. This theory demonstrates that structure, people, technology, and tasks are highly interrelated and considered within two interdependent systems, which are social system and technical system. As such, the Fintech ecosystem will be determined through three perspectives: human actors, institutions, and technologies in this study.

Besides, Ernst and Young (2016) declared that the benchmark of the Fintech ecosystem offers the best indicator of Fintech's potential growth. Looking at the previous literature, only a few articles and reports (such as Koonprasert & Mohammad, 2020; Ernst and & Young, (2018); Brett, 2017; Nicoletti, 2017; and Diemers et al., 2015) address the core components of a strong Fintech ecosystem.

Firstly, as stated by Koonprasert and Mohammad (2020), Center for Latin American Monetary Studies (2019), Ernst and Young (2018) Brett (2017), and Diemers et al. (2015), a well-defined regulatory structure is required to establish the favorable atmosphere for Fintech growth. This is because an increasing regulatory transparency will draw more business and foster creativity in Fintech. Likewise,

Fintech's success requires government support in terms of financial aid and tax incentives (Koonprasert & Mohammad, 2020). The empirical findings from Haddad and Hornuf (2019) also showrd that there is a positive relationship between market regulation and the number of Fintech start-ups. Hieminga and Lande (2016) also suggested that an unfavorable political environment will make the Fintech investment less attractive.

Besides, technologies are important in Fintech ecosystem, as mentioned by Ernst and Young (2018) and Nicoletti (2017). The study from Lewan (2018) also showed that most people agreed that the mobile Internet is an important factor in Fintech's growth. This is because the widespread technology infrastructure makes it easier for Fintech to reach more consumers. Similarly, the empirical findings from Laidroo and Avarmaa (2019) showed that the ICT export service showed a positive relationship with Fintech formation. Also, the findings from Haddad and Hornuf (2019) suggested that secure Internet servers and mobile penetration positively affect the number of Fintech start-ups. Thus, the country with more advanced ICT will attract more Fintech entrepreneurs.

Moreover, various literatures declared that the demand is critical for a well-functioning Fintech ecosystem, for instance, Ernst and Young (2018), Brett (2017), and Nicoletti (2017). An increasing market appetite is critical to forward the financial inclusion agenda (Ernst & Young, 2016). The cConsumer demand was required to make a product and service viable (Brett, 2017). This is because a good business understands its customers' needs and collaborates with various ecosystem actors to deliver offerings that better meet those needs.

A stream of studies (Koonprasert & Mohammad, 2020; Ernst and & Young, 2018; Brett, 2017; Nicoletti, 2017; and Diemers et al., 2015) suggested that both talent and capital are essential for Fintech innovation. This is because Fintech requires advanced talent like skilled professionals and financial computer talent to support its rapid growth (Bhatnagar, 2020; Mei et al., 2018). Correspondingly, the empirical findings from Haddad and Hornuf (2018) showed that Fintech formation is more frequent in countries with greater venture capital availability. This is because the capital is needed to fund the initiatives to enhance collaboration across different players in the Fintech ecosystem (Brett, 2017).

Based on the review of past empirical studies, there are five key components of a Fintech ecosystem, namely legislation and policy, technology, demand, and innovative products and services. These components will be aggregated into an index to determine the progress of the Fintech ecosystem in ASEAN-6 countries.

On this note, Organisation for Economic Co-operation and Development and Joint Research Centre (2008) declared that an index is a result of the merger of several indicators based on the multi-dimensional concept to compare the performance between countries. Several Fintech-related indexes available include The Global Fintech Index, Global Fintech Adoption Index, Global Fintech Hub Index, Global Fintech Ranking, and APEC Fintech E-payment Readiness Index. We constructed the index to make a comparison between various countries to determine the area that required improvement for more effective policymaking.

Yet, these indexes are with different objectives and are on a one-year basis. The Global Fintech Index, founded by Skoglund et al. (2019), aimed to measure the quality, quantity, and environment of Fintech in a particular country. Bull et al. (2019) constructed the Global Fintech Adoption through a survey method to determine the adoption rate of Fintech in 17 selected markets. Ben et al. (2018) proposed the Global Fintech Hub Index to identify the development of Fintech industry, Fintech consumer experience, and Fintech ecosystem of 70 cities. In addition, Ankenbrand and Bieri (2017) founded a Global Fintech Ranking to determine the potential development of Fintech in 30 selected countries. Australia Asia-Pacific Economic Cooperation Study Centre and The Technology Research Project (2016) constructed the APEC Fintech E-payment Index to study the readiness and capacity to engage in e-payment, demand, as well as the potential development of e-payment for APEC countries. Out of these indexes, only APEC Fintech E-payment index 2016 covers the ASEAN- 6 countries but focuses only on e-payment. Additionally, previous studies are based on subjective surveys and weighting.

Furthermore, there are also indexes studies from other fields, such as Digital Economy and Society Index (European Commission, 2020), Regional Sustainable Development Index (Rahma et al. 2019), Regional Sustainable Development (Shi et al., 2019), Cisco Digital Readiness Index (Cisco, 2019), Index of Financial Inclusion (Wang & Guan, 2017), and

CSGR Globalisation Index (University of Warwick, 2014). These indices served as references to reinforce the index construction in this study. The authors constructed their index through various methods not limited to panel min-max normalization, principal component analysis, arithmetic mean, geometric mean, and entropy method.

Consequently, this study will propose an index construction based on a more objective-based methodology for three conservative years, from 2017 to 2019, to fill the gaps in the progress of the Fintech ecosystem in ASEAN-6 countries.

Method

There are four dimensions identified: regulatory and policy, infrastructure, demand and innovative product, and services. The 15 indicators categorized within each respective dimension are shown in Table 1.

Procedures to Conduct Index

There are several steps involved in constructing an index. First, outlier detection is required to treat those extreme values, which may distort the comparability of the data, as suggested by Wang and Guan (2017). European Commission (2020) stated that indicators with skewness larger than 2.5 and kurtosis more than 3.0 indicate the presence of outliers. The formula of skewness is as shown in Equation (1), while kurtosis is as shown in Equation (2).

$$\text{Skewness} = \frac{\sum_{i=1}^{N}\left(Y_i - \bar{Y}\right)^3/N}{s^3} \quad (1)$$

$$\text{Kurtosis} = \frac{\sum_{i=1}^{N}\left(Y_i - \bar{Y}\right)^4/N}{s^4} \quad (2)$$

Therefore, winsorization is used to treat these extreme values, as suggested by Wang and Guan

Table 1

Dimensions and Indicators of ASEAN Fintech Index (AFI)

Dimensions	Indicators	Relationship
Regulatory and policy, *reg*	Corruption perceptions index, *c*	Positive
	Political stability and absence of violence and terrorism index, *p*	Positive
	Strength of legal rights, *s*	Positive
	Total tax and contribution rate, *tt*	Negative
	Ease of doing business, *e*	Positive
	Political stability and absence of violence and terrorism index, *p*	Positive
Infrastructure, *inf*	Internet users, *i*	Positive
	Mobile broadband subscriptions, *m*	Positive
	Access to electricity, *at*	Positive
Demand, *dem*	Users in Digital Payment, *dp*	Positive
	Users in Digital Remittances and Roboadvisor, *dr*	Positive
	Users in Alternative Lending, *al*	Positive
	Users in Alternative Financing, *af*	Positive
Innovative Product and Service, *inn*	Percentage of graduates from Science, Technology, Engineering and Mathematics programs in tertiary education, both sexes, st	Positive
	Ease of getting credit, *ea*	Positive
	Venture capital deals, *vc*	Positive

Note. The framework is constructed according to Castro et al. (2020) and Australia Asia-Pacific Economic Cooperation Study Centre and The Technology Research Project (2016).

(2017), to protect against the effects of outliers, which may damage the comparability of the data by replacing the extreme value with a less extreme value.

Subsequently, Shi et al. (2019) mentioned that correlation analysis should be done to avoid the presence of highly correlated variables, which may give rise to the problem of double weighting. Basta et al. (2014) suggested that indicators with a correlation of more than 0.8 should be removed, and a low correlation ensures that the indicators used in this study are statistically different.

The Pearson correlation is used as shown in Equation (3).

$$r_{xy} = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{(n-1)s_x s_y} \tag{3}$$

Above and beyond, discriminant analysis is needed to ensure that the data can discern feature variations in the object being analyzed. According to Shi et al. (2019), coefficient variation less than 0.12 indicates a weak discriminant. Thus, indicators with weak discriminants are removed to ensure that the remaining indicators are able to recognize the difference in the Fintech ecosystem development level of each country. The formula of coefficient and variation is shown in Equation (4).

$$\text{Coefficient of variation} = \frac{S_i}{\bar{X}} \tag{4}$$

Afterward, the data is normalized through panel min-max normalization into a common scale range from 1 to 100, as shown in Equation (5) for comparability.

$$I_q^t = \left(\frac{x_q^t - min(x_q)}{max(x_q) - min(x_q)} * 99 \right) + 1 \tag{5}$$

Equation (6) shows the reversed normalization for the indicator with a negative relation measure to ensure that the indicator will conform to the positive interpretation of the index.

$$I_q^t = \left(99 - \left(\frac{x_q^t - min(x_q)}{max(x_q) - min(x_q)} * 99 \right) \right) + 1 \tag{6}$$

Basically, the panel min-max normalization allows a meaningful comparison over time for a country and between countries by normalizing all the data together into a range between 1 and 100, as suggested by the Centre for the Study of Globalisation and Regionalisation (2012).

Later, the normalized data are averaged to compute the score of each dimension in which equal weighting is presumed for each indicator, as shown in Equation (7).

$$Dimension_i = \frac{\sum x_i}{n} \tag{7}$$

According to Greco et al. (2018), most of the composite index presumes an equal weighting as each variable is presumed to be equally essential.

The score of each dimension is later aggregated through different approaches such as the arithmetic mean, geometric mean, and entropy method. Equation (8) denotes the formula of arithmetic mean, whereas Equation (9) denotes the formula for geometric mean.

$$Arithmetic\ Mean = \frac{\sum x_i}{n} \tag{8}$$

$$Geometric\ Mean = \sqrt[n]{x_1 \ldots x_n} \tag{9}$$

The entropy method is slightly different from the arithmetic mean and geometric mean in which it involves objective weighting as proposed by Shannon (1948). The entropy weight for each dimension is calculated in Equation (10).

$$w_j = \frac{(1 - E_j)}{n - \sum_{i=1}^{n} E_j} \tag{10}$$

where Ej is calculated as shown in Equation (11),

$$E_{ij} = -k \sum_{i=1}^{m} p_{ij}\, Inp_{ij} \tag{11}$$

where k formula is as shown in Equation (12),

$$E_{ij} = -k \sum_{i=1}^{m} p_{ij}\, Inp_{ij} \tag{12}$$

where the p_{ij} formula is as shown in Equation (13),

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (13)$$

The entropy weight is then multiplied by the score of respective dimensions to compute the score result from the entropy method.

The final score of the index, which is known as AFI, is obtained through the averaging score of each different aggregation, that is, arithmetic mean (*am*), geometric mean (*gm*), and entropy method (*e*), to give a more comprehensive measurement that is easy to be implemented, as shown in Equation (14) as referred to the study from Rahma et al. (2019).

$$AFI = \frac{am_{afi} + gm_{afi} + e_{afi}}{3} \quad (14)$$

Finally, the sensitivity of the index towards different normalizations are checked through a comparison between the rank result from different normalizations such as distance to a group leader, as shown in Equation (11), and reversed normalization for indicator with a negative relation, as shown in Equation (12). According to Organisation for Economic Cooperation and Development and Joint Research Centre (2008), sensitivity analysis is required to check the robustness of a composite index through the impact of different normalization methods. The same ranking result from different normalization methods denotes that the index provides an accurate measure of mean robustness (Rahma et al., 2019).

$$I_q^t = \left(\frac{x_q^t}{max(x_q)} * 99 \right) + 1 \quad (15)$$

$$I_q^t = \left(99 - \left(\frac{x_q^t}{max(x_q)} * 99 \right) \right) + 1 \quad (16)$$

The index is further clustered through hierarchical clustering with average linkage to group the countries with similar characteristics within one cluster. It is a simple clustering method that groups the cluster with similar genes together by grouping the highly correlated genes iteratively and is expressed in a dendrogram to enhance interpretability (Eisen et al., 2018). The optimal cluster is selected based on the agglomeration schedule coefficient. The results are then visualized to enhance the interpretability.

Results

Outliers Detection

The results show that the indicators of the strength of legal rights, users in digital payment, users in digital remittances and robo-advisor, users in alternative financing, and ease of getting credit are detected with the presence of outliers. Thus, these outliers are minorized to treat the extreme value.

Correlation Analysis

From the result, the indicators retained only those with a correlation of less than 0.8. Therefore, the indicators, corruption perceptions index, political stability and absence of violence and terrorism index, ease of doing business, access to electricity, and venture capital deals are excluded due to their extremely correlated properties.

Discriminant Analysis

Table 2 shows the coefficient of variations of indicators used in this study.

Table 2

Coefficient of Variations of Indicators

Indicator	Coefficient of Variation
Strength of legal rights, *s*	0.12
Total tax and contribution rate, *tt*	0.23
Internet users, *i*	0.27
Mobile broadband subscriptions, *m*	0.15
Users in digital payment, *dp*	0.20
Users in digital remittances and roboadvisor, *dr*	0.57
Users in alternative lending, *al*	1.51
Users in alternative financing, *af*	0.78
Percentage of graduates from science, technology, engineering, and mathematics programs in tertiary education, *st*	0.23
Ease of getting credit, *ea*	0.21

Based on the findings shown in Table 2, there are no indicators with a coefficient of variation less than 0.12. Thus, these indicators are proved to have the ability to distinguish the feature differences and are able to recognize the difference in the Fintech ecosystem development level of each country.

Scores of Dimensions in Each Country

Table 3 demonstrates the score of dimensions for each country from 2017 to 2019.

Overall, there are no changes in the ranking of each country for each dimension from 2018 to 2019. Looking at the regulation and policy dimension, Singapore ranked the highest, followed by Vietnam, Thailand, Malaysia, Indonesia, and the Philippines. It is well known that Singapore as the global Fintech hub is widely supported by its regulatory climate, mainly driven by the efforts of the Monetary Authority of Singapore (MAS).

Besides, Vietnam possesses a higher rank in regulatory and policy dimensions as compared to Thailand and Malaysia, mainly because of its fewer regulatory restrictions resulting from the single permitting procedure, which eases the acquisition of basic licenses for Fintech entrepreneurship (Andreasson et al., 2018).

Additionally, Singapore also ranked at the top in the infrastructure dimension. As a developed country, it is not surprising that Singapore possessed sufficient enabling technology for Fintech activities. Likewise,

Table 3

Scores of Dimensions 2017 to 2019

				2019				
Country	**reg**	**Rank**	**inf**	**Rank**	**dem**	**Rank**	**inn**	**Rank**
Indonesia	29.22	5	25.76	6	42.96	5	39.91	5
Malaysia	35.30	4	65.55	3	45.52	4	90.24	1
Philippine	1.00	6	39.44	5	35.02	6	23.52	6
Singapore	98.48	1	80.61	1	99.6	1	77.54	2
Thailand	55.28	3	80.52	2	50.07	3	58.86	3
Vietnam	62.44	2	53.06	4	47.39	2	53.45	4
				2018				
Country	**reg**	**Rank**	**inf**	**Rank**	**dem**	**Rank**	**inn**	**Rank**
Indonesia	29.22	5	13.87	6	25.68	5	33.72	5
Malaysia	34.22	4	59.62	3	32.49	4	100.00	1
Philippine	1.43	6	25.26	5	20.48	6	23.52	6
Singapore	99.35	1	72.98	1	88.98	1	77.54	2
Thailand	55.28	3	68.04	2	42.64	2	58.86	3
Vietnam	62.01	2	58.38	4	38.16	3	53.45	4
				2017				
Country	**reg**	**Rank**	**inf**	**Rank**	**dem**	**Rank**	**inn**	**Rank**
Indonesia	29.44	5	36.36	4	14.07	5	25.75	5
Malaysia	34.22	4	59.72	3	23.87	4	73.30	2
Philippine	1.43	6	25.26	6	10.63	6	23.52	6
Singapore	100.00	1	70.47	1	76.53	1	80.66	1
Thailand	57.01	3	61.62	2	24.98	3	34.11	4
Vietnam	61.36	2	34.48	5	30.95	2	47.27	3

Note. The scores of dimensions are calculated by averaging the normalized value of indicators underlying each respective dimension.

the high mobile penetration in Thailand, as compared to others, has provided it with a more supportive infrastructure environment for Fintech development among ASEAN-6 countries.

Yet again, Singapore scored the highest in the demand dimension. So far, there is an obvious gap in Fintech demand between Singapore and the rest of the ASEAN-6 countries. The findings from Fintech Adoption Index 2019 have concluded that Singapore accounts for an average of 67% of Fintech adoption, ahead of the Asia-Pacific average global rate of 64%.

However, Malaysia surpasses Singapore and Thailand in the innovative product and service dimension. Malaysia is found to have a higher capability for Fintech innovation when compared to Singapore and Thailand mainly because of its high percentage of graduates from STEM programs in tertiary education, as reported by the World Bank (2019). This phenomenon is further reinforced by an article reporting that the number of STEM graduates in Singapore is on the decline (Quek, 2019).

Likewise, both the Philippines and Indonesia are found to account for a lower rank in all the dimensions as compared to the rest of the ASEAN-6 countries. The less conducive business environment, restrictive government regulation, and limited access to funding are the major challenges for Fintech in Indonesia (Andreasson et al., 2018). Also, a low banking penetration restricts the Fintech market opportunities in the Philippines (Andreasson et al., 2018). Although the Philippines is ranked lower in the ASEAN-6 Fintech Index than Indonesia, the former is ranked higher in the infrastructure dimension. In fact, Indonesia faces difficulties in building ICT infrastructure due to its geographical position, which comprises over 17,000 islands (Hieminga and Lande, 2016). To sum up, there is no single country topping in all the dimensions. Every country has different weaknesses and strengths.

Scores and Rank of AFAI

Table 4 shows the score result from three aggregation methods, which shows that there are no changes in the

Table 4

Scores of Arithmetic Mean, Geometric Mean, Entropy Method, and ASEAN-6 Fintech Index (AFI)

Country	Year	Arithmetic Mean		Geometric Mean		Entropy Method		ASEAN-6 Fintech Index (AFI)	
		Score	Rank	Score	Rank	Score	Rank	Score	Rank
Indonesia	2019	34.46	5	33.70	5	34.13	5	34.10	5
Malaysia	2019	59.15	3	55.53	3	58.94	3	57.87	3
Philippine	2019	24.74	6	13.43	6	26.09	6	21.42	6
Singapore	2019	89.06	1	88.49	1	88.92	1	88.82	1
Thailand	2019	61.18	2	60.18	2	62.12	2	61.16	2
Vietnam	2019	54.08	4	53.82	4	53.79	4	53.90	4
Indonesia	2018	25.62	5	24.34	5	24.79	5	24.92	5
Malaysia	2018	56.58	2	50.74	4	55.72	3	54.35	3
Philippine	2018	17.67	6	11.49	6	18.24	6	15.80	6
Singapore	2018	84.71	1	84.10	1	84.11	1	84.31	1
Thailand	2018	56.20	3	55.43	2	56.52	2	56.05	2
Vietnam	2018	53.00	4	52.13	3	52.86	4	52.66	4
Indonesia	2017	26.40	5	24.95	5	26.66	5	26.01	5
Malaysia	2017	47.78	2	43.48	2	47.62	2	46.29	2
Philippine	2017	15.21	6	9.75	6	15.68	6	13.55	6
Singapore	2017	81.91	1	81.21	1	80.97	1	81.37	1
Thailand	2017	44.43	3	41.59	4	44.98	3	43.67	3
Vietnam	2017	43.51	4	41.94	3	42.25	4	42.64	4

Note. AFI is calculated by averaging the score from the arithmetic mean, geometric mean, and entropy method.

ranking result from different aggregation methods and the scoring are with small difference between each alternative. Thus, this shows that the score produced from the entropy method is proved to provide a robust measure in contrast to the non-weighting aggregation methods.

From 2017 to 2019, the ASEAN-6 Fintech Index has grown in general. This suggests that the ASEAN-6 Fintech ecosystem is developing because each country's ranking has stayed stable from 2017 to 2019, with Singapore leading the list, followed by Thailand, Malaysia, Vietnam, Indonesia, and the Philippines. So far, there has been a ranking change between Malaysia and Thailand, with the former ranked lower after 2017 mainly due to the higher advancement of infrastructure in Thailand as compared to Malaysia. In addition, the drastic decline in ICT infrastructure to promote Fintech growth resulted in a small reduction in Indonesia's ranking in 2018. Furthermore, both the mean and median score of AFI is improving as compared to the past, demonstrating that there is an overall enhancement in the Fintech ecosystem among the ASEAN-6 countries.

Sensitivity Analysis (Robustness)

Figure 1 shows that regardless of the normalization process used, the ranking remains the same, indicating that the index is robust. The only distinction is that the distance to the group leader results in marginally higher scoring. Also, as shown in previous Table 4, the scoring result from different aggregation alternatives have a small difference. Therefore, the AFI is an accurate index that is robust toward different normalization and aggregation methods.

Clustering

From the findings, the optimal number of clusters is 3 based on the agglomeration schedule coefficients. The first cluster country (only Singapore) has a strong achievement in all the dimensions, scoring more than 80. The second cluster is relatively strong in certain dimensions, with a scoring between 50 and 80. The countries in this cluster include Thailand, Malaysia, and Vietnam. The third cluster is countries with weak performance in all the with overall index scoring below 50. Countries such as the Philippines and Indonesia are categorized under this cluster.

AFI vs GDP

Figure 2 shows the high positive correlation between the GDP per capita, purchasing power parity (current international $), and the AFI 2019 implies that a higher GDP country tends to do better in ASEAN-6 Fintech Index. However, Thailand and Vietnam are exceptions because both countries have higher index scores compared to their peers. The study also revealed that the propensity of Fintech demand is widespread regardless of the income level of the ASEAN-6 countries.

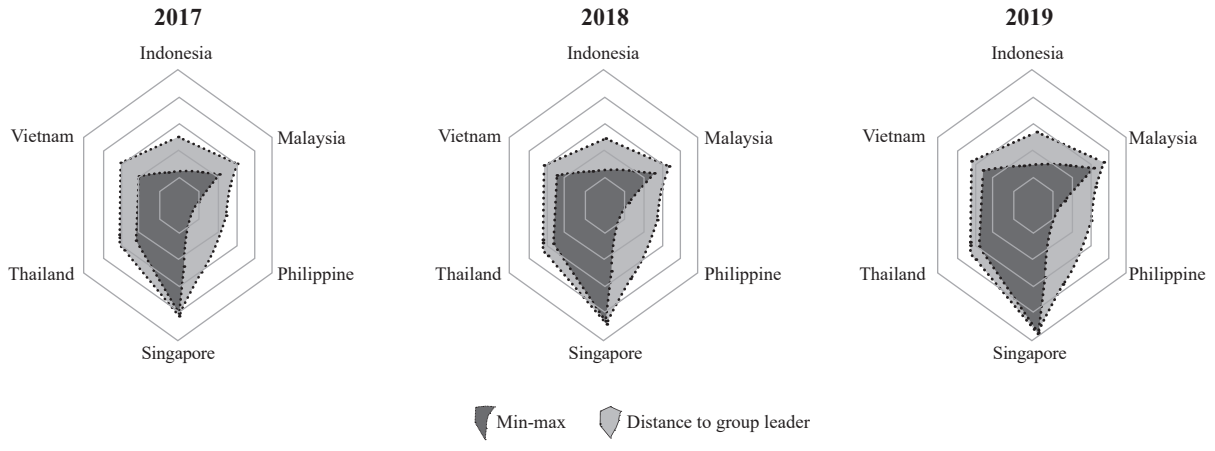

Figure 1. Sensitivity of AFI Based on Different Normalization Methods

Note. There is no difference in ranking results from normalization methods across three years.

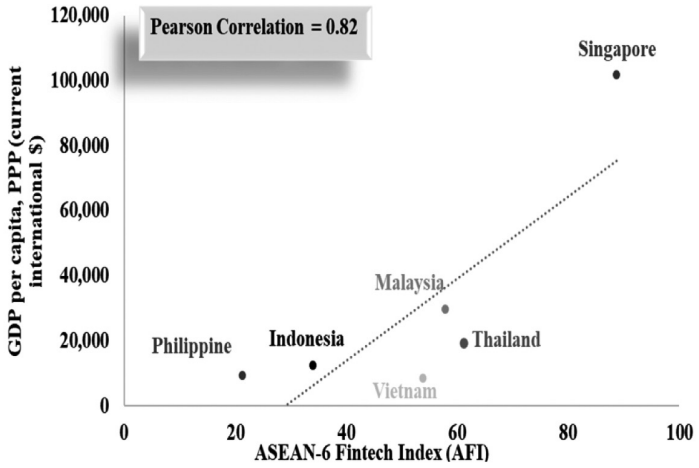

Figure 2. ASEAN-6 Fintech Index vs GDP

Note. ASEAN-6 Fintech Index shows a positive relationship with the gross domestic product per capita in 2019.

AFI vs Loo (2019)

As refer to the study from Loo (2019), countries with the best growth market for Fintech ranked the top from Vietnam, Lao PDR, Cambodia, Philippines, Indonesia, Singapore, Malaysia, Myanmar, Brunei, and Thailand subsequently. The result seems to contradict the results of this study as it identified the countries with the highest need for financial inclusion as the best market for Fintech rather than identifying the countries with higher development in the Fintech ecosystem as the best market for Fintech. Thus, this study provides a valuable finding from a different perspective in contrast to the studies from Loo (2019).

Conclusion

Fintech is changing the way traditional financial institutions operate in ASEAN-6 with the introduction of new innovative financial services. More competition arises as Fintech seems to provide a more efficient and cost-less service. The widespread use of mobile Internet also led to the acquisition of Fintech services and products in ASEAN-6. Recently, people remained optimistic about its future despite the COVID-19 pandemic.

Overall, this study assesses the readiness of each ASEAN-6 country to participate in Fintech activity, demand for Fintech, and future potential Fintech growth based on the macro-level success of the Fintech ecosystem through the construction of an index, namely ASEAN-6 Fintech Index (AFI) for 2017 to 2019. In contrast to the previous index, this study provides a more objective and comprehensive measurement in delivering the progress of the Fintech ecosystem in ASEAN-6 countries.

From the findings, all the ASEAN-6 countries show an increasing trend in AFI from 2017 to 2019, implying that the Fintech ecosystem in these countries is growing. Singapore is ranked the highest in AFI 2019 followed by Thailand, Malaysia, Vietnam, Indonesia, and the Philippines. This implies that Singapore has the best Fintech ecosystem, whereas the Philippines is the worst among the ASEAN-6 countries. There are three clusters generated: the first cluster is made up of Singapore (strong), the second cluster (medium) includes Thailand and Malaysia, and the third cluster (weak) includes Vietnam, Indonesia, and the Philippines.

So far, there is no single nation dominating the index by overlapping all aspects. The study found that Singapore faces difficulties in generating talent from STEM programs required for Fintech innovation. Thailand and Vietnam are both having problems stimulating consumer appetite for Fintech products and services. For Malaysia and the Philippines, the regulatory and policy climate is the biggest obstacle, whereas, in Indonesia, the main concern is the promotion of ICT facilities to support Fintech's development. Thus, ASEAN-6 countries are advised

to resolve these obstacles to enhance the Fintech development in their country. Likewise, the study revealed that the country with a higher GDP tends to do better in AFI. Moreover, the propensity of Fintech demand is widespread regardless of the income level of the countries. Thus, all the ASEAN countries have equal opportunities to develop Fintech regardless of their income level.

Above all, this study also gives a brief picture of the trend and the phenomenon of the Fintech ecosystem in ASEAN-6 countries, which act as the benchmark for evaluating the Fintech performance in the context of Fintech ecosystem development. The results obtained from visualization will not only improve policymakers' interpretability but also make the Fintech ecosystem scenario clear, insightful, and simple for laymen in the field. A greater understanding of Fintech's ecosystem scenario will help to draft an effective policy for Fintech development. Additionally, the components of the Fintech ecosystem could act as a potential proxy for the evaluation of successes and failures of the policy development for Fintech.

Lastly, there are some limitations to this study: it only covers a three-year period and focuses only on a few countries. Therefore, the study suggests that future research should include a longer time period and more countries for a more comprehensive result. Also, the indicators series in the construction of the AFI should be updated from time to time to better suit the complex trends in the future market. Future research into the particular factors that influence Fintech growth is also needed so that policymakers can expand their Fintech through more effective and efficient policies.

Declaration of Ownership

This report is our original work.

Conflict of Interest

None.

Ethical Clearance

This study was approved by our institution.

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