International Journal of Technology 13(3) 655-663 (2022)
Received February 2021 / Revised June 2021 / Accepted September 2021

International Journal of Technology

http://ijtech.eng.ui.ac.id

A Mathematical Model of Successful-Product Development by Considering the Indonesian Culture

Ratih Setyaningrum[1*], Subagyo[2], Andi Wijaya[2]

[1]*Industrial Department, Faculty of Engineering, Dian Nuswantoro University, Nakula Street, Semarang, 50131, Indonesia*
[2]*Mechanichal and Industrial Department, Faculty of Engineering, Gadjah Mada University, Grafika Street, Yogjakarta, 55281, Indonesia*

Abstract. Product development activities must be well managed; this will increase company productivity by optimizing the success factor strategy, which will inevitably lead to success. Furthermore, Some evidence suggests that product development that considers culture could lead to greater success in Indonesia, even on a global scale. This paper aims to build a mathematical model of successful product development by considering Hofstede culture and deciding the culture's contribution to product success and at the same time to do Indonesian culture mapping. The first step of this research was started by deciding the relationship of culture to product success and by clustering the culture based on 805 Indonesian respondents. The next step was deciding success factor variable and building the mathematical model of product development by using 304 data of automotive products, netbooks, smartphones, souvenirs, and services. Furthermore, the research used methods to manage culture such as Hofstede dimension counting, Principal Component Analysis and Agglomerative Hierarchical Cluster. In the step on building mathematical model of successful product, experiment designed and Kano were used. The result of the Indonesian cultural cluster dimension showed that Indonesian culture could be divided into four clusters, including cluster 1 (C1), Cluster 2 (C2), cluster 3 (C3), and cluster 4 (C4), which are presented in Table 2. The Indonesian culture is divided into two dimensions such as intrinsic characteristics and environmental and future characteristics. While the result of the Kano mathematical model showed that price, product performance, services and marketing were put into a one-dimensional category. The model which considered culture was able to increase determination value (R2) and it was included in a one-dimensional category, so explicitly it was the most desired by the customers and was able to increase customer's satisfaction indeed. That model was expected to be a quidance on product development in increasing its product market share.

Keywords: Hofstede dimension; KANO methods; Market share; Success product

1. Introduction

1.1. Background

The product development needs to be managed well to minimize the failure. Product development that is not managed properly will affect productivity and lead to failure. An increase of company's productivity will be gained once product development is well managed (Li et al. 2006; Cooper et.al, 2008 and Cooper, 2000). The company needs to

*Corresponding author's email: ratih.setyaningrum@dsn.dinus.ac.id, Telp/Fax : 024-355628
doi: 10.14716/ijtech.v13i3.4751

manage product development activity to elevate it's productivity and reach success. (Holt & Cameron, 2014). The various products which have successfully applied cultural innovation strategy developed by product design (Ben & Jerry's, Starbucks, Vitamin water), printed advertisement (Jack Daniel's), company's business policy (Ben & Jerry's, Freelancers Union), retail design (Starbucks), packing (Starbucks, Vitamin water), television advertisement (Nike, Marlboro, and Levi's). Apple and Nokia are also examples of developing a cultural-based product in the global market. Apple designed more efficient laptops with silent laptop fans (Isaacson, 2013). It is developed by adopting "zen", a culture in Japan, and it can lead 35% of the global market. On the other product, the Apple tablet also has increased its sales by 61.4% (Tribune, 2014). On the other case, Nokia also uses the culture aspect to design dual sim mobile in India. Besides smartphone products, automotive products with cultural backgrounds have also been developed and loved by Indonesians. For example, the MPV (Multiple Purpose Vehicle) product has seven seats and was to reach 79% sale. While there is Viar a product with occupational background, a motorcycle design with three wheels and an open container on the back. It gained a 30% increase in sales (Sukarno, 2013). Almost the same case leads the "bentor" product (combination between a pedicab and motorcycle design) as the cultural symbol of Gorontalo which gains its success too. Those examples prove that cultural-based automotive products are well developed and desired by Indonesians.

Based on the above explanation, the research takes some problems as mentioned below:

a) How does the mathematical model on product development work while considering culture, and
b) How does culture contribute to product success, and how Indonesian culture mapping by using Hofstede's cultural dimension could be done.

1.2. Benefits

Based on accessible research, the explicit model to formulate the relationship between success factors to product success which considers culture has not been found yet. By that condition, this research is expected to give benefits to researchers and expertise as mentioned below:

a) To produce mathematical model on product development that considers culture, and
b) Determine the culture contribution to product success, and the Indonesian culture mapping by using Hofstede cultural dimension could be done.

1.3. Research originality

The previous research that has the scope, methods and fields of study similar to this research among other build a mathematical model in digital innovation, whom his research clustering in economic security and build growth kinetics models. This paper builds a mathematical model of a successful product using clustering Indonesian culture.

There are some indications of culture involvement in product development based on the literature review, but there is no detailed review on how culture contributes to successful product development. Several factors affecting product success have been explained in the literature review but it remains no standardization of those factors in predicting the success of various products. For all these reasons, this research is conducted with its originality such as the culture contribution of product development, cluster, and Indonesian culture mapping by using Hofstede dimension, standardization of factors that effect product success, and the modeling of the relationship between those factors and market share (success).

2. Methods

2.1. Research object and subject

This research takes some marketed products such as:

a) Automotive products including car products from various brands (Toyota, Suzuki, Honda, Daihatsu, Mitsubishi, Nissan, Hyundai, Volkswagen, Mazda and so on) with several types e.g. LCGC, City car, Hatchback (small, compact and medium), SUV (compact, medium and big), MPV (low, compact, medium and big), sedan (small, medium and big). Moreover, the sport and underbone motorcycle products from various brands e.g Honda, Yamaha, Suzuki.

b) Smartphonse from various brands e.g Samsung, Apple, Nokia, HTC and laptop/netbook e.g Sony, Toshiba, Macbook, Aspire, Samsung, Hawlett-Packard, and Acer.

c) Souvenir including foods (chocolate, "bakpia"/ traditional cookies, packaged "gudeg"/traditional cuisine from jackfruit, breads, meat floss), clothes ("batk", T-shirt,abaya, hijab/scarf, long scarf/"mukena"), furniture (shelves, dining table, chairs), woman bag/leather bag, and bamboos made product.

d) Services like cards, internet and telecommunication providers, aircraft industry, midwife and nursing clinic, and clinical laboratory.

There were many Indonesians being subject of the research. They were coming from several backgounds (civil servants, non-governmental workers, or entrepreneurs) who live in different islands and cities such as Sumatra (Jambi, Pekanbaru, Tanjung Pinang), Java (Cirebon, Bogor, Sumedang-Ciamis, Semarang, Solo, Yogyakarta, Surabaya, Madura), Kalimantan (Banjarmasin), Sulawesi (Makassar, Kendari, Gorontalo), Ambon and Kupang.

2.2. Research Steps

This research consists of two steps:

1. Mapping and clustering This step to map and make clusters of culture based on Hofstede from Hofstede score dimension counting, simplifying Hofstede culture dimension (PCA) and culture cluster (Hair et al, 2010). The step begun by managing questionnaire data of Hofstede (2013). There were 805 culture data on this case. Power Distance (PDI) indicates how society accepts inequality in power among institutions, organizations and people. Uncertainty Avoidance (UAI) is how the extent to which members of a society feel uncomfortable with unstructured situations and ambiguity. Individualism in this context is the integration of individuals into primary groups and also the degree to which individuals are supposed to look after themselves or remain integrated in groups. Individualism and collectivism (IDV) in a society strongly affect the nature of the relationship between a person and the organization to which they belong. The masculinity (MAS) is the extent to which the dominant values (such as assertiveness, the acquisition of money and objects, heroism, achievement, the quality of life, cooperation, relationships and group decisions) in the society are ''masculine''. Long-term orientation (LTO) as ''the fostering of virtues oriented towards future rewards, in particular, perseverance and thrift''. Mapping and clustering Indonesian culture using VSM 2013 Hofstede Questionnaire. VSM 2013 Hofstede questionnaire consisted of cultural dimensions included the Power Distance Index (PDI), Individualism (IDV), Masculitiny (MAS), Long-Term Orientation (LTO) and Uncertainty Avoidance (UAI). The measurement of cultural dimension was using VSM 2013. Further it also used *Principal Component Analysis* (PCA), while cultural grouping by using *clustering* (*Agglomerative clustering*).
2. Managing mathematical model. It was divided into 2 steps, by designing experiment design (DOE) and mathematical model of Kano (Kano, 2001). In the step of experiment

design, it used anykind of success factors which had linear function to market share. The output was categorized into one-dimentional factor. The next one is step of Kano, the step to build mathematical model which had linear function, logarithmic, and exponential. The output explained the relationship betwee success factors to market share.

3. Results and Discussion

Based on previous research related to meta-analysis review showed that culture had positive correlation to product success. Culture on moderator variable including organization, project, and product were positively correlated but the correlation on marketing factor could not be concluded (Setyaningrum et al, 2016).

3.1. Hofstede's culture categorization

VSM Hofstede Questionnaire was used to measure culture in Pekanbaru, Tanjung Pinang, Jambi, Bogor, Sumedang, Cirebon, Yogyakarta, Semarang, Solo, Surabaya, Madura, Kupang, Ambon, Banjarmasin, Makassar, Kendari, Gorontalo. It showed reliable results or capable ones.

The next step was managing the dimension of culture by using PCA with purpose to simplify Hostede's culture dimension. The measurement can be seen on Table 1, then 82.28% as the biggest value of cumulative extraction sum of square loading was chosen. The mapping of five dimensions of Hofstede and Indonesian regions is figured out on Figure 1. It showed that the mapping on those dimensions were on 3 quadrants spread, followed by cities mapping in Indonesia. The next process was Indonesan culture clustering. The result showed by Agglomerative Hierarchy Clustering (AHC) on Table 2.

Table 1 Component score coeficient matrix of culture dimension on 2 PC

Culture	*Principal Component*	
Dimension	1	2
PDI	0.390	-0.199
MAS	0.322	0.199
COLL	0.372	0.037
UAI	0.077	0.491
LTO	-0.087	0.659

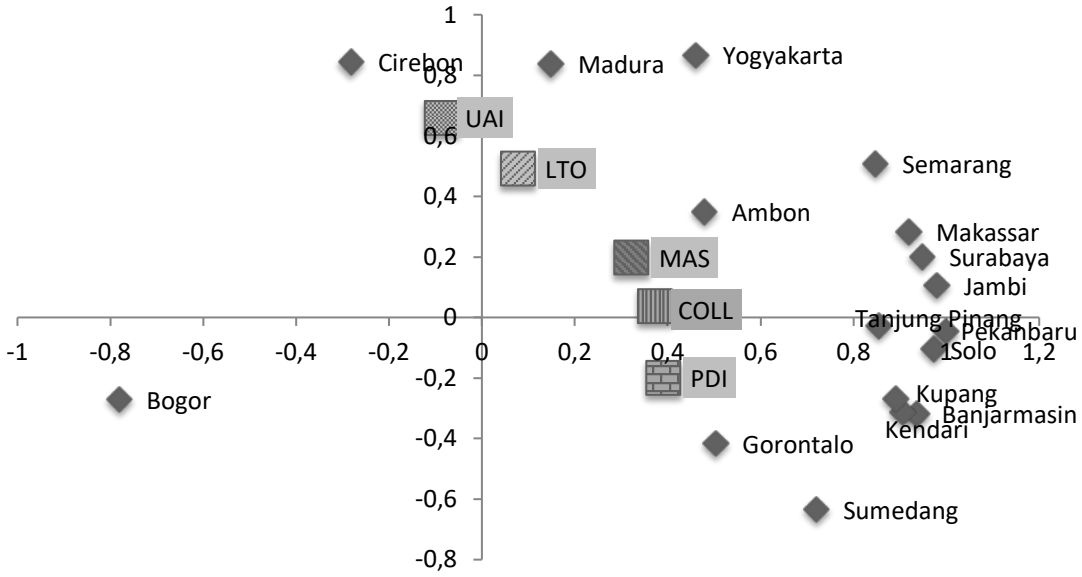

Figure 1 Mapping of Hofstede culture dimension by 2 PC

Table 2 The result of Indonesian culture grouping based on AHC

C1	C2	C3	C4
Bogor	Yogyakarta	Pekanbaru	Sumedang
	Madura	Tanjung Pinang	Kendari
	Cirebon	Jambi	Gorontalo
		Semarang	Banjarmasin
		Solo	Kupang
		Surabaya	
		Makassar	
		Ambon	

The result of culture clustering on Table 2 is divided into four groups. Based on those explanations, Indonesian culture can be divided into 2 dimensions. The dimension of intrinsic characteristics consists of power distance index (PDI), *collectivism* (COLL) and *masculinity* (MAS). It learns people's behaviour related to power gaps, individualism, and success preference. The dimension of environmental and future characteristics consists of uncertainty avoidance (UAI) and long-term orientation (LTO). It is the dimension which learns the avoidance of uncertainty and long-term life orientation.

The formulation process to standardize the value of culture was conducted because cultural value was independent variable (X7) as input on developing Kano mathematical model. The equation represents the function of culture on 2 PC (please see Equation (1) and (2)).

$$f\ (culture)pc1 = \ 0.39\ PDI + \ 0.32\ COLL + \ 0.37\ MAS + \ 0.07\ UAI - \ 0.09\ LTO \quad (1)$$

$$f\ (culture)pc2 = -0.19PDI + 0.19\ COLL + 0.037\ MAS + 0.49\ UAI - \ 0.66LTO \quad (2)$$

The result between those equation would be used as input to build Kano mathematical model of product success which considers culture. The culture itself is reviewed from two inputs: PC 1 (X7) and PC 2 (X8)

The value of culture dimension PDI, MAS, COLL were dominant on PC1 while UAI and LTO were dominant on PC2. Those were used as input of variable of culture in building Kano mathematical model. By this reason, it needs a process of standardization of numeric culture value (BN) which has range between 0 to 100. The value of standardized culture value (X7 and X8) can be seen on Table 3 and it shows that standardized culture value being used as input of Kano mathematical model which considers culture.

Table 3 Culture input X7 with PC 2 and X8 with PC 2 on Kano model

Indonesian Region	X7	X8
East Java (Surabaya & Madura)	0.00	100.00
Banjarmasin	55.48	98.15
Pekanbaru	100.00	0.00
Makassar	30.41	74.45

3.2. Mathematical model by using Kano concept

This step is a continued step of experiment design processing. The result of this experiment design processing is used to determine the variable of success factor (Setyaningrum et al, 2020). Variables used in the Kano mathematical model include price (X1), product performance (X2), brand (X3), aesthetics design (X4), services (X5), Marketing (X6) and culture (X7). The seven variables X and variable Y have been processed using Kano which are showed in Table 4, Table 5 and Table 6.

3.2.1. To build mathematical equation model by using Kano on various products

The result of mathematical equation by using Kano on various products can be seen on Table 4. Based on it, the variable of marketing has the biggest effect on increasing market share. The result of mathematical is supported by research done to review firm marketing capability (Lee & Zhou, 2012). Variable of services in the mathematical model of souvenirs, clothes, *furniture*, and services belong to the must-be (MB) category, which is regarding telecommunication product. Other variables are mapped into must-be (MB), one-dimentional (OD) and attractive (A) categories as showed in Table 4.

3.2.2. Kano usage to build mathematical model by considering culture on automotive product

The result of this research shows that culture contributes to product development with 0.364 value and there are 4 (four) cluster on Indonesian culture mapping with 2 (two) Hofstede culture dimensions, the internal characteristics and future environment characteristics. These would be beneficial to understand the mapping of Indonesian society and at the same time the culture involvement in the determiner of successful products.

The success factors that effects product success are price, product performance, brand, aesthetic design, service and time launching (Setyaningrum et al. 2020). All of those six variables can be used to predict success on various products based on market share parameters. Furthermore, the formulated mathematical model shows that model which puts culture can increase its model determination value. The result of culture's contribution scenario in predicting the successfull on various products showed in Table 5. Culture (X7) is included to OD (one-dimensional) category which means that the application of culture on development of a successful products will be equivalent to the increasing market share. The results of this research may be used as a reference point for producers in considering customer's culture.

Table 4 The result of Kano mathematical model for various products

No	Scenario Culture	Process	Data and mathematical equation	Result
1	Mathematical model of various product (automotive, *smartphone, netbook*, *souvenir*, *furniture*, clothes, services)		Y1 : 0.041 X3 Y2 : 0.1 X1+0.09 X2+ 0.16 X5 + 0.37 X6 Y3 : 0.47 X4 Z= -5.2 – 0.28 ln Y1+ 1.1 Y2+23.3 e $^{(-6,3Y3)}$	
2	Mathematical model of innovative product (automotive, *smartphone, netbook*)	KANO	142 data: innovative product Y1 : 0.033 X1 Y2 : 0.04X1-0.08X2+ 0.11X5 +0.43X6 Y3 : 0.39 X4 Z= -4.8+0.48 ln Y1+ 1.1 Y2+9.18 e $^{(-2.2Y3)}$	R^2 = 40%
3	Mathematical model of *souvenir,* clothes, *furniture*, services	KANO	140 data: *souvenir* and services Y2 : 0.165X1+ 0.25X2+ 0.2 X5 + 0.38 X6 Y3 : 0.347 X3 + 0.41 X4 Z= 7.43+0.81Y2+36.3 e $^{(-0.1Y3)}$	R^2 =22.2%
4	Mathematical model of automotive product	KANO	110 data: automotive product Y1 : 0.204 X3 and Y3 : 0.284 X4 Y2 : 0.075X1- 0.33X2+ 0.123 X5 + 0.65 X6 Z= 175.75+0.01 ln Y1+ 1.1 Y2-188.8 e $^{(-0.004Y3)}$	R^2 =51%

Table 5 The result of culture's contribution scenario in predicting success on various products

PART	No	Scenario Culture	Process	Data and mathematical equation	Result
CORE	5	Culture-*internal characteristics*-X7 (general equation): Y1= 0.204 X3 Y2= 0.075X1 – 0.33 X2 + 0.123 X5 + 0.65X6 **– 0.086X7** Y3 = 0.28 X4 Z= 175.7 + 0.008 ln Y1 + 0.99Y2 -188.8 e $^{(-0.004Y3)}$	KANO	120 - automotive *Internal Characteristics* (1PC)	
				MB: 0.043 X7	R^2 = 52.4%
				OD: -0.086 X7	R^2 = 52.6%
				A : 0.19 X7	R^2 = 51.4%
	6	Culture (*internal & environment future characteristics*):X7 and X8 (general equation) Y1= 0.204 X3 Y2= 0.075X1 – 0.33 X2 + 0.123 X5 + 0.65X6 **+ 0.23 X7 + 0.02 X8** Y3 = 0.28 X4 Z= 175.7 + 0.008 ln Y1 + 0.99Y2 -188.8 e $^{(-0.004Y3)}$	KANO	130 - automotive *Internal & EF Characteristics*	
				MB: 0,36 X7 + 0,19 X8	R^2 = 42%
				OD: 0,23 X7 + 0,02 X8	R^2 = 43.6%
				A : 0, 27X7 + 0,124 X8	R^2 = 43.2%
	7	Culture-*internal characteristics*-X7 (general equation-modification) Y1= 0.204 X3 **+ 0.43 X7** Y2= 0.075X1 – 0.33 X2 + 0.123 X5 + 0.65X6 Y3 = 0.28 X4 Z= 16.5+ 0.01 ln Y1 + 0.98Y2 -36 e $^{(-0,005Y3)}$	KANO	120 - automotive *Internal Characteristics* (1PC)	
				MB: 0.043 X7	R^2 = 52.6%
				OD: -0.083 X7	R^2 = 49.8%
				A : 0.17 X7	R^2 = 49.7%
	8	Culture (*internal & enviroment -future characteristics*): X7 and X8 (general equation-modification) Y1= 0.204 X3 Y2= 0.094X1 – 0.2 X2 + 0.07 X5 + 0.47X6 **+ 0.23 X7 + 0.074 X8** Y3 = 0.28 X4 Z= -1.1 + 0.3 ln Y1 + 1.03Y2 +11 e $^{(-31,6Y3)}$	KANO	130 - automotive *Internal & EF Characteristics*	
				MB: 0.36 X7 + 0.19 X8	R^2 = 45.7%
				OD: 0.23 X7 + 0.074 X8	R^2 = 47.8%
				A : 0,.27X7 + 0.13 X8	R^2 = 44.6%

Table 6 The result of culture's contribution scenario in predicting success on various products (continues)

PART	No.	Scenario Culture	Process	Data and mathematical equation	Result
CORE	9	Culture (*internal characteristics*) X7: *souveni*r and services - (general equation) Y2= 0.165 X1+ 0.25X2 + 0.25 X5+ 0.38 X6 **+0.088 X7** Y3 = 0.347 X3 + 0.41 X4 Z = 7.43 + 0.81 Y2 + 36.6 e $^{(-0.1\ Y3)}$	KANO	140 Souvenir & services *Internal Characteristics* (1PC) OD : 0.088 X7 A : 0.22 X7	R^2 = 21.7% R^2 = 20.4%
	10	Culture (*internal characteristics*) X7- *souvenir* and services- (general equation-modification) Y2= 0.075 X1+ 0.18X2 + 0.19 X5+ 0.28 X6 **+0.5 X7** Y3 = 0.347 X3 + 0.41 X4 Z = -4.4 + 1.03 Y2 + 35.4 e $^{(-0.1\ Y3)}$	KANO	140 Souvenir & services *Internal Characteristics* (1PC) OD : 0.57 X7 A : 0.16 X7	R^2 = 21.4% R^2 = 17%
	11	Culture-*internal characteristics*-X7 (general equation-modification) Y1= 0.337 X3 **+ 0.43 X7** Y2= 0.043X1 – 0.081 X2 + 0.11 X5 + 0.43X6 Y3 = 0.388 X4 Z= -4.75+ 0.45 ln Y1 + 1.1 Y2 + 8.72 e $^{(-20.65Y3)}$	KANO	140 - inovatif (car, *smartphone, netbook*) *Internal Characteristics* (1PC) MB: 0.043 X7 OD: -0.05 X7 A : 0.093 X7	R^2 = 39.63% R^2 = 39.42% R^2 = 39.65%

4. Conclusions

Kano mathematical model shows that price, product performance, services and marketing are included to one-dimensional category. Brand is on must-be and attractive category. Culture is on one-dimensional category so that it is explicitly wanted by customers and will able to increase customer satisfaction. The mathematical model of product success which considers culture is able to increase determination value (R^2). The mapping of Indonesian culture based on Hofstede culture dimension produces 4 clusters which have 2 main characteristics, *internal characteristics* and *environmental and future characteristics.* It is necessarily to do the next research by using mathematical model of product success development with more culture dimension variations.

Acknowledgements

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article. This article is financially supported by The Ministry of Research, Technology and Higher Education of The Republic of Indonesia (project number 025/E3/2017).

References

Cooper, R.G., Edgett, S.J., 2008, Maximizing Productivity in Product Innovation, *Research-Technology Management*, Volume 51(2), pp. 47–58

Cooper, R.G., 2000, *Doing it right: Winning with New Products*. White paper, Product Development Institute & Member Company Stage-Gate International

Hair, J.F., Black, B.C., Babin, B.J., Anderson, R.E., 2010. *Multivariate Data Analysis: A Global Perspective*. Seventh Edition, Person

Hofstede, 2013. *The Hofstede Centre: Cultural Survey Report*. Itim International, Available online at http://www.geert-hofstede.com, Accessed on August 28, 2013

Holt, D., Cameron, D., 2014. *Cultural Strategy*. PT.Elex Media Komputindo: Jakarta

Isaacson, W., 2013, *Steve Jobs*, First edition, Bentang, Yogjakarta

Jackson, J.E., 1991, *A User's Guide to Principal Component*. John Wiley and Sons, Inc

Kano, N., 2001. Life Cycle and Creation of Attractive Quality. *In:* The 4th QMOD Conference Procedings, University of Linkoping, Linkoping, Sweden, pp. 18-36

Lee, R.P., Zhou, K.Z., 2012. Is Product Imitaion Good for Firm Performance? An Examination of Product Imitation Types and Contingency Factors. *Journal of International Marketing*, Volume 20(3), pp. 1–16

Setyaningrum, R., Wijaya, A.R., Subagyo., 2016. Meta-Analysis of Cultural Correlation and Product Success. *Advanced Science Letters,* Volume 22(12), pp. 4155–4158

Setyaningrum, R., Subagyo, Wijaya, A.R., 2020, A Mathematichal Model of Factors Driving Product Success in an Indonesian Market Using Design Experiment. *International Journal of Technology*, Volume 11(2), pp. 322–332

Sukarno, P.A., 2013. Penjualan Viar Jateng naik 30% (*Sales of Viar Cental Java up to 30%*), Available online at http://www.bisnisjateng.com, Accessed on Juni 10, 2013

Tribunews, 2014. Penjualan Tablet Android Sukses Telikung iPad *(Android Tablet Sales Succeed in Turning iPad)*. Available online at http://www.tribunews.com, Accessed on March, 05, 2014