

Identifying Simultaneous Equation Modelling for the Digital Competitiveness Index (IDSD) and Foreign Direct Investment (FDI) in their Influence on Economic Digitalization

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Abstrak: *Technological advances are causing rapid and comprehensive changes, especially in the digital economy sector. The strength of a society's digital competitiveness is an important asset to support the growth of the national digital economy and attract foreign direct investment. This study aims to identify the simultaneous relationship between the Digital Competitiveness Index (IDSD) and Foreign Direct Investment (FDI). The method used is Two Stage Least Squares (2SLS) to overcome endogeneity problems in existing regression models, using STATA 17 software for calculations. The data analyzed are panel data from 34 provinces in Indonesia for 4 years (2020, 2021, 2022, and 2023). The analysis shows that in the FDI model, IDSD, GRDP growth rate, and non-oil and gas exports have a significant effect on FDI. However, in the IDSD model, FDI has no significant effect on IDSD, while fintech lending and ICT capability of the community have a significant effect on IDSD. Based on the results, there is no simultaneous relationship between FDI and IDSD.*

Kata Kunci: Digital Economy, IDSD, FDI, Simultaneous Equation, 2SLS.

JEL: C360; E2; O110;

1. INTRODUCTION

In the current era of globalization, the rapid and inclusive development of technology is one of the phenomena that increasingly supports the ease of accessibility and mobilization of people in their daily activities. Starting from driving, interacting, to carrying out economic activities carried out to ensure the fulfillment of their daily needs. According to Anggraeni & Yasa (2012) in Nagri (2021) states that the digital era can help an individual in carrying out the buying and selling process and other economic interactions that can be carried out anywhere without any time and place restrictions (Nagri, 2021).

Economic digitalization is a system that exists in the economy of a region with characteristics possessed as an intelligence space, consisting of information, various information access, information processing, and communication capacity Ansori (2016) in Nagri (2021). According to Machmud *et al.* (2010) in Nagri (2021) states that digitalization in the economy is able to develop very quickly through the existence of e-commerce platforms and e-money services that can facilitate the process of purchasing product transactions by consumers only through the use of devices (Nagri, 2021).

Indonesia is one of the largest archipelagic countries in the world. A country where all accessibility and connectivity between islands is needed to maintain synergy and strengthen sectoral economies. According to data from Dudhat & Agarwal (2023), Indonesia is the first country that will experience economic growth through the adoption of the digital economy. This is certainly a breath of fresh air for the speed of economic growth and development in Indonesia towards conventional and sustainable economic conditions (Dudhat & Agarwal, 2023).

In building a digitized economy, the need to see the readiness and potential of digital competitiveness in each region is very important to ensure that the process of digitizing the national economy runs well and systematically. Based on EV-DCI data (2023), it shows that DKI Jakarta <https://equity.ubb.ac.id/index.php/equity> doi 10.33019/equity.v%vi%i.310

Province is one of the regions in Indonesia that has the highest Digital Competitiveness Index (IDSD) through a score of 76.6 in 2023. This figure is relatively greater than the achievement of results in other provincial areas through an average achievement below 50. This is a fact that digital competitiveness in Indonesia is still relatively low (East Ventures, 2023).

Investment is a very important input in supporting the success of an existing development. In the context of economic digitalization, investment capital can be a stimulus to advance the digital economy sector in Indonesia. According to Sarwedi (2002), it is stated that Foreign Direct Investment (FDI) is an international capital flow where companies within a country want to establish or expand their companies in other countries (Sarwedi, 2002). In this regard, the existence of foreign direct investment is very influential for the economic growth of developing countries such as Indonesia. The phenomenon of lack of capital, low savings value, and small investment size is still an obstacle to the development of developing countries (Muzakki & Sukim, 2022). Through this statement, the development of the digital economy in Indonesia also has the potential to be hampered without direct investment flows.

Therefore, this study will analyze the effect of the Digital Competitiveness Index (IDSD) on Foreign Direct Investment (FDI) to see the significance of the amount of direct investment issued by foreigners when looking at digital competitiveness between provinces in Indonesia. Vice versa, the effect of Foreign Direct Investment (FDI) on the Digital Competitiveness Index (IDSD) will also be analyzed as a step to observe the significance of the amount of investment on digital competitiveness among provinces in Indonesia. The research will use the panel data simultaneous equation model through the Two Stage Least Square (2SLS) method as a calculation procedure carried out to get good results. It is hoped that this research can be a source of reference and renewable research related to the lack of research that discusses it.

2. LITERATURE REVIEW

2.1. Digital Competitiveness Index

According to the website of East Ventures, an investment company engaged in the digital economy, the progress of competitiveness and the digital economy in Indonesia in each province has been calculated and formulated in an index. The index is in a report called the East Ventures-Digital Competitiveness Index (EV-DCI). EV-DCI measures and maps the development of digital competitiveness across cities and provinces in Indonesia. EV-DCI has 50 indicators used in its calculation which are divided into inputs (Human Resources, ICT Usage, and ICT Spending), outputs (Economy, Entrepreneurship, and Productivity), and supports (Infrastructure, Finance, and Local Government Regulation and Capacity) (East Ventures, 2023).

2.2. Foreign Direct Investment (FDI)

Foreign Direct Investment (FDI) refers to capital inflows from abroad to the private sector, both in the form of direct investment and indirect investment (portfolio investment). This capital includes assets in the form of money or other forms that have economic value, owned by the investing party (Manuaba, dalam Dewi et al., 2019). Menurut Undang-Undang Nomor 1 tahun 1967, Penanaman Modal Asing (PMA) merupakan Menurut Undang-Undang Nomor 1 of 1967, Foreign Investment (PMA) is an investment in foreign means of payment that is not included in Indonesian foreign exchange or capital that is entered into the country from abroad and does not come from Indonesian foreign exchange (Dewi & Dewi, 2019).

2.3. Economic Digitization

According to Saputra (2021) in Ermawati & Lestari (2022) economic digitalization is a shift towards a telecommunications-based economy, where all economic activities of society undergo transformation. With digitalization, the boundaries of space, time, and distance become irrelevant. The presence of digitalization provides various benefits for all parties, especially for economic actors. According to data from YouGov cited by Facebook for Business, social media usage increased 38% during the COVID-19 pandemic. This opportunity is a place for economic actors in Indonesia to digitize (Ermawati & Lestari, 2022).

3. METHODE

This study uses quantitative research methods, and uses panel data which is a combination of time series data in the period 2020-2023 and cross section data in 34 provincial areas in Indonesia. The latest provincial data, namely Central Papua, South Papua, Mountainous Papua, and Southwest Papua Provinces, are not included. This is due to the limitations and incompleteness of the latest data related to the inauguration of these provinces which were fairly recently inaugurated in 2022. Data collection was conducted comprehensively through an e-library study approach, by accessing data sourced from e-journals and official websites of the Central Statistics Agency (BPS), Financial Services Authority (OJK), and East Ventures. The data that has been obtained is then transformed into natural logarithm values to harmonize the value of the units being analyzed. The dataset involved various variables, namely Digital Competitiveness Index (IDSD) per province (East Ventures, 2023), *Foreign Direct Investment (FDI) per province* (BPS, 2024c), *Fintech Lending (Accumulated Number of Lender Accounts) per province* (OJK, 2024), GRDP per province (BPS, 2024a), Non-Oil and Gas Export Level per province (Kemendag, 2024), and ICT Capability per province (BPS, 2024b). A simultaneous equation model through the Two Stage Least Squares (2SLS) method is applied as the analysis method, which includes order conditions, classical assumption tests and hypothesis testing, as well as model fit testing using the Stata 17 application as a data analysis tool. The econometric model of 2SLS method is used in this study as follows:

- The simultaneous equation model of Digital Competitiveness Index (IDSD) on FDI can be written as follows:

$$Y_{1nt} = \beta_1 + \beta_2 Y_{2nt} + \beta_3 X_{1nt} + \beta_4 X_{2nt} + e_{1nt}$$

- The simultaneous equation model of FDI on the Digital Competitiveness Index (IDSD) can be written as follows:

$$Y_{2nt} = \alpha_1 + \alpha_2 Y_{1nt} + \alpha_3 X_{3nt} + \alpha_4 X_{4nt} + e_{2nt}$$

Description of Research Variables:

- **Endogenous Variables:**
 Y_{1nt} : Digital Competitiveness Index (IDSD) on FDI
 Y_{2nt} : Foreign Direct Investment (FDI) to Digital Competitiveness Index (IDSD)
- **Exogenous/predetermined Variables:**
 X_{1nt} : Fintech Lending (Accumulated Number of Lender Accounts) per province
 X_{2nt} : ICT Capability per province
 X_{3nt} : GRDP per province
 X_{4nt} : Non-oil Export Level per province

4. RESULTS AND DISCUSSION

4.1. The Order Condition

In conducting simultaneous modeling, we first identify whether the equation can be estimated or not. One of the identification methods is through the Order Condition with three categories, namely exactly identified, overidentified, and unidentified. In relation to simultaneous equation modeling using the Two Stage Least Squares (2SLS) method, an equation is said to be estimated using the 2SLS method if it is included in the identified or overidentified category (Primadona, 2016).

Tabel 1. Order Condition

Equation	Nilai K - k	Syarat	Nilai m - 1	Identifikasi
1	(6-3)	>	(1-1)	<i>Overidentified</i>
2	(6-3)	>	(1-1)	<i>Overidentified</i>

Source: Data Processed (2024)

Through the table above, it can be seen that the simultaneous equation in the model is overidentified based on the results of $K-k > m-1$. Thus, the simultaneous equation in this study has met the requirements to be estimated using the Two Stage Least Square (2SLS) method.

4.2. Pengujian Asumsi Klasik

The classical assumptions carried out in this study include normality test, heteroscedasticity test, multicollinearity test, and autocorrelation test. Normality testing using the Shapiro-Wilk test obtained a decision to reject H_0 so that the conclusion obtained was that the residuals in the simultaneous equation were normally distributed. Heteroscedasticity test in each equation shows different results. For the FDI equation, the results show that there are symptoms of heteroscedasticity so that it fails to reject H_0 , while the IDSD equation does not show any symptoms, which means it can reject H_0 . The multicollinearity test shows that both equations do not experience multicollinearity symptoms through the Variance Inflation Error (VIF) value in each equation model with a value of less than ten, so both equations reject H_0 . In the autocorrelation test, there are different results where the FDI model experiences autocorrelation problems so that it accepts H_0 , while the IDSD model does not show any autocorrelation problems, so it can be stated that it rejects H_0 .

4.3. Simultaneous Equation Model

4.3.1. OLS and 2SLS Results for IDSD

Tabel 2. OLS and 2SLS Results for IDSD Model

Variable	OLS Coefficient	OLS Significance	2SLS Coefficient	2SLS Significance
FDI	0.001067	0.889	-0.00967	0.389
<i>Fintech Lending</i>	0.093211	0.000	0.100634	0.000
ICT	0.571302	0.000	0.561456	0.000
Constant	0.325152	0.170	0.363074	0.123
Number of Observations	136		136	
F-Statistik	0.0000		(-)	
<i>Prob>chi2</i>	(-)		0.0000	
<i>R-Squared</i>	0.7602		0.7566	
<i>Root MSE</i>	0.12922		0.12825	
<i>Instrumented Instruments</i>	FDI FL TIK PDRB EX			

Source: Data Processed (2024)

4.3.2. OLS and 2SLS Results for FDI

Table 3. OLS and 2SLS Results for FDI Model

Variable	OLS Coefficient	OLS Significance	2SLS Coefficient	2SLS Significance
IDSD	1.007108	0.014	1.095626	0.018
PDRB	-0.867198	0.002	-0.87522	0.001
EXPORT	0.604194	0.000	0.599184	0.000
Constant	0.21477	0.888	-0.03951	0.981
Number of Observations	136		136	
F-Statistik	0.0000		(-)	
Prob>chi2	(-)		0.0000	
R-Squared	0.5927		0.5925	
Root MSE	1.1225		1.1061	
Instrumented	IDSD			
Instruments	PDRB EX FL TIK			

Source: Data Processed (2024)

4.4. Hausman Simultaneity Test

Basically, in regression equations, simultaneity problems always arise due to the relationship between endogenous variables and disturbance variables. Therefore, to measure the quality of the regression analyzed, a test is needed to see whether there is a simultaneity problem in a regression equation model. One of the test methods that can be used is to use the Hausman simultaneous test with the basis for decision making if Probability < 0.05 (significance level) indicates a simultaneity problem, while if Probability > 0.05 (significance level) means there is no simultaneity problem.

Table 4. Simultaneity Test of IDSD Model

Test of Endogeneity IDSD	
H0: variabel are exogenous	
Durbin (score) chi(2) (1)	1.70997 (p = 0.1910)
Wu-Hausman F (1,131)	1.66807 (p = 0.1988)

Source: Data Processed (2024)

Table 5. Simultaneity Test of FDI Model

Test of Endogeneity FDI	
H0: variabel are exogenous	
Durbin (score) chi(2) (1)	0.136158 (p = 0.7121)
Wu-Hausman F (1,131)	0.131284 (p = 0.7177)

Source: Data Processed (2024)

In the two simultaneous equations above between IDSD and FDI, the Hausman test results are $0.1988 > 0.05$ and $0.7121 > 0.05$ respectively, which means that there is no simultaneity problem in the two simultaneous equations. Thus, it can be said that both equation models are feasible to be analyzed further and produce valid quantitie

4.5. Model Fit Test

4.5.1. Discussion of Simultaneous Equation Model Results

4.5.1.1. DSD Simultaneous Model

Based on the table of calculation results above, the simultaneous equation between the Digital Competitiveness Index (IDSD) and FDI is obtained as follows:

$$\text{IDSD} = 0.3630 - 0.0096\text{FDI} + 0.1006\text{FL} + 0.5614\text{TIK} + e$$

Description:

IDSD : Digital Competitiveness Index (IDSD)

FDI : *Foreign Direct Investment*

FL : *Fintech Lending*

TIK : *Information and Communication Technology*

e : *standard of error*

The results of the OLS calculation in Table 2. above show a positive but insignificant value of the FDI variable partially. That is, every one percent increase in FDI will increase the value of digital competitiveness of all provinces in Indonesia. However, the FDI variable as one of the variables that can be influenced by other exogenous variables, causing the potential emergence of endogeneity issues and reciprocal relationships between variables in the OLS model is very risky. This causes the need for further analysis, one of which can use the simultaneous equation model of Instrumental Variables (IV) through the Two Stage Least Square (2SLS) approach to clarify the impact that occurs.

The results of the 2SLS calculation show the relationship between FDI, fintech lending, and ICT capabilities on the Digital Competitiveness Index (IDSD) with GRDP and non-oil and gas export levels as instrument variables. The modeling results above show a constant value of 0.3630 which indicates that when all variables are zero, the IDSD will be 0.3630. The amount of FDI shows negative and insignificant results on IDSD, meaning that the greater the foreign direct investment tends to reduce the strength of national digital competitiveness. This is indicated by the FDI achievement of -0.0096, which means that every 1 percent increase in FDI will reduce the digital competitiveness index by 0.0096 with the assumption that other variables are said to be fixed (*ceteris paribus*). This is contrary to research conducted by Zekos (2005) which states that FDI plays an important role in the emergence and development of the digital economy in the European Union (Zekos, 2005).

The results of the calculation of fintech Lending show a positive and significant value that affects the digital competitiveness index. This means that the greater the ability of fintech Lending each community will increase the level of national digital competitiveness. The evidence is shown in the value of fintech Lending of 0.1006 which means that every 1 percent increase in fintech Lending will affect the increase in the digital competitiveness index by 0.1006 with the assumption that other variables are said to be in a fixed condition (*ceteris paribus*).

Furthermore, the ICT calculation results again show a positive and significant value that affects the digital competitiveness index. This means that the higher the community's ability to master information and communication technology will increase the achievement of the national digital competitiveness index. The evidence is shown by the value of ICT capability of 0.5614, which means that every 1 percent increase in the ICT capability of the community will affect the increase in the digital competitiveness index by 0.5614 under the condition that other variables are said to be in a fixed condition (*ceteris paribus*). This finding is in line with research conducted by Wang et al (2024) which states that the ability of

employees to master new digital technologies will have an impact on the digital performance of Chinese MSME employees, especially in a competitive climate (Wang et al., 2024).

4.5.1.2. Simultaneous FDI Model

Based on the calculation results table above, the simultaneous equation between Foreign Direct Investment (FDI) and the Digital Competitiveness Index (IDSD) is as follows:

$$\text{FDI} = -0.0395 + 1.0956\text{IDSD} - 0.8752\text{PDRB} + 0.5992\text{EX} + e$$

Explanation:

FDI : Foreign Direct Investment
 IDSD : Digital Competitiveness Index
 PDRB : GDP Growth Rate
 EX : Non-Oil and Gas Exports
 e : Standard Error

The OLS calculation results in Table 3 above show that the IDSD variable is positive and partially significant. This means that every one percent increase in IDSD will increase the value of direct foreign investment in all provinces in Indonesia. However, since the IDSD variable can be influenced by other exogenous variables, there is potential for endogeneity issues and reciprocal relationships between variables in the OLS model, which is very risky. This necessitates further analysis, one of which can be done using the simultaneous equation model with Instrumental Variables (IV) through the Two-Stage Least Squares (2SLS) approach to clarify the impacts that occur.

The 2SLS simultaneous equation results above show the relationship between the Digital Competitiveness Index (IDSD), GDP growth rate, and non-oil and gas exports on Foreign Direct Investment (FDI), with fintech lending and ICT capability as instrumental variables. The modeling results above show a constant value of -0.0395, which means that when all independent variables are zero, the FDI value will be -0.0395. The IDSD variable has a positive and significant effect on FDI, meaning that the higher the digital competitiveness index value, the more likely it is to increase direct foreign investment. The IDSD variable has a coefficient of 1.0956, meaning that each one percent increase in IDSD will increase FDI by 1.0956, assuming other variables remain constant (*ceteris paribus*). This is consistent with the findings of Wang et al. (2024), who state that digital transformation significantly increases direct foreign investment, especially in state-owned enterprises and competitive industries. This can occur because digital transformation can reduce foreign operational costs and enhance technological innovation capabilities (Wang et al., 2024).

The calculation results of the GDP growth rate variable show a significant negative effect on foreign direct investment. This means that the higher the GDP growth rate, the lower the amount of foreign direct investment. The GDP growth rate variable has a coefficient value of -0.8752, which means that every one percent increase in the GDP growth rate variable will decrease FDI by 0.8752, assuming other variables remain constant (*ceteris paribus*). This finding contradicts the research conducted by Febriana (2014), which states that GDP has a significant positive effect on foreign direct investment in the long term (Febriana, 2014). However, it is in line with the research conducted by Swannitarini (2016),

which states that GDP has a positive effect on foreign direct investment (Swanitarini, 2016).

Furthermore, the non-oil and gas export variable shows a significant positive effect on foreign direct investment. This means that the greater the non-oil and gas exports, the higher the amount of direct foreign investment. The non-oil and gas export variable has a coefficient value of 0.5992, which means that every one-unit increase in the GDP growth rate variable will increase FDI by 0.5992, assuming other variables remain constant (*ceteris paribus*). This is consistent with the findings of Febriana (2014), which state that exports have a positive and significant effect on foreign direct investment in the short term. However, it can have a significant negative effect in the long term (Febriana, 2014).

4.6. Goodness of Fit Testing

4.6.1. Simultaneous F Test and Coefficient of Determination

Table 6. Simultaneous F Test Results

Component Model	FDI	IDSD
Number of Observations	136	136
<i>Wald chi2 (3)</i>	196.97	425.56
<i>Prob > chi2</i>	0.000	0.000
<i>R-Squared</i>	0.5925	0.7566
<i>Root MSE</i>	1.1061	0.12825

Source: Processed Data (2024)

The simultaneous test on the regression coefficients of the simultaneous equation between IDSD with FDI, fintech lending, and ICT capability above shows a probability value $> \chi^2$ of 0.0000 (< 0.05), so H_0 is accepted, meaning that foreign direct investment, fintech lending companies, and ICT capability jointly influence the digital competitiveness index. The simultaneous test on the regression coefficients of the simultaneous equation between FDI with IDSD, GDP growth rate, and non-oil and gas exports above shows a probability value $> \chi^2$ of 0.0000 (< 0.05), so H_0 is accepted, meaning that the digital competitiveness index, GDP growth rate, and non-oil and gas exports jointly influence the amount of foreign direct investment.

The coefficient of determination (R-Squared) test results for the simultaneous equation between FDI with IDSD, GDP growth rate, and non-oil and gas exports with fintech lending and ICT capability as instrumental variables show a determination value of 0.5925. This means that the FDI variable can be explained by the IDSD, GDP growth rate, and non-oil and gas export variables by 0.5925 or 59.25%, while the remaining 40.75% is explained by other variables outside the study. The coefficient of determination test results for the simultaneous equation between IDSD with FDI, fintech lending, and ICT capability with GDP growth rate and non-oil and gas exports as instrumental variables show an R-squared value of 0.7566. This means that the IDSD variable can be explained by FDI, fintech lending, and ICT capability by 0.7566 or 75.66%, while the remaining 24.34% is explained by other variables outside the study.

4.6.2. Partial t-test

Table 7. Partial t-test Results

Variable	$P > z $	Result
IDSD	0.018	Significant
PDRB	0.001	Significant
EX	0.000	Significant
FDI	0.389	Not Significant
FL	0.000	Significant
TIK	0.000	Significant

Source: Processed Data (2024)

The partial t-test results from the simultaneous equation model show that nearly all independent variables have values less than 0.05, except for the FDI variable with a significance value of 0.389, indicating that Foreign Direct Investment (FDI) does not have a significant effect on the simultaneous modeling.

5. CONCLUSION

This study aimed to analyze the simultaneous effects of the Digital Competitiveness Index (IDSD) and Foreign Direct Investment (FDI) with their determinant variables. Therefore, this research utilized panel data from 34 provinces over 4 years to examine the impacts of IDSD, Gross Regional Domestic Product (PDRB) growth rate, and non-oil and gas exports on FDI, as well as the impacts of FDI, fintech lending, and ICT capabilities on the digital competitiveness index. The study also employed instrumental variables to address endogeneity issues in the Two Stage Least Squares (2SLS) simultaneous equation model.

The analysis results are as follows:

1. The Digital Competitiveness Index has a significantly positive effect on FDI.
2. The growth rate of PDRB has a significantly negative effect on FDI.
3. Non-oil and gas exports have a significantly positive impact on FDI.
4. FDI has a negative and nonsignificant effect on the digital competitiveness index.
5. Fintech lending has a significantly positive effect on the digital competitiveness index.
6. ICT capabilities of the society have a significantly positive effect on the digital competitiveness index.

Based on the above description, the Digital Competitiveness Index significantly influences FDI, while FDI does not significantly influence the digital competitiveness index. Therefore, it can be concluded that there is no simultaneous relationship between FDI and the Digital Competitiveness Index in the digital economic development of Indonesia. Hence, all provinces in Indonesia should focus on enhancing the Digital Competitiveness Index for the advancement of digitalization in the economy.

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