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Article

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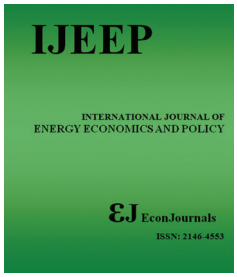

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Relationship between Energy Consumption, Foreign Direct Investment, and Labor Force Participation Using the VECM Model: Empirical Study in OECD Countries

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ABSTRACT

The purpose of this study is to determine the causal relationship as well as the long-term and short-term relationship between total energy consumption, foreign direct investment (FDI), and labor force participation rates in OECD countries from 1994 to 2019 using Granger Causality Test and Vector Error Correction Model (VCEM). In this study, it is found that energy consumption and FDI have a two-way causality, energy consumption and the labor force participation rate have a two-way causality and FDI and the labor force participation rate have a two-way causality. In the long term, FDI has a significant positive effect on energy consumption while labor force participation has an insignificant negative effect on energy consumption. Meanwhile, in the short term, FDI and labor force participation rates have no effect. This research contributes to decision-making in the field of energy, FDI, and improving the quality and quantity of the workforce in OECD countries.

Keywords: Granger Causality; VCEM, Energy, FDI, OECD
JEL Classifications: K32, E22, E24

1. INTRODUCTION

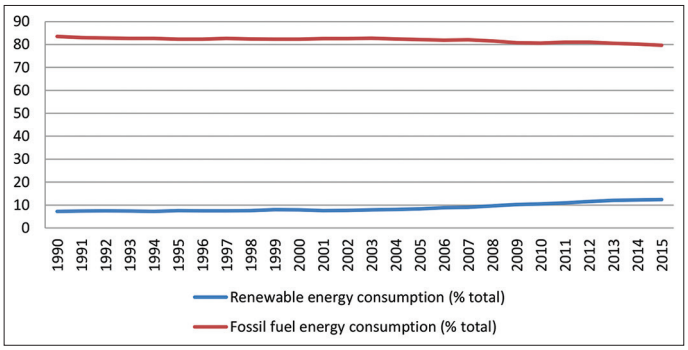
The Organization for Economic Cooperation and Development (OECD) is one of the largest multilateral organizations in the world. The aim of the OECD admission-making and find policy solutions to stimulate growth and improve living conditions in developing countries (OECD, 2022). Carrying out activities that support economic growth, of course, is closely related to the production process. The use of energy in a production process has a very important role (Setiyawan, 2018).

One of the main environmental challenges facing the world today is the emission of greenhouse gases that pollute the environment and ensure energy for sustainable development in the long term (Matei, 2018). Energy availability has an important role in the survival of individuals and industries. Energy needs are certainly needed in every production and consumption activity. OECD countries have a type of capital-intensive industry where this industry requires large capital and uses high-tech machines, where machines require large amounts of energy (Setiyawan, 2018).

Energy consumption and demand continue to increase, and most of the energy is obtained from non-renewable resources (Ziolo et al., 2020). On the supply side, researchers look at energy, capital, and labor as the main production factors and show that energy consumption has a positive effect on economic growth (Matei, 2018). Energy consumption in OECD countries is quite high. One of the OECD member countries is Indonesia, where Indonesia is expected to reach an energy deficit in 2019 if the country's energy management does not improve (Djulius, 2017). The following is data on the use of fossil fuels and renewable energy in OECD countries from 1990 to 2015.

Based on Figure 1, it can be seen that the dependence on fossil fuel energy is higher than the use of sustainable energy. This is

Figure 1: Consumption of renewable energy and fossil fuel energy in the OECD 1990-2015



Data Source: World Bank (2022)

certainly a new problem in the future. Fossil fuel is non-renewable energy so if it is used continuously it can cause scarcity. OECD countries have a high opportunity to develop the use of renewable energy. According to reports OECD (2016) renewable energy is being championed as a potentially significant source of new jobs and rural growth in OECD countries, and a means of addressing environmental and energy security issues. However, of course, in the course of implementing renewable energy, there are various obstacles, one of which is the high cost required for the deployment of renewable energy.

Amid the problems of energy use, at the same time, foreign direct investment (FDI) has been found to have a prominent effect on energy intensity (De Vita et al., 2021). The rapid development of technology and the need for sustainable capital are needed by the state to run the economy. One of the capital flows that can support a country's economy is foreign direct investment (FDI). OECD countries are active in carrying out foreign investment. Andreica and Maricescu (2011) revealed that the OECD made guidelines for multinational companies to commit to promoting, stipulating that companies should adopt practices that "permit the transfer and rapid diffusion of technologies and know-how, with due regard to the protection of intellectual property rights." This shows that OECD countries are very concerned about policies related to FDI.

Understanding the impact of FDI on energy intensity has important policy implications (Cao et al., 2020). In the long term, energy consumption affects FDI, but in the short term, energy consumption does not affect FDI (Bekhet and Othman, 2011; Khan and Ozturk, 2020). Meanwhile, research conducted by Zeng et al., (2020) suggests that FDI inflows drive energy consumption, and energy consumption drives FDI inflows. Thus there is a two-way causality relationship between FDI and energy consumption. In addition to the physical capital factor, human capital certainly has an impact on energy use.

Research Odhiambo (2010) found a unidirectional causality between energy and labor participation. In addition to affecting energy, labor also has an impact on FDI. Based on research conducted by Nguyen (2021) manpower plays an important role in attracting foreign direct investment (FDI) in both developed and developing countries. FDI can be defined as the main engine for the process of economic growth, especially in developing countries (Çetin, 2019). However, the labor force cannot be an appropriate indicator to determine the projected level of potential gross domestic product (GDP). Therefore, the labor participation rate can be chosen to understand the possible behavior and trends in the labor market (Çetin, 2019).

In contrast to short-term capital flows, foreign direct investment (FDI) usually includes long-term investment which is usually defined as a key factor in the process of economic development, especially for developing countries. Several studies have examined the causal relationship between energy consumption and economic growth, prices, employment, and foreign direct investment (FDI) but have not found consistent or contradictory results (Bekhet and Othman, 2011). Thus, this study analyzes the case causality relationship between total energy consumption, FDI, and labor force participation rates in OECD countries.

2. LITERATURE REVIEW

The causal relationship between total energy consumption and FDI has been studied extensively, but with conflicting results. Research conducted by Polat (2018) entitled "The Influence of FDI on Energy Consumption in Developing and Developed Countries: A Dynamic Panel Data Approach" FDI affects energy through two channels; first, the presence of foreign firms in the host country can force domestic firms to be more competitive, especially since energy is usually the most important, scarce, and expensive input for producing goods and services; both companies can adopt energy-saving technologies if the country of the investor directs the funding to use high environmental standards. Based on the first channel, FDI hurts the environment, where an increase in FDI will increase energy use. According to Cao et al. (2020), the existence of foreign direct investment can bring better management practices, more sophisticated corporate systems, and business philosophy in increasing the efficiency of the use of energy from the host to reduce the intensity of this view, it is known that FDI has a positive influence on the environment. Where increasing FDI can reduce energy use.

Furthermore, the effect of energy consumption on FDI. Research Pao and Tsai (2011) in his research entitled "Multivariate Granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): Evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries" found that energy consumption and FDI have a two-way causal relationship. The use of energy can increase production in a country. This is evidenced by research conducted by Dai et al., (2022) in his research entitled "Relationship between Economic Growth and Energy Consumption from the Perspective of Sustainable Development" which found that energy consumption has a significant positive effect on economic growth. Investors will be very interested in investing in countries with high economic growth. Thus the use of energy can increase FDI.

The high percentage of fossil energy use compared to renewable energy indicates that there is environmental damage in economic activity. One of the important factors in the economy apart from inputs (energy) and capital is the existence of a labor force. The

labor force participation rate is considered more representative of the labor market (Çetin, 2019). A study conducted by Korra (2017) in his research entitled "Kajian Dampak Konsumsi Energi terhadap Pertumbuhan Ekonomi di Indonesia: Analisis Kausalitas dan Peramalan" found that there is a causal relationship between energy consumption and labor. Changes in the level of labor force participation will cause changes in energy consumption.

A study conducted by Wahyuningtias (2019) suggested that currently the role of technology is proxied by machines, which has an impact on shifting the role of the labor market. Thus, it can cause a decrease in the role of the workforce which will then cause a shift in investment that leads to being capital-intensive compared to labor-intensive. This causes an increase in income to affect the decrease in the level of labor force participation. From this point of view it can be concluded that increasing the level of labor participation has a neghurtsonsumption.

Research from Kalantzis and Niczyporuk (2022) found that there is a causal relationship between energy efficiency investment and labor productivity. The existence of a reduction in energy consumption which is characterized by increasing energy efficiency can increase labor productivity. (Kalantzis and Niczyporuk, 2022) An increase in labor force participation has an impact on increasing output, increasing output can increase demand for energy consumption. To overcome this problem, a policy from the government and the private sector is needed to increase energy efficiency by improving the quality of production inputs that use renewable energy.

This study also examines the relationship between FDI and the level of labor force participation. Research conducted by Indrajaya (2021) examined the causal relationship between FDI and the labor force. The presence of foreign direct investment can increase the level of labor force participation. This is because the flow of capital from investors can increase the supply of output. Where to produce output, labor is needed to run the production process. Thus, the presence of FDI affects the level of labor force participation.

The availability of labor in a country is considered by investors in investing their capital. The existence of a young and cheap workforce certainly attracts investors to invest. One of the comparative advantages of developing countries such as Indonesia, which is a member of the OECD is the workforce. According to the eclectic hypothesis put forward by Dunning, refers to large and cheap labor is a location advantage of developing countries because these advantages are immovable and specific to the host country (Dunning and Lundan, 2008). The high availability of labor makes wages a major cost in labor-intensive industries, when the number of workers and the level of labor force participation are high it can suppress wages. Thus the level of labor force participation affects the interest of foreign investors to invest.

On the other hand, an increase in the labor force participation rate can hurt foreign direct investment. If the available manpower does not meet the demands of foreign investors. Research conducted by Gharaibeh, 2015; Zeb et al., (2014) found that the level of labor force participation has a negative effect hurts in addition, research from Zamzami et al., (2015) revealed that foreign direct investment can hurt the level of hurt If the investment provided by foreign investors wants the labor used to come from their country, in other words, do not use domestic workers.

3. RESEARCH METHODS

The data used in this study is secondary data, in the form of panel data. Panel data is a combination of time series and cross-section data. The time series data starts from 1994 to 2019. The cross-section covers 21 OECD countries. The object of this study uses the population of OECD countries and the availability of the data needed in this study. The variables used in this study include Total Energy Consumption (ET), Foreign Direct Investment (FDI), and Labor Force Participation Rate (LFP). Data on total energy consumption is sourced from the Energy Information Administration (https://www.eia.gov/international/data/world/total-energy/total-energy-consumption), FDI data and labor force participation rates are sourced from the World Bank (https http://databank.worldbank.org/source/world-development-indicators#).

This study uses the help of the EViews 10 application. The data analysis method used in this study is Vector Autoregressive (VAR) or Vector Error Correction Model (VECM). Testing the stationarity of the data is the first step in making the VAR model. The model used is the unrestricted VAR model when the data is stationary at the level. On the other hand, if the data is stationary at different points, it is necessary to perform a cointegration test to determine whether the data is related in the long term or not. The VECM model is used if there is cointegration (VECM), but if the data is not cointegrated then the VAR method is used.

3.1. Unit Root Test

The unit root test panel test aims to ensure that the data used in the study is stationary. This is to prevent spurious regression between the dependent variable and the independent variable (Widarjono, 2018). The test statistics used in testing the unit root panel consist of two types, namely the common unit root which consists of Levin, Lin and Chu (LLC) and Breitung test statistics, while the individual unit root consists of LM, Pesaran and Shin (IPS) test statistics), ADF-Fisher test and Phillips Perron (PP)-Fisher test (Gujarati, 2009). The hypothesis is:

H_0: $\gamma = 0$, meaning the data is not stationary (contains unit root)
H_a: $\gamma - < 0$, means data is stationary (does not contain unit root)

The decision is if the probability value is smaller than the significance level, then it fails to reject H_a, and vice versa when the probability value is greater than the significance level, it fails to accept H_a.

3.2. Optimum Lag Determination

Optimal lag measurement aims to ensure that the model can explain dynamically and thoroughly and efficiently, in determining the optimal lag it should not be too short or too long where when the lag length is too short it affects the model's inability to fully explain the dynamics of the model, otherwise the lag is too long. makes the measurement model inefficient

(Faizin, 2020). The length of the selected lag is based on the minimum AIC or SIC value by taking the absolute value. The Eviews software has displayed valuable information from AIC and SIC (Widarjono, 2018).

3.3. Stability Test

The VAR stability test was carried out by calculating the roots of the polynomial function or known as the roots of the characteristic polynomial. If all the roots of the polynomial function are in the unit circle or if the absolute value is less than 1, then the VAR is considered stable so that the resulting Impulse Response Function (IRF) and Variance Decomposition (VD) are considered valid (Firdaus, 2020).

3.4. Cointegration Test

The concept of cointegration is basically to determine the possibility of a long-term equilibrium relationship on the variables to be observed (Sekaran and Bougie, 2017). Johansen's test is one of the tests that can be used to determine the cointegration of several variables (Widarjono, 2018). This test is carried out after the stationary test because the variables to be observed need to be tested for cointegration to see whether there is a long-term relationship between variables or integrated with the hypothesis developed for the cointegration test is as follows:

$H_{0:}$ There are no cointegration variables
$H_{a:}$ Variables have cointegration

The decision is to fail to reject H_a when the probability value is less than the significance level. On the other hand, it fails to accept Ha when the probability value is greater than the significance level. If there is cointegration then the model is used in VECM but if there is no cointegration in the variables used then the model used is VAR.

3.5. Granger Causality Test

The causality test aims to see whether endogenous variables can also act as exogenous variables. The hypothesis is:

$H_{0:}$ The variables have no causality
$H_{a:}$ Variables have causality

The decision is to fail to reject H_a when the probability value is less than the significance level. On the other hand, it fails to accept Ha when the probability value is greater than the significance level.

3.6. VECM Estimate

VECM where this test is used to see how the long-term relationship and the short-term relationship of the dependent variable to the independent variable. In this VECM method, there are two important components in the interpretation of the results, namely Impulse Response Function (IRF) and Variance Decomposition (VD). IRF is a method used to see the response of an endogenous variable to a particular shock. VD is an analysis that is used to describe how important the independent variables in the VECM model are due to shock and explain how strong the role of variables is to other variables.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistical Analysis

The statistical analysis examined in this study included the mean, highest (maximum) and lowest (minimum) values. The following are the results of statistical analysis in this study.

Based on Table 1, it is known that the average value of the total energy consumption variable is 5.071China and Japan are countries with total energy (ET) above average Japan. Meanwhile, Indonesia, Thailand, Malaysia, Singapore, the Philippines, Hong Kong, New Zeland, Myanmar, Mongolia, Brunei Darussalam, Papua New Guinea, Lao PDR, Cambodia, Macao SAR, Fiji, Tonga, Solomon, Samoa, and Vanuatu have an average total below average energy consumption. The country with the highest level of energy consumption during the 1994-2019 period in the OECD countries was China in 2018 at 137.5429 while the country with the lowest energy consumption was Vanuatu in 1997 at 0.000722. The standard value of foreign exchange for the total energy consumption variable is 17,36947.

The average value of the FDI variable in OECD countries during the period 1994-2019 is 5.447482%. Countries with above-average FDI are Hong Kong, Singapore, Mongolia, Cambodia, Vanuatu, and Macao SAR. Meanwhile, Fiji, Brunei Darussalam, Lao PDR, Myanmar, Solomon, Malaysia, China, Thailand, Papua New Guinea, Tonga, Samoa, Philippines, Indonesia, and Japan have below-average FDI. Hong Kong was the country with the highest foreign investment receipts in 2015 among other OECD countries, reaching 58.51875%. Meanwhile, the country with the lowest FDI receipts was Mongolia in 2016 which only reached −37.17265%. The standard deviation for the FDI variable is 7.845843.

The average value of the labor force participation rate (LFP) variable during the 1994-2019 period is 70.0404. Countries with above-average labor force participation rates are Solomin, Cambodia, Lao PDR, China, Thailand, New Zealand, Japan, Macao SAR, Myanmar, Singapore, Hong Kong, and Vanuatu. Meanwhile, Brunei Darussalam, Indonesia, Malaysia, Philippines, Mongolia, Fiji, Papua New Guinea, Tonga, and Samoa have below-average labor force participation rates. The country with the highest labor force participation rate (LFP) in the OECD countries from 1994 to 2019 was Cambodia in 2011 reaching 87.98%. Meanwhile, the country with the lowest labor force participation rate was Samoa in 2019 at 46.42%. The standard deviation for the labor force participation rate variable is 9.840007.

4.2. Stationary Test

To prevent regression errors between independent and dependent variables, the panel unit root test attempted to guarantee that the data used in the study were power stationary stationery. Variables that are not stationary, in certain situations where the estimation results show a significant regression coefficient and a high coefficient of determination but the relationship between the independent variable and the dependent variable is not related or not cointegrated, according to Ekananda (2016) will produce a wrong estimate. In the works here are the results of the unit root test.

Based on the Unit-Root Panel Test Table 2, it is known that all variables are stationary at the first different level. This can be seen from the probability value of each variable used in the study which is smaller than $\alpha = 0.05$. Thus this test can be continued through the cointegration test.

4.3. Determination of Optimum Lag Length

The length of the lag can be determined based on the Akaike Information Criterion (AIC) and Schwarz Information (SIC) criteria which can be seen in Table 3. The length of the selected lag is based on the AIC value or the minimum by taking the absolute value. The results of the optimal lag length test in this study were carried out using the Akaike Information Criterion (AIC) criteria showing the optimal lag was 5.

The optimum lag in this study is 5. This means that together the exogenous variables affect the endogenous variables in the equation model for 5 periods on total energy consumption.

Table 1: Descriptive statistics results

Descriptive Statistical	ET	FDI	LFP
Mean	5.071186	5.447482	70.0404
Median	0.151927	3.063483	70.25
Maximum	137.5429	58.51875	87.98
Minimum	0.000722	−37.17265	46.42
SD	17.36947	7.845843	9.840007
Sum Sq. Dev.	164425.7	33548.7	52770.02
Observations	546	546	546

4.4. Stability Test

Before conducting further analysis, a VAR stability test was first performed. If the VAR estimation result is unstable, then the impulse response and variance decomposition analysis will also be invalid. To test whether the VAR estimate is stable or not, Inverse Roots of AR Characteristic Polynomial and Roots of Characteristic Polynomial can be used.

Based on Table 4 var stability test results such as with lag 5, it can be concluded that the estimated VAR to be used for IR and VD analysis is stable at lag 5 because all roots have a modulus smaller than one (ranging from 0.411028 to 0.948795) so that the results of the IR and VD analysis used in this study is valid. In addition, the stability test can be seen in the image below.

Based on Figure 2, the VAR stability test using the roots of AR characteristic polynomial shows the points on the circle or the data distribution is not outside the circle, which means that the data is valid for further analysis using the VAR model. Based on the VAR stability test using the roots of the characteristic polynomial and the roots of AR the characteristic polynomial, it is valid, which means that the impulse response and variance decomposition analysis in the VAR estimation is valid.

4.5. Cointegration Test

Sekaran and Bougie (2017) suggested the idea underlying cointegration was to determine whether there might be a long-run equilibrium relationship between the variables to be observed. Here are the results of the cointegration test.

Table 2: Unit root panel test

Variable	Unit-Root Panel Test Method	Intercept		Intercept and Trend	
		Level	1st different	Level	1st different
ET	LLC	0.8669	0.0030*	0.3791	0.4580
	Breitung	-	-	1.0000	0.8069
	IPS	1.0000	0.0000*	0.7356	0.0000*
	ADF-Fisher	1.0000	0.0000*	0.2418	0.0000*
	PP-Fisher	1.0000	0.0000*	0.8076	0.0000*
FDI	LLC	0.0012*	0.0000*	0.0164*	0.0000*
	Breitung	-	-	0.0000*	0.0000*
	IPS	0.0000*	0.0000*	0.0000*	0.0000*
	ADF-Fisher	0.0000*	0.0000*	0.0000*	0.0000*
	PP-Fisher	0.0000*	0.0000*	0.0000*	0.0000*
LFP	LLC	0.0018*	0.0048*	0.0724	0.0298*
	Breitung	-	-	0.9185	0.1649
	IPS	0.9610	0.0000*	0.6044	0.0000*
	ADF-Fisher	0.2505	0.0000*	0.2433	0.0000*
	PP-Fisher	0.9216	0.0000*	0.9993	0.0000*

*significant at 5%

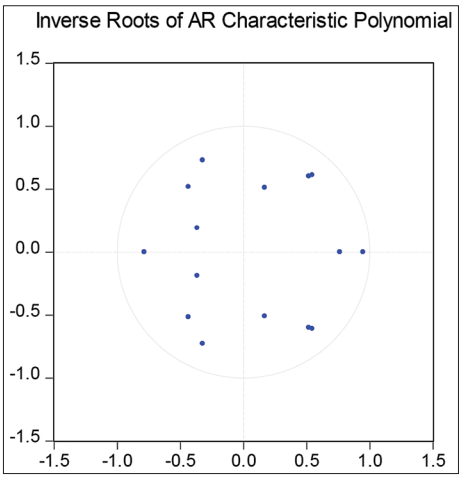
Table 3: Optimum lag length

Lag	Log L	LR	FPE	AIC	SC	HQ
0	−2151.235	NA	34.98467	12.06854	12.10113	12.08150
1	−1749.407	794.6499	3.873661	9.867828	9.998172	9.919672
2	−1720.924	55.84934	3.473153	9.758679	9.986781*	9.849405*
3	−1718.100	5.490589	3.595521	9.793276	10.11914	9.922885
4	−1708.749	18.02124	3.588644	9.791309	10.21493	9.959800
5	−1684.620	46.09541*	3.297290*	9.706552*	10.22793	9.913926
6	−1680.906	7.030923	3.396826	9.736171	10.35530	9.982427
7	−1672.609	15.57250	3.410789	9.740106	10.45700	10.02524
8	−1670.481	3.957112	3.545448	9.778607	10.59326	10.10263

Table 4: Roots of characteristic polynomial VAR. stability test results

Root	Modulus
0.948795	0.948795
0.546606–0.610759i	0.819637
0.546606+0.610759i	0.819637
−0.323084–0.728856i	0.797254
−0.323084+0.728856i	0.797254
0.518104–0.60954i	0.793459
0.518104+0.60954i	0.793459
−0.785085	0.785085
0.764591	0.764591
−0.434888–0.517363i	0.675864
−0.434888+0.517363i	0.675864
0.168780–0.510907i	0.538063
0.168780+0.510907i	0.538063
−0.364878–0.189231i	0.411028
−0.364878+0.189231i	0.411028

Figure 2: Roots of AR characteristic polynomial stability test results



Based on the results of Table 5 that have been carried out, it can be seen that the trace statistic value is greater than the Critical Value, namely 189.4918 > 29.79707 at = 5%. The trace statistic value indicates that there is a significant cointegration rank indicated by a centric sign (*). This explains that all research variables have a long-term equilibrium relationship. Thus the model chosen is the Vector Error Correction Model (VECM).

4.6. Causality Test

Granger's Causality Test is an analytical technique to determine the relationship in which one variable can affect another (independent variable) and in which the independent variable can be identified as the dependent position variable. This kind of relationship is often referred to as a Kawai or reciprocal relationship.

Based on Table 6, it is known that FDI has a causal relationship to total energy consumption and vice versa where the probability values of 0.0490 and 0.0029 are smaller than $\alpha = 0.05$ so that FDI and energy consumption have a two-way causal relationship. The bidirectional causality relationship between total energy consumption and FDI by research conducted by (Pao and Tsai, 2011). Labor force and energy consumption also have a two-way

Table 5: Cointegration test

Unrestricted cointegration rank test (Trace)				
Hypothesized No. of CE (s)	Eigenvalue	Trace Statistics	0.05 Critical Value	Prob.**
None*	0.309835	189.4918	29.79707	0.0001
At most 1*	0.088780	41.53261	15.49471	0.0000
At most 2*	0.011059	4.437077	3.841466	0.0352

Table 6: Causality test results

Null hypothesis	W-Stats.	Zbar-Stat.	Prob.
FDI does not homogeneously cause ET	3.31605	1,96865	0.0490
ET does not homogeneously cause FDI	3.87083	2.97924	0.0029
LFP does not homogeneously cause ET	4.24274	3.65668	0.0003
ET does not homogeneously cause LFP	3.96059	3.14273	0.0017
LFP does not homogeneously cause FDI	3.50032	2.30432	0.0212
FDI does not homogeneously cause LFP	4.58181	4.27432	0.0002

causality relationship. With probability values of 0.0003 and 0.001 smaller than $\alpha = 0.05$. The results of this study are in line with research conducted by (Korra, 2017). Meanwhile, labor force participation and FDI also have a two-way causal relationship. With probability values 0.0212 and 0.0002 smaller than $\alpha = 0.05$. This result is in line with the research conducted by (Indrajaya, 2021).

4.7. VECM Result

Based on the cointegration test, the model in this study is VCEM. Following are the results of VECM estimation using Eviews 10.

Based on Table 7, it generally consists of two parts. The top part shows the long-term relationship while the bottom section shows the short-term relationship. In the long-term relationship, it is known that FDI has a positive and significant effect on energy consumption. Meanwhile, labor force participation has an insignificant negative effect on energy consumption in OECD countries. This is indicated by the estimated coefficient for FDI is 23.63742, meaning that if FDI increases by 1%, energy consumption will increase by 23.63742%. Meanwhile, the labor force participation rate has a negative and insignificant effect on energy consumption. For the short-term relationship, the FDI variable and the level of labor participation do not affect energy consumption. Where in the short term, energy consumption is influenced by energy consumption in the previous year, namely (−3), (−4), and (−5).

In the short term, FDI does not affect energy consumption while in the long term FDI has a positive effect on energy consumption. An increase in investment means an increase in the flow of capital, increasing the supply of output. The existence of this need increases energy demand, which in turn increases energy consumption. The FDI variable is not significant for energy consumption, because FDI usually includes long-term investments.

Table 7: Vector error correction estimates

Cointegrating Eq:	CointEq1		
D (ET [−1])	1.0000000		
D (FDI [−1])	23.63742		
	(1.80354)		
	[13.1061]		
D (LFP [−1])	−2.309870		
	(4.64144)		
	[−0.49766]		
C	−2.592675		
Error correction	D (ET,2)	D (FDI,2)	D (LFP,2)
CointEq1	0.000113	−0.109436	0.000620
	(0.00100)	(0.00852)	(0.00125)
	[0.11331]	[−12.8422]	[0.49531]
D (ET [−1], 2)	0.095182	0.040692	0.026456
	(0.05439)	(0.46521)	(0.06828)
	[1.74985]	[0.08747]	[0.38745]
D (ET [−2], 2)	−0.233388	0.140449	−0.012319
	(0.05212)	(0.44580)	(0.06543)
	[−4.47757]*	[0.31505]	[−0.18828]
D (ET [−3], 2)	−0.152274	0.138667	0.017602
	(0.05804)	(0.49644)	(0.07287)
	[−2.62339]*	[0.27932]	[0.24157]
D (ET [−4], 2)	−0.336525	0.074639	0.041639
	(0.05535)	(0.47341)	(0.06949)
	[−6.07970]*	[0.15766]	[0.59925]
D (ET(−5),2)	−0.154615	0.017687	−0.013673
	(0.06208)	(0.53093)	(0.07793)
	[−2.49064]*	[0.03331]	[−0.17545]
D (FDI [−1], 2)	−0.002519	1.227674	−0.007355
	(0.02067)	(0.17674)	(0.02594)
	[−0.12189]	[6.94618]	[−0.28351]
D (FDI [−2], 2)	−0.001805	0.947359	0.008140
	(0.01773)	(0.15164)	(0.02226)
	[−0.10179]	[6.24751]	[0.36573]
D (FDI [−3], 2)	7.42E−05	0.727346	0.007521
	(0.01485)	(0.12701)	(0.01864)
	[0.00500]	[5.72673]	[0.40344]
D (FDI [−4], 2)	0.000302	0.464051	0.009754
	(0.01101)	(0.09418)	(0.01382)
	[0.02744]	[4.92718]	[0.70560]
D (FDI [−5], 2)	−1.99E-06	0.112188	0.006355
	(0.00708)	(0.06056)	(0.00889)
	[−0.00028]	[1.85254]	[0.71501]
D (LFP [−1], 2)	0.006661	−0.128973	−0.537130
	(0.04170)	(0.35668)	(0.05235)
	[0.15972]	[−0.36159]	[−10,2600]
D (LFP [−2], 2)	0.004501	0.005360	−0.365904
	(0.04730)	(0.40452)	(0.05937)
	[0.09516]	[0.01325]	[−6.16265]
D (LFP[−3], 2)	0.002090	−0.037544	−0.319458
	(0.04768)	(0.40781)	(0.05986)
	[0.04384]	[−0.09206]	[−5.33706]
D (LFP [−4], 2)	0.004244	−0.160515	−0.109815
	(0.04192)	(0.35849)	(0.05262)
	[0.10126]	[−0.44775]	[−2,08703]
D (LFP[−5], 2)	−0.005893	−0.698656	0.000526
	(0.03647)	(0.31193)	(0.04578)
	[−0.16157]	[−2.23981]	[0.01148]
C	0.006158	−0.041148	0.008669
	(0.02903)	(0.24827)	(0.03644)
	[0.21214]	[−0.16574]	[0.23790]
R-squared	0.156126	0.685775	0.245153
adj. R-squared	0.120780	0.672613	0.213537
Sum sq. resides	126.9681	9287,411	200.0830
SE equation	0.576522	4.930780	0.723725

(*Contd...*)

Table 7: (*Continued*)

Cointegrating Eq:	CointEq1		
F-statistics	4.417130	52.10553	7.753947
Likelihood logs	−337.7238	−1194.073	−428.4558
Akaike AIC	1.778064	6.070544	2.232861
Schwarz SC	1.948020	6.240500	2.402817
Mean dependent	−0.009119	−0.043180	0.003083
SD dependent	0.614847	8.617579	0.816083
Determinant resid covariance (dof adj.)		4.123335	
Determinant resid covariance		3.618429	
Likelihood logs		−1955,034	
Akaike information criterion		10.07035	
Schwarz criterion		10.61021	
Number of coefficients		54	

Meanwhile, the level of labor force participation in both the short and long term does not affect energy consumption. In the long term, the VECM results show that the labor force participation rate has a negative and insignificant effect on energy consumption. The high level of labor force participation has the opportunity to create a labor-intensive industry, where the largest use of energy is for the use of high-tech machines. These machines certainly require a large amount of energy to run the production process. When a labor-intensive industry is run, it can reduce the use of machines that require energy, which in turn can reduce energy consumption in OECD countries. The non-significance of the labor force participation rate variable due to the phenomenon in OECD countries is that women are much more likely than men to move or leave work, this certainly increases the tendency of women to drop out of school and reduce the level of labor force participation (Causa et al., 2021).

4.7.1. Response impulse test

After knowing the results of the VECM estimation and fulfilling the stability test, then a response impulse test is carried out. An impulse response is used to determine the variable response to the shock of other variables. The following is the result of the response impulse test.

Based on Table 8, FDI has a positive response to total energy consumption (ET) from period 1 to period 6. While in period 7 to period 9 it has a negative response and returns positive in period 10. For the variable, the level of labor participation has a positive response to the consumption of energy in period 1 to period 5. Meanwhile, in periods 6 and period 7, the labor participation rate responded negatively and again responded positively in periods 8 to period 10.

4.7.2. Variance decomposition test

Variance decomposition (VD) to determine the contribution of total energy consumption, FDI, and labor force participation variables to changes in total energy consumption in the next several periods. Following are the results of the variance decomposition for 10 periods.

For the explanation of Table 9, the Variance Decomposition of D (ET) section shows the contribution of the total energy consumption variable in period 1 by 100% where the FDI and

Table 8: Impulse value of energy consumption variable response

Response of D (ET)			
Period	D (ET)	D (FDI)	D (LFP)
1	0.576522	0.000000	0.000000
2	0.631584	0.001472	0.004572
3	0.502453	0.005192	0.005587
4	0.389516	0.013432	0.004024
5	0.206568	0.010420	0.004730
6	0.127650	0.002649	−0.001989
7	0.214911	−0.000791	−0.001302
8	0.327421	−0.004390	0.000322
9	0.408683	−0.003395	0.001390
10	0.431417	0.003090	0.003392

Table 9: Variance decomposition results

Variance decomposition of D (ET)				
Period	SE	D (ET)	D (FDI)	D (LFP)
1	0.576522	100.0000	0.000000	0.000000
2	0.855160	99.9685	0.000296	0.002858
3	0.991875	99.99174	0.002961	0.005298
4	1.065709	99.97554	0.018450	0.006014
5	1.085604	99.96531	0.026994	0.007695
6	1.093088	99.96487	0.027212	0.007921
7	1.114016	99.96599	0.026250	0.007763
8	1.161144	99.96726	0.025592	0.007153
9	1.230971	99.96998	0.023531	0.006492
10	1.304389	99.97202	0.021518	0.006458

LFP variables have not contributed to energy consumption. This can be seen from the value of D (FDI) and D (LF) is zero. In the second period, the previous total energy consumption contributed 99.9685% to the total energy consumption, the FDI variable contributed 0.000296%, and the labor force participation rate variable contributed 0.002858% to the total energy consumption. Until the 10th period, total energy consumption in the previous period contributed 99.97202%, while FDI and the labor force participation rate each contributed 0.021518% and 0.006458%.

5. CONCLUSION AND SUGGESTION

5.1. Conclusion

The results of studies using the variables of total energy consumption, FDI, and labor force participation rates in OECD countries between 1994 and 2019 show mixed results. Based on the results of the causality test on the two-way relationship between each variable, namely total energy consumption, FDI, and the level of labor force participation. The explanation of the estimation results of the VECM model in general shows that there is a long-term relationship between each variable, but in the short term, only the previous year's total energy consumption variable influences total energy consumption. IRF analysis shows that there is a response to shocks that occur in the total energy consumption variable itself and other variables. Meanwhile, the VD analysis shows that there is a large contribution role from the energy consumption variable itself and partly the contribution of its formation comes from the FDI variable and the level of labor force participation.

5.2. Suggestion

The existence of a causal relationship between total energy consumption, FDI, and the level of labor force participation implies that the three variables influence other variables. The increase in FDI which has a significant positive effect on energy indicates that the incoming investment requires a large amount of energy in carrying out the production process. Countries in the OECD should implement regulations for foreign investors to transfer their knowledge and capital related to the use of energy efficiency, through the use of renewable energy in the production process. Furthermore, the labor force participation rate variable has a negative and insignificant effect on energy consumption. This means that it is necessary to increase the quality and quantity of labor force participation in OECD countries. The government, the private sector, and the community can work together to improve the quality of the workforce through the provision of training and career development. In addition, implementing regulations that investors who will invest in destination countries use domestic workers so that FDI can provide opportunities for the workforce to find work. The things above certainly require efforts and cooperation from various parties so that the economic process can reduce energy consumption and optimize the level of labor force participation. Further research is recommended to look at the causal relationship of renewable energy variables, sustainable energy, FDI, male labor force participation rates, female labor force participation rates, and other variables that are interrelated to energy consumption.

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