Advances in Social Science, Education and Humanities Research (ASSEHR), volume 216
Achieving and Sustaining SDGs 2018 Conference:
Harnessing the Power of Frontier Technology to Achieve the Sustainable Development Goals (ASSDG 2018)

ECONOMIC PERFORMANCE OF CITIES IN INDONESIA: IMPACT ANALYSIS OF SMART CITY CONCEPT IMPLEMENTATION

Ayu Dwi Putri[1], Khoirunurrofik[2]
[1] Department of Economics, Universitas Indonesia, Indonesia
[2] Institute for Economic and Social Research, and Department of Economics, Universitas Indonesia, Indonesia

ayudwiputri14@gmail.com

ABSTRACT
Since 2012, many local governments in Indonesia have independently initiated city development by implementing the concept of 'the smart city'. This concept uses technology to improve city performance by solving problems more effectively and efficiently. The smart city concept includes not only the use of technology but also human capital, social and environmental issues as indicators of smart city attributes. As the central government of Indonesia launched its programme 'The Movement Towards 100 Smart Cities'in 2017, it is important to measure the success of city development in terms of the smart city concept. This study aims to estimate the effect of smart city concept implementation on the economic performance of cities in Indonesia using the two stages least squares(2SLS) method. This study also uses instrument variables (IV) by applying city smartness indicators to control some factors which will affect smart city concept implementation. The smartness indicators used are smart economy, smart people, smart governance, smart environment, smart mobilityand smart living. The results prove that the implementation of the smart city concept in districts or cities in Indonesia has a significant positive effect on the economic performance of cities in Indonesia.

Keywords: smart city, economic performance of cities, city smartness indicator, 2SLS, instrument variables

1. INTRODUCTION

The 'Movement Towards 100 Smart Cities' programme was officially launched in Indonesia in 2017. It was initiated by the Ministry of Communication and Information (Kominfo) together with the Ministry of Home Affairs, Ministry of Public Works and Public Housing (PUPR), the National Development Planning Agency (Bappenas) and the Presidential Staff Office (Kominfo, 2017). In the same year, the Indonesia Smart City Rating (RKCI) was awarded to the 15 best smart cities by the Bandung Institute of Technology. The RKCI rewards, evaluates and maps cities that are considered to have potential and are characterized as smart cities, so that each can innovate based on the particular conditions and characteristics of Indonesian cities (RKCI, 2017).

As well as the cities selected in the Movement Towards 100 Smart Cities programme and the RKCI, there are other cities that have also implemented the smart city concept since 2012. With support from the central government through the programme it is expected that the number of cities that will implement the smart city concept will continue to grow in the next years. It is therefore important to know whether cities that implement the smart city concept will be successful or not in improving their economic performance.

The concept of the 'smart' city aims to solve various problems of cities efficiently and effectively to improve the quality of life of urban communities, through the use of information and communication technology. According to Lombardi et al. (2012), the main focus of smart city development is not only limited to information and communication technology and its infrastructure; it alsoencompasses the role of human capital and education, social issues and environmental problems.

The concept of the smart city typically emphasizes the use of technology and the internet. Several definitions of the smart city have been put forward, one of which is that, according to Giffinger et al. (2007) a smart city is one with good performance and a forward-looking attitude, and which displays six characteristics (or dimensions) built from a combination of 'smartness', independence and public awareness. The 'smart' dimensions proposed by Giffinger et al. (2007) are smart economy, smart people, smart governance, smart mobility, smart environment and smart living. In addition to these six dimensions, Nam and Pardo (2011) developed a further three dimensions of the smart city, including technology (hardware and software infrastructure), population (creativity, diversity and education), and institutions (government and policy). From these various dimensions it can be seen that technology and the internet are not only the goals of smart cities; rather, they are also tools that support the application of the smart city concept. According to Caragliu et al. (2011), a city becomes smart when it invests in human capital, social aspects, transportation and information and communication technology so as to encourage sustainable economic growth and a high quality of life, combined with wise natural resource management and government participation. Therefore, the label 'smart city' should indicate the delivery of smart solutions which allow cities to develop through increasing productivity, both in qualitative and quantitative terms.

According to the European Commission (2017), a smart city is a place with networks and services that are made more efficient for the benefit of society and business through the use of technology. Endogenous growth theory is used to support this research, in which city development through the concept of the smart city uses technology and is also supported by human capital in order to solve urban problems efficiently and effectively. The importance of technology in the economy began to be supported following the neo-classical Solow growth theory, with a basic model based on Mankiw et al. (1992) and Mankiw (2010) as follows:

$$Y = AF(K,L) \qquad (1)$$

The basic model of Solow's growth theory explains the influence of technology on production. First, it assumes that the production function consists of exogenous variables of production input, namely capital (K) and labour (L); then technology (A) plays a role in influencing output (Y). Increase in output in this model is not only caused by an increase in capital and labour, but also an increase in the productivity of production factors due to the use of technology. If inputs do not change, but productivity of the production factor increases, output will increase. From this, it can be concluded that technology plays an important role in economic growth.

By adding to the influence of technology, productivity will be increased, thus encouraging the increased economic performance of cities, with per capita GDRP standing as its proxy. In endogenous growth theory, technology is also influenced by other factors. In this study, the concept of the smart city represents a technological factor, because in its application it is always characterized as the use of technology through which the economic performance of the city can increase. In accordance with theory, technology is endogenous, which is influenced by other factors. In this study, the application of the smart city concept is influenced by factors derived from the indicators of city smartness initiated by Giffinger et al. (2007): smart mobility, smart economy, smart people, smart governance, smart environment and smart living. Then, all investments originating from within and outside the country in all sectors become part of capital. Meanwhile, labour here is seen as a highly educated workforce, because endogenous growth theory focuses on the importance of education and increasing human capital.

In neo-classical theory, however, technology is exogenous, as part of the production process, and has a constant growth of *g*. This cannot describe the current condition of technological development. Therefore, in endogenous growth theory, technology is seen as endogenous, meaning that it is also influenced by other factors. However, in the theory of endogenous growth, increasing human resources is the main driver of increasing economic productivity, through learning by doing and through new discoveries (Prijambodo, 1995). According to Howitt (2010), endogenous growth is long-term economic growth that is determined by economic factors and forces that regulate opportunities and incentives to create technological knowledge resulting in long-term economic growth. The output growth rate per person is determined by the level of technological progress. In long-term economic growth, technological progress is influenced by economic factors which occur through innovation, in the form of new products, processes, markets and the results of economic activities.

Several studies of the application of the smart city concept in the context of regional and urban economics have been carried out,looking at various aspects with different objectives. For example, a study conducted by Boscacci et al. (2014) looked at the effect of applying the smart city concept to the attractiveness of the city and housing market prices. Mundula and Auci (2013) verified the robustness of the city smartness indicators proposed by Giffinger et al. (2007) in explaining the efficiency of cities in Europe. Meanwhile, Caragliu et al. (2011) conducted a study with the same purpose as this present study, by analysing the effect of the application of the smart city concept on the economic performance of the city. Although having similar objectives to the study conducted by Caragliu et al. (2011), the use of different methods and variables in this study are novel in this area of research. A study in Indonesia carried out by Ramadhan (2017) aimed to rank the results of smart city implementation in metropolitan cities in Indonesia using the analytical hierarchy process method. This differsfrom the present study which aims to discover the success of smart city concept implementation by looking at the relationship between the application of the concept and the economic performance of cities and districts in Indonesia, both those that have and have not implemented the smart city concept,and not solely metropolitan cities. The study period of 2012 to 2016 is also longer than previous studies, and in each year cities that have not and have applied the concept of ‘smartness’ are researched,while the research conducted by Ramadhan (2017) only looked at the year 2015.

In this study, the city smartness indicators used to analyse the concepts and definitions of the smart city are the concepts proposed by Giffinger (2007), namely smart economy, smart people, smart governance, smart environment, smart mobility and smart living. Thisset of urban qualities based on the characteristics of ‘smartness’ proposed by Giffinger et al. (2007) can explain the differences in economic performance of each city. Furthermore, the application of smartness concepts is adjusted to the conditions of cities in Indonesia.

Each city has different characteristics and smart city programme implementations, but their goalsare, of course, the same: to improve the performance of the city in solving urban problems effectively and efficiently to create improved welfare and quality of life in urban areas. Economic performance can be described through the per capita gross domestic regional product (GDRP) of each city. Based on data from the Central Bureau of Statistics (2018), Indonesia's economy in 2017, measured by per capita GDP, reached Rp 51.89 million or US$3,876.8, which means that Indonesia’s economy in 2017 grew 5.07 percent, a higher rate than the 2016 achievement of 5.03 percent. In terms of production, the highest growth, of9.81 per cent, was achieved in the information and communication business sector. This coincides with the increase in the number of cities implementing the smart city concept since the Movement Towards 100 Smart Cities programme was launched in 2017. It is therefore necessary to examine the influence of the application of the smart city concept on the economic performance of cities in Indonesia. The

results prove that the implementation of the smart city concept in districts or cities in Indonesia has a significant positive effect on their economic performance.

2. METHOD

This research applies two-stage least squares(2SLS) regression analysis using instrument variables(IV). The analysis examines the application of the smart city concept in each city by looking at the influence of the application of the smart city concept – with various instruments of urban smartness – on their economic performance. The 2SLS method is used because using the ordinary least squares(OLS) method can cause estimation results to be biased and inconsistent (Wooldridge, 2013). The 2SLS method assumes that there are factors that can affect whether a city will apply the smart city concept or not. This means that there are endogenous variables which are correlated with errors. In addition, the research model is thought to have a two-way correlation between the main independent variables and the dependent variable: not only does the application of the smart city concept affect the economic performance of cities, but also per capita GDRP affects the cities in their application of the smart city concept. To understand this problem in this study, the basic model for the 2SLS equation was formed based on the model referring to Nagler (1999). The following is the model in stage one and stage two of the estimation of this study.

$$smartcity_{it} = b_0 + b_1 Z_{it} + b_2 lninvestment_{it} + b_3 lnhighedu_{it} + b_4 popdensity_{it} \quad (1)$$

$$lngdrpcap_{it} = b_0 + b_1(smartcity_{it}) + b_2 lninvestment_{it} + b_3 lnhighedu_{it} + b_4 popdensity_{it} + (u_{it} + b_1 v_1) \quad (2)$$

In Equations 1 and 2, *i* is a city or district and *t* is the year. The dependent variable used in this study is the log of per capita GDP. The data is obtained from the Central Bureau of Statistics and CEIC. The independent variable which is the focus of this research is the *smartcity* variable, which is a dummy variable worth 1 if the city or district has implemented smart city concepts in a given year and is 0 if it has not applied them. In this study, a city is assumed to have applied the concept of the smart city when it has implemented one of the indicators or dimensions of urban smartness as proposed by Giffinger et al. (2007).

Other independent variables which constitute the control in this study are investment variables that represents capital (K) in endogenous growth theory. The variable*lnnvestment*is the value of investment originating in the country (PMDA) and foreign investment (PMA). This data was obtained from the Investment Coordinating Board (BKPM). The *lnhighedu* variable is a highly educated workforce that represents the labour (L) factor in endogenous growth theory. Data for this variable was obtainedfrom the Indonesia Labour Force Survey (Sakernas). The *popdensity* variable, which represents regional density, is the control variable in this study and data for it was obtained from the Ministry of Home Affairs and CEIC.

In the 2SLS method, instrument variables (IV) are needed, beingZ which can determine X_1 but does not affect Y. In this research, instrument variables are needed that can affect a city in applying the concept of smart city or not, but these variables may not affect the log of per capita GDRP directly. Instrument variables (Z) in this study refer to the indicators proposed by Giffinger et al. (2007) and Cohen (2014) and developingindicators from Ramadhan (2017).

The first instrument is the *internet* variable, which is the percentage of internet penetration, used as an instrument as well as representing indicators of urban smartness in the aspect of smart mobility. Data for this variable was obtained from the National Socio-Economic Survey (Susenas). The second instrument is the *schoolenrollment* variable, which is the percentage of school participation at ages 16–18 years or high school level, as a proxy indicator of city smartness for the smart people aspect. Data for this was obtained from the World Bank. The next instrument

variable is the proxy for the smart economy which is the *entrepreneur* variable, or a work force that is self-employed. Data sources were drawn from the National Labour Force Survey (Sakernas). The smart city concept is also a solution to environmental problems according to city smartness indicators Giffinger et al. (2007). The instrument used in the smart environment aspect is flood, which is the percentage of flood events in a region. The proxy was used because one of the environmental aspects that was considered in implementing the smart environment aspect in Indonesia was monitoring and handling of floods. In addition, monitoring of flood regions, as well as reporting on waste and environmental issues is also an example of smart city programme. The application of the smart city concept is needed to solve the problem of flood in Indonesia. For the smart environment aspect, the *lnflood* variable is used, which is the flood frequency in an area. Data was obtained from The National Agency for Disaster Countermeasures (BNPB). Another instrument variable is, which is a categorical assessment of local government accountability based on the opinions given in the financial statements of the Audit Board of the Republic of Indonesia (BPK). Value 4 is given for an 'unqualified' opinion (WTP), value 3 is an 'unqualified' opinion with an explanatory paragraph (WTP DPP), value 2 for a 'fair' opinion with exception (WDP), value 1 for an 'unreasonable' opinion (TW) and 0 is a refusal to give an opinion or not expressing an opinion (TMP). Finally, the *crime* variable used in this study is the percentage of crime occurrences as a proxy of smart living.

The sample of this study is all districts or cities in Indonesia divided into treatment groups: cities that have implemented the smart city concept in a given year, and control groups: cities that have not implemented smart city concepts. It is known that there are 65 districts or cities that implemented smart city concepts from 2012 to 2016. The process of data collection is performed by searching for information on the internet. In this study, the city or districtis said to have implemented a smart city concept if they already have a programme that has begun to apply at least one of Giffinger et al.'s (2007) city smartness indicators.

3. RESULTS

Statistics based on the data can reveal facts about differences in the characteristics of cities that apply and do not apply smart city concepts in a given year. FromFigure 1 it can be seen that cities which implemented smart city concepts have an average per capita GDRP which is higher than those that did not apply such conceptsbetween 2012 and 2016. In addition, there is a fluctuation in per capita GDRP in a city that applies the smart city concept. This happens because in every year there are additional cities that have just applied smart city concepts and have a lower per capita GDRP value than cities that had implemented them in the previous year. This causes a decrease in the average per capita GDRP in the city group that had implemented smart city concepts in the following year. For example, in 2012 it was found that only Surabaya had implemented smart city concepts, with its per capita GDRP for that year being Rp95.2 million. Then in 2013, Semarang began implementing smart city concepts,with its per capita GDRPbeingRp61.9 million in 2013, causing a decrease in the average GDRP per capita in the city group that had adopted smart city concepts in 2013.

Based on data from the Central Bureau of Statistics and CEIC, it is known that there are cities that had good performance before applying the smart city concept, such as Semarang. The per capita GDRP of Semarang in 2012, when it did not apply the smart city concept, was Rp58.4 million. This means that there was an increase in the per capita GDRP of Semarang in 2013 after applying the smart city concept to 61.9 million. However, it is known based on data that the city of Semarang had had high GDRP per capita since 2012, that is, from before applying the smart city concept. There are other cities that had not implemented the smart city concept in 2012 buthad a

much lower per capita GDP value than Semarang City. Therefore, further exploration is needed into the effect of applying the smart city concept on per capita GDRP.

The data from Central Bureau of Statistics shows that the lowest per capita GDRP per year is found in cities that have not implemented the smart city concept, so that the average per capita GDRP of the city group that has not applied the smart city concept has reduced. Therefore, based on Figure 4.1it can be seen that the average per capita GDRP of the cities that have implemented smart city concepts in every year is always higher than the cities that have not implemented them. Per capita GDRP in this study is used to represent the economic performance of cities. Therefore, based on statistics, the data shows that cities that implement the smart city concept have better urban economic performance than cities that do not implement the smart city concept.

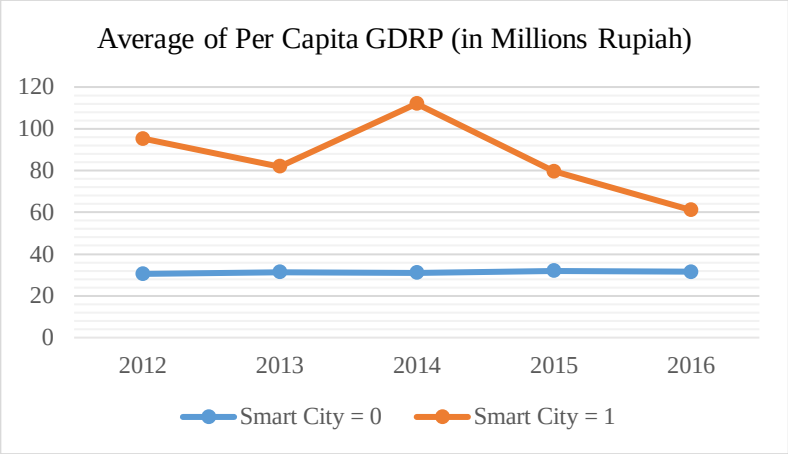

Figure 1. Average per capita GDRP in cities that have and have not applied the smart city concept
Source: Central Bureau of Statistics and CEIC, processed by the author

This study uses two regression methods: OLS and 2SLS estimations. The first step is to find out the relationship between the application of the smart city concept to the economic performance of cities in Indonesia, and estimation using OLS regression is performed regardless of the influence of endogeneity on the model. The fixed effect method is used because the data comprises a panel consisting of several districts or cities and years. Another reason is because there are differences in characteristics for each district or city in Indonesia, so we could not conduct sample selection for this research. In addition, after testing the model selection using the Hausman test, it was established that the panel model in this study is a fixed effect model.

However, by using OLS regression, the *smartcity* variable in dummy form is considered potentially inaccurate as a variable that shows the application of the smart city concept, because it is potentially an under- or over-estimate. Therefore, the results of OLS regression may be biased because there is a problem of endogeneity, which means there is a strong correlation between errors with other factors that can affect the application of the smart city concept in a district or city. Based on this, the 2SLS method is needed, using instrument variables that influence the application of the smart city concept to overcome the problem of endogeneity. Regression results using both methods can be seen in Table 1.

The 2SLS estimation presented in Table 1 uses six instrument variables, each of which is a proxy for one of the six city smartness indicators initiated by Giffinger et al. (2007). From Table 4.1 it can be seen that R-squared OLS is greater than IV-2SLS because OLS minimizes the residual sum of squares (Wooldridge, 2013). The results show that the application of the smart city concept has a significant positive effect on the percentage change in per capita GDP. Furthermore,

it is known that there are quite high differences in the coefficient values from the regression results using both methods. By using the OLS method, it is found that if the district or city applies the smart city concept, then per capita GDP will increase by 9% more than the city that does not apply the smart city concept. Using the 2SLS method using IV, it is found that if a district or city applies the smart city concept, the per capita GDRP will increase by 83.9% more than the city that does not implement the smart city concept. These results occur because of bias and inconsistency due to the use of the OLS method (Wooldridge, 2013). While other control variables have little difference for the regression coefficient.

The results show that the *lninvestment* and *lnhighedu*variables have a positive relationship with *lngdrpcap*, that is, the higher the percentage of investment and the percentage of the workforce with higher education in a city, the higher the per capita GDP. Meanwhile, the *popdensity*variable has a negative relationship with *lngdrpcap*. That is, the higher the regional density, the lower the per capita GDP.

Following these steps, it is necessary to perform a Davidson-MacKinnon test to discover whether the model has endogeneity problems, so we can ascertain whether this study requires an instrument variable. The results show that the model has an endogenous problem, and sorequires the 2SLS method with a variable instrument (VI) to be used. The mean Variance Inflation Factor (VIF) is 2.55, meaning there is no multicollinearity problem in the model. None of the variables used have a correlation value of more than 0.8; thus, instrument variables can be used because they do not have a direct correlation with the dependent variable and other control independent variables.

Table 1 Regression results of the relationship between the application of the smart city concept and the economic performance of cities, using fixed effect models in OLS and 2SLS

	FE OLS	**FE IV**
VARIABLES	*lngdrpcap*	*lngdrpcap*
smartcity	0.0912***	0.839***
	(0.0172)	(0.140)
lninvestment	0.00140**	0.00107*
	(0.000557)	(0.000598)
lnhighedu	0.0993***	0.0302**
	(0.00920)	(0.0151)
popdensity	-0.000186***	-0.000268***
	(3.85e-05)	(3.67e-05)
Constant	16.24***	16.99***
	(0.0966)	(0.159)
Observations	2,466	2,366
Number of cities	509	504
R-squared	0.244	0.133

Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1
Source: Author's calculation

A strong instrument is needed to get the best estimation results using the 2SLS-IV method. The results of the weak-identification test indicate that the value of the Cragg-Donald Wald F

statistic is 17.01 which, as it is greater than 10 means that the six instruments used are strong instruments. However, the results of the Sargan-Hansen test carried out to ascertain the validity of over-identifying restrictions (Table 2) indicate that the validity of the instrumentsare doubtful.

From Table 2 it can be seen that the instruments that significantly affect the application of the smart city concept are *internet*, *flood* and *accountability*. That is, these variables are 'good' instruments. The *internet* and *lnflood* variables have a positive relationship with the probability of a city applying the smart city concept. This suggests that a higher percentage of internet penetration and more flood events in an area will increase the probability of districts or cities to implement the smart city concept. The application of the smart city concept is needed in cities that have a high incidence of flooding. Furthermore, the *accountability* variable has a negative relationship with the application of the smart city concept. The implication is that the application of the smart city concept is needed in regions that have a poor local government accountability so that by building the smart city concept, it can be expected that a city will have a smart governance or a better local government accountability. In addition, the *schoolenrollment*, *entrepreneurship* and *crime* variables do not significantly affect the application of the smart city concept. If we look at the regression coefficient, it can be seen that the relationship between the *internet* variable and the application of the smart city concept has a higher elasticity (coefficient of more than 1), which means changes in internet penetration will be very sensitive to the probability of a city implementing or not implementing the smart city concept.

In the first stage regression model in Table 2, other exogenous variables such as *lninvestment*, *lnhighedu*, and *popdensity* need to be included to determine the relationship with the *smartcity* variable. Other exogenous variables may not affect the endogenous variables,which in this study is the *smartcity* variable. If it is influential, this means that exogenous variables have an influence on instrument variables; this is not allowed in the 2SLS-IV method. The results in Table 2 show that other exogenous variables do not significantly affect the *smartcity* variable.

Table 2. Results of the estimation of the relationship of the six instrument variables and the application of the smart city concept

VARIABLES	*smartcity*
internet	1.0875***
	(0.201)
schoolenrollment	-0.0028
	(0.053)
lnentrepreneur	-0.0329
	(0.049)
lnflood	0.0184**
	(0.0088)
accountability	-0.0128**
	(0.006)
crime	-1.287
	(0.807)
lninvestment	0.00004
	(0.934)
lnhighedu	0.026
	(0.0135)
popdensity	0.00009
	(0.00006)
_cons	-0.0913
	(0.539)
Sargan-Hansen stat.	0.000
Cragg-Donald Wald F stat.	17.01

Source: Author's calculations

Based on the results presented in Table 2, instrument variables that significantly affect the probability of cities implementingthe smart city concept are *internet*, *lnflood* and *accountability*, which are proxies of indicators of urban smartness for smart mobility, smart environment and smart governance factors. When regressed using the three instruments, the results show that by focusing on these three aspects, the application of the smart city concept has a significant positive effect on per capita GDP.

All three instruments can be seen to be strong. This is shown by the Cragg-Donald Wald F statistic value of 32.87. Even so, the over-identified model has a validity problem, which is shown by the results of the Sargan-Hansen test having a p-value of 0.0005. That is, the instrument is not issued correctly from the estimation of the equation and possibly correlates with the error.

Table 3. Results of the estimation of the relationship between implementation of the smart city concept and the economic performance of cities using three significant instrument variables

VARIABLES	*lngdrpcap*
smartcity	0.871***
	(0.145)
lninvestment	0.00103*
	(0.000621)
lnhighedu	0.0304**
	(0.0146)
popdensity	-0.000273***
	(3.85e-05)
Constant	16.98***
	(0.155)
Observations	2,465
Number of cities	509

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: Author's calculation

4.3. Analysis of each city's smartness indicators in smart city concept implementation and economic performance

If the regression is carried out using each instrument individually, these being each of the proxies from the city smartness indicators, we can know which of the city's aspects of smartness most strongly appliedin the development of the smart city. The results in Table 4 show that only the use of the *internet* instrument and *schoolenrollment* variables can lead the application of the smart city conceptto have a significant positive effect on per capita GDP, as shown in columns 1 and 2. The *internet* variable is a proxy of the smart mobility indicator and the *schoolenrollment* variable is a proxy of the smart people indicator.

Table 4. Results of estimated relationship in implementing the smart city concept and per capita GDRP using each smart city indicator as a single instrument

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
VARIABLES	*lngdrpcap*	*lngdrpcap*	*lngdrpcap*	*lngdrpcap*	*lngdrpcap*	*lngdrpcap*
smartcity	1.063***	1.875***	4.461	-0.255	11.94	0.192
	(0.186)	(0.553)	(13.77)	(0.440)	(30.02)	(0.335)
lninvestment	0.00094	0.000495	-0.00066	0.00157**	-0.00419	0.00135**
	(0.00066)	(0.0009)	(0.00708)	(0.00062)	(0.014)	(0.00055)
lnhighedu	0.0135	-0.0584	-0.287	0.130***	-0.948	0.0913***
	(0.0170)	(0.0501)	(1.213)	(0.0411)	(2.653)	(0.0312)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	*lngdrpcap*	*lngdrpcap*	*lngdrpcap*	*lngdrpcap*	*lngdrpcap*	*lngdrpcap*
popdensity	-0.0003***	-0.0004***	-0.00068	-0.00015**	-0.0015	-0.0002***
	(4.79e-05)	(0.00011)	(0.00157)	(7.03e-05)	(0.00348)	(5.52e-05)
Constant	17.17***	17.94***	20.41	15.91***	27.56	16.33***
	(0.182)	(0.552)	(13.14)	(0.438)	(28.74)	(0.346)
Observations	2,466	2,414	2,466	2,465	2,466	2,416
Number of cities	509	504	509	509	509	509

*Robust standard errors in parentheses**** p<0.01, ** p<0.05, * p<0.1Source: Author's calculation

The results inTable 5 show that *internet* and *schoolenrollment* are strong instrument variables, based on the Cragg-Donald Wald F statistic value. This indicates the instrument variableshave a strong relationship with endogenous variables, namely thes*martcity* variable. The results show that the *internet* and *schoolenrollment* variables have a significant positive effect on smart city implementation at a 99% confidence level.

Inflood and *crime*, which are proxies of the smart environment and smart living indicators, respectively, significantly influence the application of the smart city concept at a 90% confidence level. The percentage increase in flooding events has a significant positive effect on the probability of a city implementing the smart city concept. That is, the application of the smart city concept is needed in cities that have a high frequency of flood events to overcome flooding problems in regions. Meanwhile, the crime rate in a district or a city has a significant negative effect on the probability of the city implementing the smart city concept. Crime can be an obstacle to the implementation of urban development through application of the smart city concept. However, because these two instruments are weak, the use of the *lnflood* and *crime* instruments does not lead to the application of smart city concepts significantly affecting per capita GDRP. The implication is that smart city development that focuses on aspects of smart environment and smart living or on the conditions of flooding and city crime does not significantly improve the city's economic performance.

Similar results apply for the *entrepreneurship* and *accountability* variables which are proxies of the smart economy and smart governance indicators. Because both are very weak instruments, the application of the smart city conceptas influenced by these factors does not significantly affect per capita GDRP. In addition, this matter was influenced by the problem of under-identification in the Canon Anderson test results. If the *entrepreneur* and *accountability* variables are used as a single instrument, the instrument experiences under-identification problems, which means that they are not relevant or do not have a relationship with the application of the smart city concept.

The *lnentrepreneur* variable has a negative relationship with the *smartcity* variable. The application of the smart city concept is needed to encourage regions that have a small number of businesses. If the percentage of the workforce who are self-employed is still fairly low, this will increase the probability of the city implementing the smart city concept. In Table 5 it is shown that the *accountability* variable has a positive relationship with the application of the smart city concept. The implication is that the better the accountability of local governments in a region, the easier it will be to implement the concept of the smart city. However, the results of this study indicate that applications of the smart city concept that focus on smart economy and smart governance in terms of entrepreneurial conditions and accountability of government do not significantly improve urban economic performance.

Overall, it can be seen that the internet as a proxy of the smart mobility indicator is the most powerful positive instrument to be applied to the smart city concept in Model 1 in Table 5. The application of the smart city concept by internet penetration can improve the economic performance of cities. In addition, the *schoolenrollment* variable is also a stronginstrument.

Table 5.Estimation results of first stage of relationship between each proxy of city smartness indicators and smart city implementation

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
VARIABLES	*smartcity*	*smartcity*	*smartcity*	*smartcity*	*smartcity*	*smartcity*
internet	0.927***					
	(0.163)					
schoolenrollment		0.142***				
		(0.049)				
lnentrepreneur			-0.014			
			(0.049)			
lnflood				0.014*		
				(0.0085)		
accountability					0.0019	
					(0.005)	
crime						-1.452*
						(0.845)
lninvestment	-0.000037	0.00033	0.00048	0.00047	0.00046	0.00045
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0005)
lnhighedu	0.022*	0.075***	0.088***	0.088***	0.087***	0.095***
	(0.013)	(0.014)	(0.015)	(0.015)	(0.015)	(0.015)
popdensity	0.00009	0.0001	0.0001	0.0001	0.0001	0.0001
	(0.00006)	(0.00007)	(0.00007)	(0.00007)	(0.00007)	(0.00007)
_cons	-0.427***	-0.9***	-0.807	-0.96***	-0.944***	-1.005***
	(0.136)	(0.155)	(0.534)	(0.157)	(0.16)	(0.163)
Cragg-Donald Wald F stat.	85.27	12.31	0.13	3.34	0.18	3.53
Anderson Canon. (p-val)	0.0000	0.0004	0.7175	0.0672	0.6745	0.0599
p>|t|, *p<0.1, **p<0.05, ***p<0.01						

Source: Author's calculation

5. DISCUSSION

Based on results, it can be said that the internet supports the implementation of the smart city concept. This study has produced the new discovery that the internet, as an aspect of smart mobility, is the most powerful instrument in influencing the probability of cities to implement smart city concepts which will in turn have a significant effect on urban economic performance. Regression results are coherent with endogenous growth theory, in which the technology in this study is a*smartcity* variable that does not appear but is influenced by other factors.

The instrument variable is therefore used to influence the application of smart city concepts. In connection with the research framework, by using city smartness indicators the smart city

concept can be said to be an element of technology that influences per capita GDRP, and this is supported by the application of the *internet* as a strong instrument variable. In addition, based on the results of the regression, the *smartcity* variable, which is a proxy of technology (A), the *lninvestment* variable, which is a proxy of capital (K), and the *lnhigheduv*ariable, which is a proxy of labour (L), give results in the direction of the relationship in accordance with theory regarding the relationship on several models, suggesting that these factors will positively affect economic performance.

There are similarities in this research to the previous study by Caragliu et al. (2011), which has similar objectives but uses different variables. Caragliu et al. (2011) only use the OLS method to see the influence of each city smartness indicator. This approach is considered less sharp and can cause over- or under-estimates in describing the concept of the smart city in the research, because regression can be performed on each variable without mentioning that the variable is an indicator of city smartness. In contrast, in this study, by creating a dummy for cities that have and have not implemented smart city concepts, and by incorporating indicators of city smartness as instrument variables that affect smart city application, we can improve the sharpness of the smart city concept in this study. This research can identify cities that have and have not implemented the smart city concept.

In addition to the level of internet penetration, a higher school participation rate can also support the city in implementing the smart city concept.Thus, economic performance of cities which implementing the smart city concept can be improved by the role of technology and human capital.

6. CONCLUSIONS

By using the 2SLS method, this study aimed to discover the influence of urban development by application of the concept of the smart city on the economic performance of cities. The results of the study show that from 2012 to 2016 the application of the smart city concept in Indonesia had a positive effect on improving the economic performance of cities. This is influenced by the level of internet penetration in an area as an instrument variable that influences the probability of the city applying or not applying the smart city concept. Therefore, it can be concluded that the level of internet penetration as an aspect of smart mobility, plays the most important role in urban development resulting from the application of the smart city concept. Indonesia government should encourage more cities to become smart by supporting the role of internet penetration first to build a sustainable smart city and also build human capital aspect in Indonesia by increasing the opportunity of school participation, since based on results also stated that the application of smart cities that focuses on human capital or school participation will improve the economic performance of cities.

Just by combining three instruments that significantly affect the application of the smart city concept: *internet*, *flood* and *accountability*, it has been possible to make the application of the smart city concept significantly influence the economic performance of cities. That is, the application of the smart city concept that is influenced by or focuses on the level of internet penetration in an area, on flood events or on the accountability of local government can improve the economic performance of cities. In other words, to improve its economic performance a city should focus on three aspects of urban ‘smartness’: smart mobility, smart environment and smart governance.

The limitations of this study can be developed in future studies. First, there is limited information regarding the application of city smartness indicators that have been applied to each city. There is no official website or information that provides a list of cities that have become smart cities. Therefore, in this study the authors conducted an assessment based on the availability

of information from various articles on the internet regarding cities that have begun to apply the concept of smart city by assuming that a district or city is considered to have implemented smart city if it has made a programme that applying indicators of smartness. So that, authors also put a judgment to state that a city is smart or not.

This study uses a proxy for each indicator of city smartness. Therefore, in future studies, other proxies can be used in each indicator of city smartness. For example, if this research uses the level of internet penetration as a proxy for the aspect of smart mobility, further research can see aspect of smart mobility in terms of transportation or otherwise. Thus, it can provide new knowledges about the application of the smart city concept in various aspects because however the types of programmes for implementing the smart city concept in each aspect vary greatly in the implementation of each region.

Second, due to limited data in 2017 and 2018, the scope of this research is limited to the application of the smart city concept from 2012 to 2016. While many cities have begun to implement the smart city concept since 2017, since the central government has supported the development of smart cities with “the Movement to 100 Smart City Programme” in Indonesia. Further studies can use a longer year scope.

BIBLIOGRAPHY

Angrist, J.D. and Krueger, A.B. (2001) 'Instrumental variables and the search for identification: From supply and demand to natural experiments,*Journal of Economic Perspectives*, 15(4), pp. 65–82.

Boscacci, F., Maltese, I., and Mariotti, I. (2014) 'Smartness and Italian cities'*Journal of Land Use, Mobility and Environment*.doi 10.6092/1970-9870/2512

Caragliu, A., Bo, C. D. and Nijkamp, P. (2011) 'Smart cities in Europe',*Journal of Urban Technology*, 18(2), pp. 65–82.

Caragliu, A. and Bo, C.D. (2012) 'Smartness and European urban performance: Assessing the local impacts of smart urban attributes',*Innovation: The European Journal of Social Science Research*, 25(2), pp. 97–113.

Cohen, B. (2014) *The smartest cities in the world 2015: Methodology*. Available at: https://www.fastcompany.com/3038818/the-smartest-cities-in-the-world-2015-methodology (Accessed: 10 February 2018).

Combes, P.-P., Duranton, G., Gobillon, L. and Roux, S. (2010) Estimating agglomeration economies with history, geology, and worker effects, *Agglomeration Economics*, pp. 15–66, Available at:https://repository.upenn.edu/real-estate_papers/21

Cracolici, M.F., Cuffaro, M. and Nijkamp, P. (2009) 'The Measurement of economic, social, and environmental performance of countries: A novel approach',*Social Indicators Research*,95(2), pp. 339–356.

European Commission (2017) *Smart cities*. Available at:https://ec.europa.eu/digital-single-market/en/smart-cities. (Accessed: 10 February 2018).

Giffinger, R., Fertner, C., Khamar, H., Kalasek, R., Pichler-Milanovic, N. and Meijers, E. (2007) Smart cities-ranking of European medium-sized cities. Available at: http://www.smart-cities.eu/download/smart_cities_final_report.pdf (Accessed: 10 February 2018).

Howitt, P. (2010) Endogenous growth theory. Available at:https://link.springer.com/chapter/10.1057/9780230280823_10.(Accessed: 1 June 2018).

Investopedia (2018) *Per capita GDP*. Available at:https://www.investopedia.com/terms/p/per-capita-gdp.asp. (Accessed: 27 February 2018)

Kanter, R.M. and Litow, S.S. (2009) 'Informed and interconnected: A manifesto for smarter cities, *Harvard Business School Working Paper*, No. 09-141.

Kominfo (2017) *LangkahMenuju "100 Smart City".*Available at:https://kominfo.go.id/content/detail/11656/langkah-menuju-100-smart-city/0/sorotan_media (Accessed: 3 February 2018).

Lombardi, P., Giordano, S., Farouh, H. and Yousef, W. (2012) 'Modelling the smart city performance',*Innovation: The European Journal of Social Science Research*, 25:2, pp. 137–149.

Mankiw, N.G. (2010)*Macroeconomics*. 7th edn. New York: Worth Publishers.

Mankiw, N.G., Romer, D. and Well, D.N. (1992) 'A contribution to the empirics of economic growth', *The Quarterly Journal of Economics*, 57, pp. 407–437.

Mundula, L. andAuci, S. (2013) 'Smart cities and a stochastic frontier analysis: A comparison among European cities',*Munich Personal RePEc Archive Paper*, No. 51586

Nagler, J. (1999) *Notes on Simultaneous Equation and Two Stage Least Squares Estimates.*Available at:www.nyu.edu/classes/nagler/quant2/notes/2slsnotes_oh.pdf. (Accessed: 17 February 2018).

Nam, T. and Pardo, T.A. (2011)*Conceptualizing smart city with dimensions of technology, people, and institutions.* https://www.researchgate.net/publication/221585167_Conceptualizing_smart_city_with_dimensions_of_technology_people_and_institutions (Accessed on: 12 February 2018)

Prijambodo, B. (1995) Endogenous Growth Theory: A brief theoretical review and its implications. Available at:http://perpustakaan.bappenas.go.id/lontar/file?file=digital/19377-%5B_Konten_%5D-Konten_%5D-Konten%20445.pdf (Accessed: 25 May 2018).

Ramadhan, E. (2017) *Peringkat Smart City dan Komponennya pada Kota-Kota Metropolitan di Indonesia*. Yogyakarta: Universitas Gadjah Mada.

RKCI (2017) *Maksud dan Tujuan RKCI.* Available at: http://ratingkotacerdas.id/. (Accessed: 2 March 2018).

Wooldridge, J.M. (2013) *Introductory econometrics: A modern approach.*5th edn.Andover, UK: Cengage Learning.