Journal of Innovative Technology Convergence
Vol. 2, No. 2 December 2020, pp. 1-8

Internet Diffusion Rate among ASEAN Countries

Josie B. Quiban*

Abstract: This paper examines the rate of Internet diffusion among the Association of Southeast Asian Nations (ASEAN) countries during the period 2001-2018. The Bass diffusion model was used to estimate the total number of potential adopters, the coefficient of innovation, and the coefficient of imitation. This paper uses the International Telecommunication Union (ITU) 2001-2018 dataset to study the rate of Internet diffusion. The results show that Internet diffusion among ASEAN countries was characterized by different S-shaped curves of the diffusion process. The estimated diffusion curves provide evidence that high-income countries in the ASEAN have higher diffusion rate as compared to the lower-income countries. Further, the study found that the country that has the highest rate in the point of inflection is also the country that has the lowest rate of Internet diffusion. The results also indicate that among the 10 members of the ASEAN countries, four of which have reached their peak of adoption before 2018, and two of which have reached the saturation point of the diffusion process, and one of which is continuously dominating since the launch of Internet up to the present while the rests are closely following the path made by high-income countries.

Keywords: ASEAN, Bass Model, Internet Adoption, Internet Diffusion Rate, S-shaped curve

1. Introduction

Globally, the exchange of information among people all over the world has been facilitated by the Internet. The Internet is a network of information that can be produced by and/or access by people in different geographic locations. This modality of information exchange has pervaded across social, economic, and political sectors in many advanced countries. It is said that Internet connectivity is a major factor in economic growth and development [1]. Nonetheless, the adoption of the Internet is observed to be varied across the different economies in the world. Thus, it is of interest to determine how the Internet diffused in different contexts specifically in the member countries of the ASEAN.

The ASEAN is an intergovernmental organization aimed primarily at promoting economic growth and regional stability among its members. According to the world population review in 2019, ASEAN has a population of over 622 million people and has one of the largest economies in the world which is

* Information Technology Department, Palompon Institute of Technology, Palompon, Leyte, Philippines
Email: josie.quiban@pit.edu.com

Received [November 15, 2020]; Revised [November 28, 2020]; Accepted [December 5, 2020]

Published by InnoCon Publishing.
ISSN 2704-4440

expected to be the 4th largest economy in the world by 2050. Also, based on the latest report from ITU in 2019 around 63% of ASEAN's population is using the Internet.

Several studies have identified significant disparity in the levels of Internet diffusion across countries in terms of political, social, educational, medical, economic, technological, and environmental factors particularly in developing nations [1][2-4][5-7]. A political context, though it is argued theoretically, that Internet diffuses faster in democracies because of essential innovation advantages. However, it is found that authoritarian regimes adopt the Internet at similar rates when the economic benefits of technology offset democratization threats [8]. Meanwhile, the individual Internet use and the diffusion of Internet hardware shape citizen's perceptions of the supply of democratic preferences [9]. Besides, a significant and positive relationship is found existing between Internet distance and the different globalization indexes such as economic, financial, political, and social globalization [10][11]. Moreover, it is also found that economic strength, infrastructure, and knowledge of the English language positively affect Internet connectivity [12].

Although many scholars have been studied and examined Internet diffusion across countries, however, previous researches on the diffusion and adoption of the Internet have been predominantly focused on the determinant factors affecting Internet diffusion and only a few have been focused on the rate of Internet diffusion particularly in the ASEAN region. This paper gives more emphasis on the data of recent years as time is an important element in the diffusion process and forecast the trends of the diffusion process using the Bass Model.

The main objective of this study was to determine the rate of Internet diffusion among ASEAN countries during the period 2001-2018. Specifically, it aims to identify the S-Shaped curves of the diffusion process, determine the countries that have the highest and lowest rates of Internet diffusion, determine the rate of an inflection point and the peak of adoption, and forecast the trend of Internet diffusion from 2018-2060 to determine the countries that have reached the saturation point. To shed light on this topic, the researcher decided to conduct research to find out the rate of Internet diffusion among ASEAN countries.

2. Methodology

This study focuses on ASEAN countries' Internet diffusion rate. Data were collected from ITU 2001-2018 dataset to study the rate of Internet diffusion.

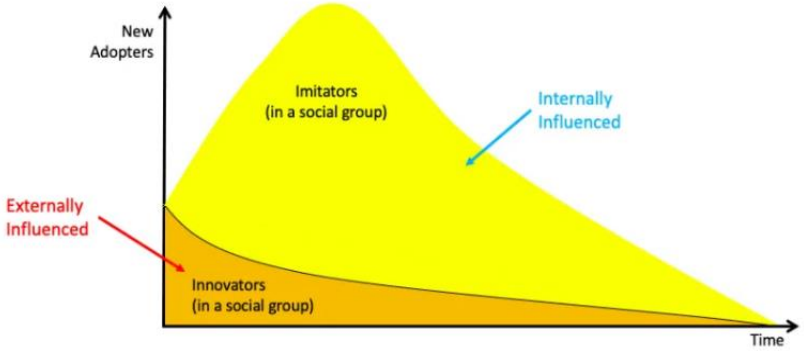

Figure 1. Bass Diffusion Model

This study anchored on the Bass Diffusion Model which was first developed by Frank M. Bass in 1969 to forecast product sales in marketing and technology innovations. However, this paper utilized

the model to forecast the trends and generate an S-shaped curve of the diffusion process. Also, the model was used to estimate the rate of Internet diffusion among ASEAN countries. Furthermore, it is assumed that the initial adoptions of the product are made by innovators and imitators [13]. Innovators are externally influenced in the timing of their initial adoption from the mass media, while imitators are internally influenced by word-of-mouth from satisfied customers as shown in Figure 1.

Bass model equation is expressed as:

$$\frac{dF(t)}{dt} = (p + qF(t))(1 - F(t)) \quad (1)$$

The rate of Internet adoption on a given year $\frac{dF(t)}{dt}$ is just the rate of Internet diffusion $p + qF(t)$ times the rate of the potential Internet adopters $(1 - F(t))$ who have not yet adopted the Internet. Rewriting equation (1), we have

$$f(t) = (p + qF(t))(1 - F(t)) \quad (2)$$

and

$$S(t) = m.f(t) \quad (3)$$

where $S(t)$ is the number of Internet adopters on a given year *t*, and *m* is the total potential Internet adopters. Equation 3 can also be rewritten to

$$S(t) = m.(p + qF(t))(1 - F(t)) \quad (4)$$

For which $Y(t) = m.F(t)$ is the cumulative Internet adoption on a given year *t*. At the start, what matters is the value of *p*. If *p*>0, this means that there is an acceleration in Internet adoptions. Once the Internet is adopted by the innovators, there will be a sudden increase rate in diffusion. Thus, the adoption takes off. However, as $Y(t)$ approaches *m*, then we have reached the saturation point, and the diffusion curve has flattened, as shown in Figure 2.

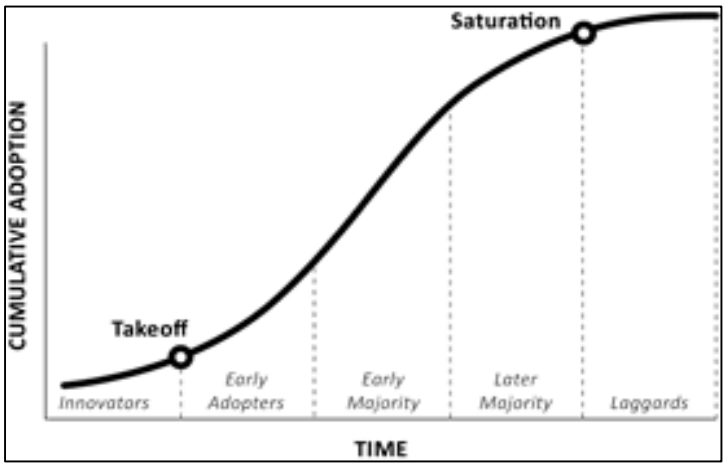

Figure 2. S-shape Curve

The saturation point is the time *t*, *t*>0 at which the curve of the function *F*(*t*) after its rapid increase started to flatten or decline in negative acceleration until, at zero growth rate, the potential market stabilizes. The flattening of the curve occurs when $\frac{dF(t)}{dt} = 0$. The saturation point, denoted by (*t**, *f* (*t**)), is given

$$t^* = \frac{lnq(1-c) - lnp}{p+q} \quad (5)$$

where *t* is the time of peak adoption, and

$$f(t^*) = m\left(\frac{q(1-c)}{4} + \frac{p}{2} + \frac{p^2}{4q(1-c)}\right) \quad (6)$$

The times of inflection points *t*** are given by

$$t^{**} = \left(\frac{lnq(1-c) - lnp \pm lnln(2+\sqrt{3}}{p+q(1-c)}\right) \quad (7)$$

or

$$t^{**} = t^* \pm \frac{lnln\,(2+\sqrt{3})}{p+q(1-c)} \quad (8)$$

Inflection point generally represents when the rate of diffusion begins declining, and the point at which the number of adopters as a function of time has peaked. After this point, diffusion reflects a "bandwagon" effect due to competitive pressures, and not "true" innovative behavior.

This study utilized the Bass Model Software to estimate the parameters *m*, *p*, *q*, and *c* using the ITU dataset from the year 2001 to 2018 in determining the rate of the diffusion process. The Bass Model assumes that *m* is the potential market that is constant but in reality, it is often gradually changing as the population of a particular country increases. Thus, *m* refers to the ultimate number of Internet adopters among members of the ASEAN countries. In addition, each Internet adopter is assumed to make one and only one adoption at time *t*. The parameter *c* is the yearly Internet diffusion rate. Furthermore, the parameter *p* refers to the innovators who have adopted the Internet based on the influence of the mass media or advertising. While the parameter *q* refers to the imitators who have adopted the Internet based on the influence of word-of-mouth from prior adopters. Consequently, the said parameters are used to measure the rate of influence the innovators have on the rate of diffusion and the influence that imitators have on the rate of diffusion across countries. Moreover, the software was used to generate diffusion curves and forecasts the trends of Internet diffusion among ASEAN countries from 2001 to 2060.

3. Results and Discussions

3.1 Internet Diffusion Using Bass Model

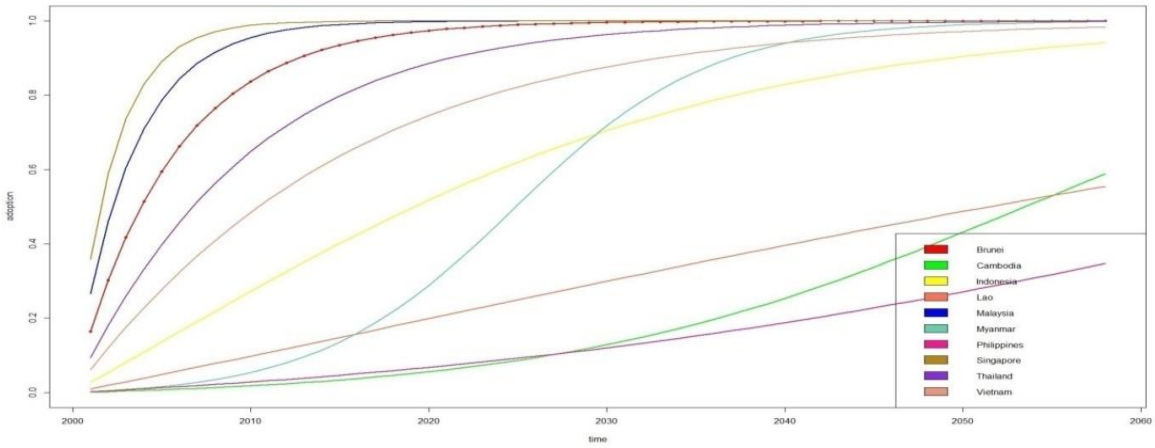

Figure 3. Internet Diffusion among ASEAN Countries using Bass Model [Source: ITU Dataset 2001-2018]

Figure 3 shows a significant disparity of Internet diffusion among ASEAN countries. The result of the Bass model indicates an S-shaped cumulative adoption curve as the general pattern of the diffusion

process. However, the results revealed that different countries in ASEAN have different Internet curves and patterns. The result was confirmed that different countries around the world have different Internet diffusion curves and patterns [14-16]. One interesting thing to notice in Figure 3 is that in low and middle-income countries diffusion of Internet accelerates within 1-20 years, whereas in upper-middle and high-income countries the process significantly flattens out. This graphical evidence also suggests that low-income countries are catching up with upper-high income countries in the diffusion of the Internet [17].

3.2 Rate of Internet Adoption in 2001

Figure 4 shows Singapore has the highest rate of Internet adoption among the ASEAN member countries, while Cambodia has the lowest rate of adoption. It is assumed that a high value for p or innovators indicates that the diffusion has a quick start [13]. It implies that during the launch of the Internet, Singapore had the highest number of adopters called innovators who have adopted the Internet quickly based on the information from the mass media while Cambodia had the lowest number of innovators or adopters and thus, slowly adopted the Internet during the early stage of the diffusion process.

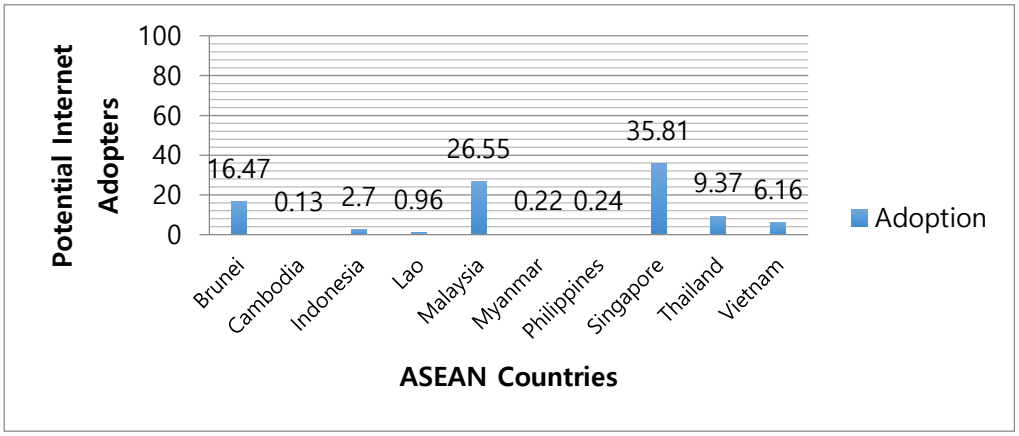

Figure 4. Rate of Internet Adoption in 2001

3.3 The Point of Inflection and Peak of the Internet Adoption

Table 1 shows the results of the point of inflection and peak of adoption among ASEAN countries. The results revealed that the Philippines had the highest point of inflection followed by Cambodia, Myanmar, Vietnam, Brunei, Malaysia, Thailand, Singapore, and lastly Indonesia. Further, the result indicates that as the Internet diffuses across countries the point of inflection slightly varies from one country to another. It is assumed that the point of inflection represents the time in the diffusion process when the rate of growth of the diffusion changes from increasing to decreasing [13]. This implies that the Philippines and Indonesia have to reach a maximum diffusion rate of 70.75% and 5.88% respectively before the diffusion process starts to accelerate or decline.

Furthermore, the peak of adoption in Table 1 shows that among the ASEAN countries, Singapore has the highest peak of adoption which is closely followed by Malaysia, Brunei, Vietnam, Thailand, Myanmar, Cambodia, Philippines, Lao, and Indonesia. It is assumed that the peak of adoption occurs when the maximum potential adopters have adopted the product or technology at a particular time [13]. Thus, by comparing the results from the rate of adoption at its peak and adoption in 2018 from Figure 5, it revealed that four of the ASEAN member countries namely Singapore, Malaysia, Thailand, and Indonesia have already reached their peak of adoption before 2018.

Table 1. Rate of Inflection Point and Peak of Adoption

ASEAN Countries	Inflection Point (100%)	Peak of Adoption (100%)
Brunei	22.35	98.30
Cambodia	54.07	51.17
Indonesia	5.88	15.48
Lao	19.92	19.80
Malaysia	16.57	99.41
Myanmar	25.76	54.02
Philippines	70.75	47.78
Singapore	12.80	99.66
Thailand	15.26	80.39
Vietnam	24.59	81.67

3.4 Rate of Internet Adoption in 2018

As shown in Figure 5 the country that had the highest rate of Internet adoption was Singapore with 99.97% followed by Malaysia, Brunei, Thailand, Vietnam, and Indonesia, while other countries such as Myanmar, Lao, and the Philippines have a lower rate of Internet adoption, and finally Cambodia with only 4.62% of Internet adoption in 2018. It is assumed that the adoptions of a new product or technology are primarily driven by word-of-mouth from satisfied customers or adopters [13].

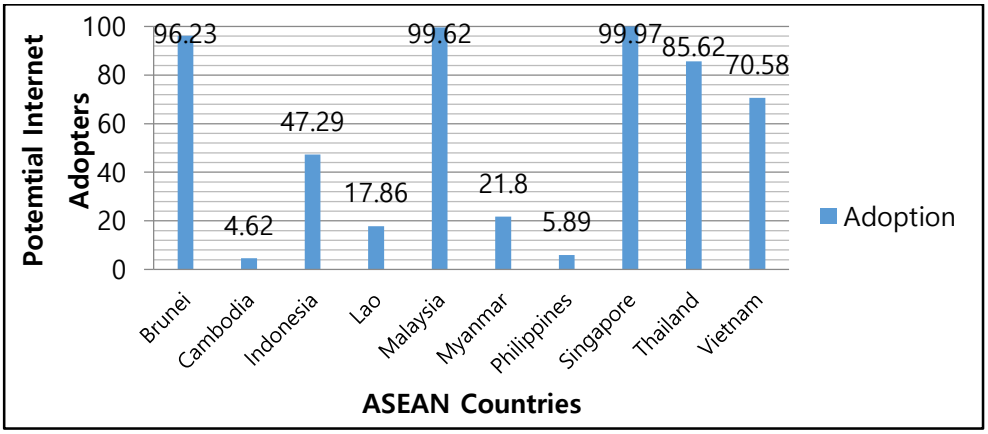

Figure 5. Rate of Internet Adoption in 2018

Thus, the result implies that Singapore's high Internet adoption rate in 2018 was highly influenced by the imitators who have adopted the Internet based on information from other people (word-of-mouth). So do also with Malaysia, Brunei, Thailand, Vietnam, and Indonesia while other countries such as Myanmar, Lao, and the Philippines were not highly influenced by the imitators most especially with Cambodia.

3.5 Rate of Internet Adoption by 2040

Figure 6 gives the forecasting results obtained from the cumulative adoptions in Figure 3 using the Bass model. The result shows that by 2040, both countries Singapore and Malaysia have reached the saturation point of adoption. This implies that 100% of the country's total population is expected to use

the Internet based on the forecasting results of the bass software. Moreover, Singapore is constantly dominating in terms of Internet diffusion across the region which is closely followed by Brunei Thailand, Vietnam, Myanmar, and Indonesia, while Lao, Cambodia, and the Philippines are lagging. The result was confirmed that Singapore is the leading player in competing with income-level peers on Information and Communications Technology (ICT) diffusion performance [7].

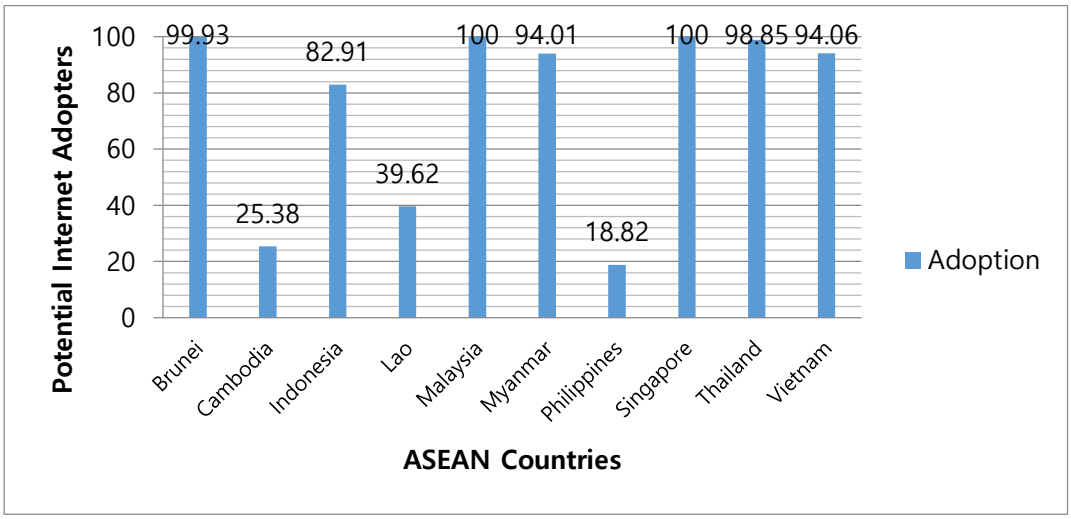

Figure 6. Rate of Internet Adoption by 2040

4. Conclusion and Recommendation

This study provides the rate of Internet adoption among ASEAN countries for the period 2001-2018. The results showed that Internet diffusion among ASEAN countries is well characterized by different S-shaped patterns. In addition, the results showed a significant difference in the Internet diffusion curves. The pattern of the curves indicates that high-income countries have a higher diffusion rate as compared to low-income countries. The result was confirmed that Internet adoption follows an S-shape pattern but the pattern is different for high-income and lower-income countries [9]. In addition, based on the result, Singapore was considered as the highly diffused country while Cambodia was considered as the lowly diffused country from 2001-2018 among ASEAN countries. In addition, the results found that the Philippines has the highest point of inflection while Indonesia has the lowest turning point in the diffusion process. However, as the Bass model forecast until 2040 the results revealed that the Philippines becomes the last in terms of Internet diffusion rate among ASEAN countries. Furthermore, the rate of adoption at peak revealed that Singapore, Malaysia, Thailand, and Indonesia have already reached the peak of adoption before 2018. However, based on the forecast results from 2018-2060, it revealed that Singapore and Malaysia are among the two countries that have reached the saturation point of the diffusion while Brunei, Thailand, Vietnam, Myanmar, Indonesia, Lao, Cambodia, and the Philippines are still following the path. The result was confirmed that developed countries had steeper Internet diffusion curves and shorter time lags than the developing countries [18].

The clearest policy implication of the findings is that to help narrow the Digital Divide among ASEAN countries, policymakers should emphasize policies that liberalize the telecommunications markets in less developed countries. In this study, the main factors were considered, namely, the time, potential adopters, innovators, and imitators to estimate the diffusion process. Further works can be done to include other factors and impacts that affect Internet diffusion among ASEAN countries to strongly support the results and findings of the study.

References

[1] H. S. Na, J. Hwang, H. Kim, "*Digital content as a fast Internet diffusion factor: Focusing on the fixed broadband Internet*", Information Development, vol. 36, no. 1, March 2020, pp.97-111, doi: 10.1177/0266666918811878.

[2] A. Jha, D. Saha, "*Forecasting and analyzing the characteristics of 3G and 4G mobile broadband diffusion in India: A comparative evaluation of Bass, Norton-Bass, Gompertz, and logistic growth models*", Technological Forecasting and Social Change, vol. 152, no. 119885, March, 2020, doi: 10.10.1016/j.techfore.2019.119885.

[3] C. Ningsih, Y. J. Choi, "*An Effect of Internet Penetration on Income Inequality in Southeast Asian Countries*", in 22nd Biennial Conference of the International Telecommunications Society (ITS): Beyond the Boundaries: Challenges for Business, Policy and Society", Seoul, Korea, June 24-27, 2018.

[4] Z. L. Maureal, J. M. Lapates, M. S. Dumandan, V. B. Vicar, D. N. Gaylo, "*Adopted Bass Diffusion Model for the Spread of COVID-19 in the Philippines: Implications to Interventions and Flattening the Curve*", International Journal of Innovation, Creativity and Change, vol. 14, no. 3, August 2020, pp.1418-1437.

[5] Z. P. Fan, Y. J. Che, Z. Y. Chen, "*Product sales forecasting using online reviews and historical sales data: A method combining the Bass model and sentiment analysis*", Journal of Business Research, vol. 74, May 2017, pp.90-100, doi: 10.1016/j.jbusres.2017.01.010.

[6] Y. Orbach, "*Parametric analysis of the Bass model*", Innovative Marketing, vol.12, no. 1, April 2016, pp.29-40, doi: 10.21511/im.12(1).2016.03.

[7] K. M. Vu, "*ICT diffusion and production in ASEAN countries: Patterns, performance, and policy directions*", Telecommunications Policy, vol. 41, Issue 10, November 2017, pp. 962-977, doi: 10.1016/j.telpol.2017.04.005.

[8] S. Stier, "*Internet diffusion and regime type: Temporal patterns in technology adoption*", Telecommunications Policy, vol. 41, Issue 1, February 2017, pp. 25-34, doi: 10.1016/j.telpol.2016.10.005.

[9] E. Stoycheff, E. Nisbet, "*What's the Bandwidth for Democracy? Deconstructing Internet penetration and Citizen Attitudes About Governance*", Political Communication, vol. 31, Issue 4, October 2014, pp.628-646, doi: 10.1080/10584609.2013.852641.

[10] T. Huang, B. Sun, "*The Impact of the Internet on Global Industry: New Evidence of Internet Measurement*", Research in International Business and Finance, vol. 37, May 2016, pp. 93-112, doi: 10.1016/j.ribaf.2015.09.008.

[11] T. Penard, N. Pousing, B. Mukoko, G. Bertrand, T. Piaptie, "*Internet adoption and usage patterns in Africa: evidence from Cameroon*", Technology in Society, vol. 42, August 2015, pp.71-80, doi: 10.1016/j.techsoc.2015.03.004.

[12] P. Wunnava, D. Leiter, "*Determinants of Intercountry Internet Diffusion Rates*", American Journal of Economics and Sociology, vol. 68, no. 2, April 2009, pp.413-426, doi: 10.1111/j.1536-7150.2009.00634.

[13] F. M. Bass, "*A new product growth for model consumer durables*", Management Science, vol. 15, no. 5, January 1969, pp.215-227, doi: 10.1287/mnsc.15.5.215.

[14] International Telecommunications Union, "*Measuring the information society*", itu.int, www.itu.int/pub/D-IND-ICTOI (accessed October 10, 2019).

[15] International Telecommunications Union, "*World information society report 2007: Beyond WSIS*", itu.int, www.itu.int/osg/spu/publications/worldinformationsociety/2007/ (accessed October 29, 2019).

[16] World Bank, "*World Development Indicators & Global Development Finance*", databank.worldbank.org, www.databank.worldbank.org/source/world-development-indicators, (accessed March 5, 2019).

[17] L. Andres, D. Cuberes, M. Diouf, T. Serebesky, "*The diffusion of the Internet: A cross-country analysis*", Telecommunications Policy, vol. 34, Issues 5-6, June-July 2010, pp.323-340, doi: 10.1016/j.telpol.2010.01.003.

[18] X. Zhang, "*Income disparity and digital divide: The Internet Consumption Model and cross-country empirical research*", Telecommunications Policy, vol. 37, no. 6-7, July-August 2013, pp.515-529, doi: 10.1016/j.telpol.2012.12.011.