APPLICATION OF ARDL MODELLING IN GLOBAL STRUCTURAL SHOCKS AND THEIR DYNAMIC IMPACT ON FDI

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Abstract
In general, sustainable economic growth is highly dependent on technological progress, managerial knowledge, and money supply in the economy. Globally, the COVID-19 pandemic has caused structural shocks to economic systems by increasing high economic uncertainty. For this reason, policymakers are exploring alternative measures to stimulate economic growth. And among these alternative measures we also find foreign direct investment, which represents an instrument widely used worldwide. There is a trend among foreign investors that they increasingly focus on the quality of institutions, especially on FDI policies in domestic countries. For this reason, governments of developing countries are increasingly adopting soft policies to attract FDI. Generally, the policies provide substantial taxation provisions. Thus, by stimulating foreign direct investment in global economic operations, short- and long-term growth is achieved. The beneficial effects of FDI are given by their unprecedented impact on achieving sustainability worldwide. The motivation of this study is to scale the effects of environmental quality and good governance on FDI inflows in European Union member countries for the period 2002-2021. We used the estimation of autoregressive distributed lag and error correction models to investigate the association and elasticity of explanatory variables on FDI inflows in EU member countries. Thus, as independent variables we use CO2 emissions from solid fuel consumption and the sum of exports and imports of goods and services. Environmental degradation comes from the depletion of resources by human activity, and ultimately this leads to increased costs and depletion of capital. As a result, environmental quality is crucial to the health of both people and businesses. In the recent economic booms, international trade needs serious attention to form new policies to invite more foreign investors. And as control variables we introduce Government effectiveness index and Gross capital formation. We introduce these variables because it is believed that weak institutional capacity can have a negative impact on economies. The study results suggest that government efficiency and a less regulated environmentally concerned economy drive capital transfer decisions.

Keywords

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FDI, CO2 emissions, government effectiveness, ARDL model

JEL Classification
F18, O13, O16

Introduction

Structural economic shocks such as natural disasters, financial crises and threats of war disrupt the global economic flow. Currently, the Covid-19 pandemic has diminished in intensity, although the aftershocks persist. This event started with a health crisis and turned into a social as well as an economic crisis. Also, the global economy is still vulnerable from the perspective of this aspect, as well as the events that took place in the context of the war launched by Russia on Ukraine. Thus, consistent effects of structural shocks can create wealth inequality, debt, and environmental destruction. And these events demonstrate the need for economic shock absorbers and viable plans to recover from structural shocks.

Foreign direct investment is seen as a potential engine for economic growth, as well as the main driver of modern globalization. Also, the multi-dynamic advantages of FDI have intensified the competition to invite FDI, especially after COVID-19, where the importance of FDI flow has changed.

1. Review of the scientific literature

Sustainable economic growth is generally based on technological progress, managerial knowledge, and money supply in the economy (Jinru et al., 2022). This has led to the emergence of FDI, which has an unprecedented impact on the achievement of sustainability worldwide. However, a few studies (Zomorrodi and Zhou, 2017; Hao et al., 2020) claim through their research that the excessive application of conventional energy causes environmental degradation.

Another study (Ssali et al., 2019) investigated the link between environmental quality and FDI. Results of the study demonstrated a positive causality of FDI on the environment through the appropriate use of eco-technology to maintain a green environment. And Saini and Sighania (2019) argue that a cleaner environment can eradicate the negative effects of economic growth on the environment.

The main findings of one study (Manigandan et al., 2022) show that higher levels of financial development, primary energy consumption and technological innovation boost per capita economic growth rates. In addition, technological innovation also moderates the financial development–economic growth and primary energy consumption–economic growth links by jointly boosting economic growth rates with these two macroeconomic variables.

The results of several studies (Dash and Parida, 2013; Shahbaz et al., 2019) indicate the presence of a bidirectional causal relationship between FDI and economic output, as

well as between service exports and economic output. Also, in the long term, trade openness, energy use and economic growth are found to positively reinforce CO2 emissions (Zameer et al., 2020).

Exchange rates, domestic capital formation and trade liberalization are generally considered to be among the key determinants of foreign capital flows. And in the study carried out by Ross (2019), the "good governance index" of the World Bank is used. And the study results demonstrate that certain aspects of country-level governance infrastructure continue to be a significant predictor of host-country FDI, with particular emphasis on governments' ability to effectively formulate and implement policies. Also, Rehman and Sohag (2022) believe that good governance, referred to as institutions and traditions, significantly influences foreign capital flows.

The economy of a state is marked by various changes. And the modification of a variable is not reflected immediately, but is distributed over future periods (Chetty, 2018). And to better capture this fact we use the ARDL model.

2. Research methodology

This study investigates the effects of good governance and environmental quality on FDI inflows across EU countries (Austria, Belgium, Bulgaria, Czech Republic, Germany, Denmark, Greece, Spain, Finland, France, Croatia, Hungary, Ireland, Iceland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Norway, Poland, Portugal, Romania, Sweden, Slovenia, Slovakia), during the period 2002-2021. The sample was limited to this number depending on the availability of data collected from the World Bank database.

The identified variables, and their description are presented in Table no. 1.

Table no. 1. Variables definition

Variable symbol	Variable name type	Description	Units
FDI	*Foreign direct investment, net inflows-dependent variable*	This indicator includes the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital.	% of GDP
CO_2	*CO2 emissions from solid fuel consumption-independent variable*	This indicator includes the carbon dioxide emissions from solid fuel consumption refer mainly to emissions from use of coal as an energy source.	% of total
TO	*Trade-independent variable*	This indicator includes reflects the sum of exports and imports of goods and services measured as a share of gross domestic product.	% of GDP
GE	*Government effectiveness index-control variable*	This indicator includes reflects perceptions of the quality of public services, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	Index
GCF	*Gross capital formation-control*	Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the	% of GDP

Variable symbol	Variable name type	Description	Units
	variable	fixed assets of the economy plus net changes in the level of inventories.	

Source: Authors' own works after World Bank database

The summary of descriptive statistics is presented in Table no. 2.

Table no. 2. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
FDI	540	12.2738	39.91086	-57.53	449.08
CO_2	401	27.58885	21.23204	0	96.17
TO	540	121.5377	63.8289	45.42	388.12
GE	540	1.092944	.6000371	-.37	2.35
GCF	540	23.05433	4.698171	11.89	54.95

Source: Authors' owns works

The dataset has 540 observations, except for the independent variable CO2 which has 401 observations. The dependent interest variable FDI has an average mean of 12.2738, a minimum of -57.53, a maximum of 449.08, and a standard deviation of 39.91086. The independent interest variable CO2 has an average mean of 27.58885, a minimum of 0, a maximum of 96.17, and a standard deviation of 21.23204. The second independent variable, TO, has an average mean of 121.5377, a minimum of 45.42, a maximum of 388.12, and a standard deviation of 63.8289.

The autoregressive distributed lag model is used to model the relationship between economic variables in a time series setup using a single equation (Kripfganz and Schneider, 2016).

The ARDL model involves a cointegration of non-stationary variables which is equivalent to an error correction (EC) process. According to some specialists (Engle and Granger, 1987; Hassler and Wolters, 2006), this model contains an EC-form reparameterization.

The generalized ARDL (p, q) model is specified as:

$$Y_t = y_{0i} + \sum_{i=1}^{p} \delta_i \boldsymbol{Y}_{t-1} + \sum_{i=0}^{q} \beta`_i \boldsymbol{X}_{t-1} + \boldsymbol{\varepsilon}_{it} \qquad (1)$$

where,

$Y`_t$ = vector

$(X`_t)$ = variables

β *and* δ = coefficients

y = constant

$i = 1, \dots, k; p, q$=optimal lag orders

ε_{it} = vector of the error terms

$unobservable\ zero$ = white noise vector process

The optimal lag orders p and q are generally obtained by the Akaike Information Criterion (AIC) which involves the minimization of a model selection criterion.

Reparameterization in conditional EC form is specified as:

$$\Delta y_t = c_0 + c_{1t} - \alpha(y_{t-1} - \boldsymbol{\theta x}_{t-1}) + \sum_{i=1}^{p-1} \psi_{yi} \Delta y_{t-1} + \omega` \Delta \boldsymbol{x}_t + \sum_{i=1}^{q-1} \psi`_{xi} \Delta \boldsymbol{x}_{t-1} + u_t \quad (2)$$

where,

$\alpha = 1 - \sum_{j=1}^{p} \phi_i$ = adjustment speed coefficient

$\theta = \frac{\sum_{j=0}^{q} \beta_j}{\alpha}$ = the long-run coefficients

3. Results and discussions

The correlation matrix in Table 3 suggests an inverse relationship between our interest variables, FDI and CO_2, and a direct relationship between FDI and TO.

Table 3: The correlation matrix

	FDI	CO_2	TO	GE	GCF
FDI	1.0000				
CO_2	-0.2479	1.0000			
TO	0.2772	-0.2189	1.0000		
GE	0.0471	-0.2467	0.164	1.0000	
GCF	-0.0440	0.2666	-0.005	-0.0768	1.0000

Source: Authors' own works

Table 4 shows the results of the regression equation.

Table 4: The OLS regression results

VARIABLES	(1) fdi
CO_2	-0.404***
	(0.104)
TO	0.209***
	(0.0346)
GE	-2.655
	(3.497)
GCF	0.0389
	(0.464)
Constant	3.041
	(12.61)
Observations	401
R-squared	0.141

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Authors' own works

The CO2 and TO variables introduced in the model are statistically significant with a probability of over 99%. From the value of R2, we conclude that 14.06% of the variation of the FDI variable is explained by the independent variables included in the model.

We also did stationarity tests, and all the variables are stationary at the level or by the first-difference test.

The table 3 contains the regression of the ARDL model at level representation.

Table no. 5. The ARDL model results (level representation)

VARIABLES	(1) fdi
L.fdi	-0.0204
	(0.0473)
CO_2	-0.400***
	(0.105)
TO	0.209***
	(0.0347)
GE	-2.602

	(3.509)
GCF	0.0620
	(0.469)
Constant	2.667
	(12.67)
Observations	400
R-squared	0.141

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors' own works

It is observed that the change in the first lag of the variation of FDI inflows is negatively influenced by 40% of CO2 emissions from solid fuel consumption during the period 2002-2021 with a significance of 99%. Thus, the need to impose a higher tax on the polluted factors is observed. This assumption is also supported by other studies in the field (Zhang and Zhang, 2018; Ulucak and Kassouri, 2020).

Also, the change in the first lag of the variation of FDI inflows is positively influenced by 20.90% of exports and imports of goods and services during the period 2002-2021 with a significance of 99%. Both exports and FDI are generally considered to have a strong and positive effect on economic growth (Liu et al., 2002; Yao, 2006).

The table no. 6 contains the error correction representation of the same model.

Table no. 6. The error correction representation

	(1)	(2)	(3)
VARIABLES	ADJ	LR	SR
CO_2		-0.392***	
		(0.106)	
TO		0.204***	
		(0.0354)	
GE		-2.550	
		(3.445)	
GCF		0.0608	
		(0.459)	
L.fdi	-1.020***		
	(0.0473)		
Constant			2.667
			(12.67)
Observations	400	400	400
R-squared	0.590	0.590	0.590

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Authors' own works

Approximately 58.70% of the variation of the dependent variable (ISD) reacts to long-term equilibrium shocks but not to short-term perturbations of the independent variable with a probability of 99%.

The model shows that prior period errors must be corrected in the current period, and the adjusted time is -1.020 with a probability of 99%.

The study documented the negative effects of CO2 emissions from solid fuel consumption on long-term FDI inflows (a coefficient of 0.392). This suggests that a 10% increase in carbon emissions will decrease FDI flows into the economy by 39.2% in the long run. CO2 can also be reduced by more determined involvement of the political factor.

Also, exports and imports of goods and services have a positive effect on long-term FDI inflows (a coefficient of 0.204). This suggests that a 10% increase in exports and imports of goods and services will increase FDI flows into the economy by 20.4% in the long run.

The results of the bounds test with our new finite-sample critical values and the approximate p-values are presented in table no. 7.

Table no. 7. The bounds test results

Pesaran, Shin, and Smith (2001) bounds test

H0: no level relationship ***F*** = 113.250

Case 3 t = -21.591

Finite sample (4 variables, 400 observations, 0 short-run coefficients)

Kripfganz and Schneider (2020) critical values and approximate p-values

	10%		5%		1%		p-value	
	I (0)	I (1)	*I (0)*	I (1)	*I (0)*	I (1)	*I (0)*	I (1)
F	*2.464*	3.527	2.889	4.027	3.799	5.077	0.000	0.000
t	*-2.568*	-3.660	-2.866	-3.985	-3.445	-4.596	0.000	0.000

do not reject H_0 if

both F and t are closer to zero than critical values for I(0) variables
(if p-values > desired level for I(0) variables)

reject H_0 if

both F and t are more extreme than critical values for I (1) variables
(if p-values < desired level for I (1) variables)

Source: Authors' own works

The result of the bounds test proves that there is a relationship between the variables, so we will not accept the null hypothesis.

Table 8 includes the results of the diagnostic tests for serial correlation.

Table no. 8. The diagnostic tests for serial correlation

Durbin Watson test

Number of gaps in sample: 4 1.961773

Breusch-Godfrey test

Number of gaps in sample: 4

Breusch-Godfrey LM test for autocorrelation

lags (p)	chi2	df	Prob > chi2
1	0.908	1	0.3405

H_0: no serial correlation

White test

White's test for H_0: homoskedasticity

against H_0: unrestricted heteroskedascity

chi2(20) = 74.42
Prob>chi2 = 0.0000

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedascity	74.42	20	0.0000
Skewness	21.54	5	0.0006
Kurtosis	3.48	1	0.0623
Total	99.44	26	0.0000

Source: Authors' own works

The Durbin Watson statistic test demonstrates that there is no serial correlation in the regression model output at 1.961773, a fact supported by the other 2 tests.

Conclusions

In conclusion, through the present study we wanted to demonstrate that the level of FDI inflows in a country is influenced by several factors. So, from the ARDL model we concluded that the change in the first lag of the variation of FDI inflows is negatively influenced by 40% of CO2 emissions from solid fuel consumption during the period 2002-2021 with a significance of 99%. Also, the change in the first lag of the variation of FDI inflows is positively influenced by 20.90% of exports and imports of goods and services during the period 2002-2021 with a significance of 99%. And a 10% increase in carbon emissions will decrease FDI flows into the economy by 39.2% in the long run.

Also, we find out from the error correction representation of the same model that a 10% increase in exports and imports of goods and services will increase FDI flows into the economy by 20.4% in the long run. And a 10% increase in carbon emissions will decrease FDI flows into the economy by 39.2% in the long run.

During the period of structural shocks caused by both the Covid-19 pandemic and the Ukraine War, economies faced significant financial problems. And the most controversial issue concerns how to quickly generate economic growth. And as a solution to this economic shutdown, economies have taken various measures to attract more foreign investment.

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