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Article

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Impact Study of Foreign Direct Investment on Carbon Dioxide Emission, Economic Growth, Trade Openness for India following ARDL Approach

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ABSTRACT

Foreign Direct Investment (FDI) is instrumental in increasing growth and development in many countries. The development outcomes of FDI must also be analysed, considering the long-term holistic implications of economic growth and environmental implications. Environmental consequences of FDI need to be analysed to better understand the developmental potentials of FDI. The objective of this study is to analyse the equilibrium relationship among carbon dioxide emission, inward FDI, trade openness, and economic growth considering India by using an autoregressive distributed lag model. This model overcomes the effect of endogeneity and indicates that there is a strong cointegrating relation between all the variables with significant long-run effects for economic growth and trade openness and insignificant results with carbon dioxide emission and inward FDI.

Keywords: Inward FDI, Carbon Dioxide Emission, Trade Openness, Economic Growth
JEL Classifications: F2, O13, O4, Q52, Q58

1. INTRODUCTION

One of the key characteristic features of the current globalised world is the expansion of global foreign direct investment (FDI). Policy makers and researchers have documented significant economic changes and their implications on host economies due to inward FDI across different countries. Of the many developments arising from FDI, the wide-ranging consequences of FDI on the natural environment are gaining momentum in the current times due to its significant nature. The implications of FDI on the environment take many forms: first, there is a growing consensus on the undesirable environmental effects due to FDI; second, the negative effects of FDI-induced development; third, relocating economic activities into regions with less stringent environmental regulations; fourth, innovating cleaner technology for pollution abatements (Annual Review, 2017).

Globalisation has enhanced development, especially financial globalisation, and has increased cross-border capital flow, enhancing the volume and frequency of international business (Nayyar, 2006). In recent years, the flow of foreign direct investment has gained enormous significance due to its multiple merits of enhancing economic development, creating absorptive capacity (Borensztein et al., 1998), increasing exports (Grossman and Helpman, 2004), contributing to productivity spillovers (Zhao and Zhang, 2010). Global FDI flow faced a slowdown in 2020 and 2021 due to the pandemic and multiple global events that continued in 2022, with international flow recording at $1.3 trillion. Developing countries grew 4% more FDI, developed regions received 37% less, and the least developed countries received very few of the FDI pie.

Enhanced cross-border investment flows in the form of FDI, accompanied by globalisation, have intensified energy use and infrastructure, which increases the pressure on the environment. One important frequent issue raised about FDI is its potential inimical consequences for the environment (Zhu et al., 2016). At the same time, it is also noteworthy to understand that the important and encouraging feature of FDI flow is that the investment in renewable energy generation continued to grow but at a slower rate of 8% in 2022 compared to 50 per cent in 2021 (UNCTAD, 2023). The focus on renewable energy is positive but inadequate, considering the current demand situation.

Increasing environmental protection and management costs can undermine the gains achieved from higher economic development (Demena and Afesorgbor 2020). As per the OECD report, the biggest rise in mortality rates is detected from air pollution for India by 2060, as more people are exposed to emissions causing premature death and diseases. Carbon dioxide (CO_2) emissions are the key contributor to Green House Gas (GHG) emissions globally, in that 76.7% are from developing countries worldwide (Stocker et al., 2013). As seen in the increase in carbon footprints due to industrialisation, the environmental impacts of industrial development have been a neglected factor for a long time (Kaltenegger et al., 2017; Chakrabarty, 2019). As more energy is consumed for industrial and financial development, an increase in energy consumption per capita is always followed by an increase in per capita carbon dioxide emission (Sadorsky, 2014; Ozturk and Acaravci, 2013; Soytas and Sari, 2009). The levels of carbon released into the environment from South Asian countries are found to be associated with economic growth, energy consumption, trade openness, FDI, and population growth (Ghosh, 2010; Shahzad et al., 2017; Shahbaz et al., 2015; Bukhari and Ahmad, 2014; Shrestha et al., 2012).

The diagonally opposite views of the Pollution Haven Hypothesis (PHH) (Copeland and Taylor, 1994) and the Porter Hypothesis (PH) (Porter, 1996; Porter and van der Linde, 1995) enriched the literature on FDI, but at the same time, provoked multiple dissimilar study outcomes. The PHH indicates that polluting industries will relocate to places with less stringent environmental regulations, which means countries without stringent environmental control and regulations have more polluting industries/firms. PH indicates that the production process becomes cleaner when more foreign firms start investing and entering a market; as a result, the domestic firms also follow them, ultimately leading to a much cleaner production process that improves environmental quality (Zarsky, 1999; Neumayer, 2001; Gill et al., 2018). Environmental Kuznet Curve (EKC), which indicates the systematic relationship between income changes and the environment, is gaining more significance with increased cross-border investments, especially in developing countries. EKC suggests a positive relationship between economic growth and environmental degradation in the short run. However, after reaching a higher income level, economic growth will likely reduce environmental degradation (Kuznets, 1955). Resource Curse Hypothesis (RCH), a phenomenon developed recently, indicates that countries having abundant natural resources are scarcely developing due to various challenges from the socioeconomic, political and technical front and institutional quality (Ploeg, 2011; Boschini et al., 2007).

Multiple literatures examined PHH, PH and EKC concepts across different economies indicate multiple relationship outcomes between economic growth and CO_2 emission, ranging from linear to N-shaped relations (Table 1). These mixed results act as a motivating factor for taking the current research.

An attempt is made in this research to understand the empirical equilibrium relationship between CO_2 emission, foreign capital flow in the form of inward FDI, globalisation and economic growth. India is enhancing her technical soundness and industrial prowess with multiple efforts at all levels. Inward FDI is vital in enhancing efficiency and skill across many sectors that are instrumental in realising higher growth rates. As more direct investment is entering India, the undesirable and challenging outcomes of economic development, in terms of environmental degradation, pollution, and urbanisation, are also on the rise for India, questioning the current levels of development. Economic gains created with the help of FDI could be negated with deleterious environmental consequences (Zhu et al., 2016; Cole et al., 2011; Pao and Tsai, 2011).

2. REVIEW OF LITERATURE

The environmental consequences of globalisation and economic development are a highly debated subject. Globalisation, especially in the trade and finance domain, was fast relative to other domains (Nayyar, 2001; Sharma et al., 2020), which created economic growth through industrialisation, enabling many countries to enhance their national income and social development (Shahbaz et al., 2018). Grossman and Krueger's pioneering study on the environmental impacts of trade liberalisation indicates that the effect of policy changes like easing trade barriers leads to enhanced intersectoral compositions of economic activities and expands the scale of international economic activities, creating unwanted environmental consequences, which demands a better understanding of the impacts of international business and financial flows on economic activities (Grossman and Krueger 1991).

A study done by Ali et al. (2021) for Pakistan using ARDL bound testing, indicates that energy consumed from fossil sources impacts carbon dioxide emission positively. Study results of Bölük and Mert (2015) indicate an inverted U-shaped relationship between CO_2 emission per capita and real GDP per capita in the short and long run for Turkey (Seker et al, 2015). As per the CWA-Compact with Africa initiative, inward FDI flows to 18 CWA participating African countries increased and promoted economic growth and development, and also increased environmental pollution, which was confirmed using the triple difference (DDD) estimation technique for 2005-2019 (Duodu et al., 2022). Miniesy and Tarek (2019) study results make it evident that lax environmental standards have become a determinant for attracting inward FDI into developing Asian regions, especially for China, Hongkong and Philippines. Further, their study also adds that country-specific studies must be undertaken to understand the environmental implication of FDI instead of generalising the results, which calls the attention that country-specific studies are essential to better understand the consequences of FDI on the environment.

China, one of the highest recipients of FDI, experienced both CO_2 emission and development due to FDI; studies conducted on emission reduction and FDI indicate that FDI contributes to emission reduction for the country as a whole, but interprovincial and intra-provincial transmission emission results are heterogenous, indicating the presence of both "Pollution Haven" and "Pollution Halo" theories (Lin et al., 2022), at the same time, Zhang (2011) using Cointegration and Granger Causality tests found limited influence of FDI on the environment for China. A positive relationship between FDI and pollution is also found in Mexico (Waldkirch and Gopinath, 2002) and South Korea (Chung, 2014).

Few authors also hold an optimistic view towards CO_2 emission and FDI, supporting the Pollution Halo hypothesis. Research conducted by Zhang and Zhou (2016) and Jiang et al. (2018) for China believed that FDI leads to improved CO_2 emission reduction due to technology transfer and knowledge about spillovers. This phenomenon is also seen in Sub-Saharan African (SSA) countries (Ewane and Ewane, 2023). From Liu et al. (2018), we know that it is challenging to extract the extended effects of different pollutants due to FDI.

Table 1: Recent research in PHH, PH, and EKC

PHH	PH	EKC
Esmaeili et al.; Naqvi et al.,; Apergis et al.; Chiriluș and Costea; Cil; Jeetoo and Chinyanga; Ozturk et al.; Bekun et al.; Firoj et al.; Niu and Wang; Raihan	Li and Shao; Olasehinde-Williams and Folorunsho; Zhong et al.; Peng; Saqib et al.; Apergis et al.; Chiriluș and Costea; Mahmood; Esmaeili et al.; Yilanci et al.;	Mahmood et al.; Pata et al.; Mahmood; Leonardo; Tabash; Ozturk; Mahmood; Uddin; Wang; Eqane; Hossain; Beton Kalmaz and Adebayo

Source: Prepared by the Author. All the literatures are from the year 2023

Aye and Edoja's (2017) investigation of the dynamic relation between economic growth and CO_2 emission for 31 developing countries identified a negative effect in countries with low growth regimes and a positive effect in high growth regime countries, showing the absence of EKC and establishing a U-shaped relationship among the variables. The authors, employing the Panel Causality Model indicate a positive causal relation among energy consumption, CO_2 emission, economic growth and financial development. The findings of Aye and Edoja (2017) emphasise the need for transformation to low-carbon technologies aimed at reducing emissions for sustainable economic growth, which can include energy efficiency and switching away from non-renewable energy to renewable energy. A summation of significant research on the effects of FDI on pollution is shown in Table 2.

3. METHODOLOGY

This research is an applied research following empirical design. The objectives of this research are to identify the long-term and short-term impact of inward foreign direct investment on carbon dioxide emission, trade openness and economic development and to understand the dynamic effects among them. The data source is from the World Bank World Development Indicator, and the time period is from 1900 to 2021. Since the variables are a mixture of I (0) at level and I (1) at first difference, Auto-Regressive Distributed Lag (ARDL) and error correction metric (ECM) are studied to understand their relationships (Narayan and Smyth, 2005). The model used in this study is specified below.

3.1. Variables Used

Variables studied are foreign capital flow, carbon dioxide emission, globalisation and economic development. Net inflows of foreign

Table 2: Effects of FDI on pollution

Authors	Country and time period	Variables	Technique	Effect of FDI on Pollution
Grossman and Krueger	NAFTA and USA, 1991	Economic growth and air quality	General equilibrium model	Positive
Miniesy and Tarek 2019.	Asian, 1996-2016	Agglomeration, market growth, market openness, natural resource endowments, labour productivity, inflation, corruption	Fixed effects model with robust standard errors	Positive
Ullah et al., 2022	Vietnam, 1975-2019	Inward FDI and fossil fuel consumption	ARDL	Bi-directional causality
Acharyya, 2009	India, 1980-2003	GDP growth, FDI inflow and CO_2 emissions	Cointegration regression	Positive
Jafri et al., 2022	China 1981-2019	FDI, CO_2 emissions	NARDL	Positive
Danlami et al., 2018	Lower Middle Income, Middle East and North African countries, 1980–2011	Economic growth, energy production, capital formation, FDI and CO2 emissions	ARDL	Positive
Bakhsh et al., 2017	Pakistan, 1980-2014	FDI, environmental pollution and economic growth	Simultaneous equation model	Positive
Singhania and Saini, 2021.	Covering 21 developed and developing countries, 1990-2016	FDI, institutional factors, financial development and sustainability	GMM, SGMM	Positive
Alfantookh et al. 2023	Saudi Arabia	FDI and CO_2	ARDL	Inverse

Source: Author's own, ARDL: Auto regressive distributed lag, NARDL: Non-linear auto regressive distributed lag, GMM: Generalized method of moments, SGMM: System-generalized methods of moments direct investment are used for measuring foreign capital flow; economic growth is measured through the gross domestic product; openness is measured through imports and exports upon the gross domestic product; and carbon dioxide emission is measured through CO_2 emissions in metric tons per capita. Inward FDI is the independent variable, and carbon dioxide emission, trade openness and GDP are the independent variables.

3.2. Model and Model Specification

The variables are first checked for stationarity. After ensuring stationarity to incorporate endogenous and exogenous variables, an autoregressive distributed lag model is employed to understand the short-run and the long-run effect, measured with bound testing; error correction will indicate the stability of the model. Once the model is ensured with short-run equilibrium and long-run cointegration and error correction, the model will be further checked for stability, normality, and collinearity. ARDL with other statistical tests like cointegration error correction were extensively employed to find out the long-run, short-run dynamic and equilibrium relationships in literatures (Ahmad et al., 2020; Narayan and Smyth., 2005). Studies like Pesaran et al. 2001; Zachariadis 2006; Chaudhry and Choudhary, 2006 have used ARDL to investigate the relations between GDP with other variables. The ARDL model used in this study is given below. Equation (1) indicates the functional relationship among the variables. The Error Correction Model (ECM) representation of ARDL is formulated with reference to equation (2) in order to examine cointegration if present, among the variables defined in equation (1)

$$DIFDI_t = f(DCO2_t, DGDP_t, DTOP_{t,}) \quad (1)$$

$$\Delta DIFDI_{(t)} = \beta 0 + \delta DCO2L_{(t-1)}) + \delta 2DGDP_{(t-1)} + \delta 3\Delta DTOP1_{(t-1)} + \varepsilon_{(t)} \quad (2)$$

where
DIFDI = inward FDI
DCO2= carbon dioxide emission
DGDP = GDP
DTOP = trade openness
t = time from 1900 to 2021
t-1 = one period lag
β = intercept
δ1, δ2, δ3 = coefficients
ε = error term

4. ANALYSIS AND INTERPRETATION

The dependent variable is inward FDI, and the independent variables are CO_2 emission, GDP and trade openness. Appendix 1 gives brief descriptions of the variables. Augmented Dicky Fuller (ADF) unit root test checks stationarity. All the variables are integrated into the I(1) order at first difference. Appendix 2 gives the details of the order of integration of variables. As the study variables follow the I(1) order of integration, the ARDL model is suitable for checking the effects between independent and dependent variables.

ARDL model is run with one period lag and is found significant as the p-value is 0.0164. Bounds test was carried out to understand the effects in the long run. Long-run Bound test estimation indicates the existence of cointegrating relations, as the F statistics value of 4.55 is above the lower and upper bound as shown in Table 3, ensuring long-run equilibrium cointegrating relations among the test variables. From Table 4, it is known that the long-run relationship between inward FDI, GDP and trade openness are significant at a 5% level but CO_2 is not significant. From the long-run coefficient scores, as mentioned in Table 4, it is seen that a 1% increase in inward FDI will lead to a 45.7% increase in GDP in the next year. At the same time, a one per cent increase in inward FDI will lead to a 14.76% increase in carbon dioxide emission in the next year.

Error Correction term, represented from the Cointegrating Equation is negative with an associated coefficient estimates of 2212–0.9750. This implies that about 97.50% of any movements into disequilibrium are corrected within one period. With a t statistics value of −5.979, it indicates that the coefficient is highly significant.

Error Correction estimates adjustments, causality, feedback, and dynamic relations among the variables. ECM integrates short-run and long-run equilibrium without losing the long-run information and takes care of spuriosity. The coefficient of error correction term shows the speed of adjustment from the short run to the long run for any disequilibrium and long-run causality relations. The error correction term is significant. The coefficient of ECM is 1.07, which means, the speed of adjustments for the previous year's errors and shocks will be corrected in the current year at a speed of adjustment of 107%. R square value is 96%, and the adjusted

Table 3: ARDL Bound Test Results

Model : $DIFDI_t = f(DCO2_t, DGDP_t, DTOP_t)$	95% critical values		
	Lower bound	Upper bound	F-Stat
Null Hypothesis for Error Correction	3.38	4.23	4.551**

No long-run relationship $\beta_1=\beta_2=\beta_3=\beta_4$

No short-run relationship $Ø_1=Ø_2=Ø_3=Ø_4$

**indicates 5% statistical significance level

Source: Authors' calculations using EViews 12

Table 4: Long-run coefficient estimates

Independent variables	Coefficient (standard error)	t stat (prob)
DGDP(-1)	4.57 (2.22)	0.00 (0.00)
DTOP(-1)	−1.99 (1.14)	0.00 (0.00)
DCO2(-1)	−14766 (7356)	−0.20 (0.846)
D (DGDP)		
D (DTOP)		

R-Square 0.96

Adjusted R-Square 0.92

Durbin Watson Stat 2.44

F Stat 5.20

Prob (F-Stat) 0.00

Normality (Jarque-Bera) 0.508

Heteroskedasticity test Breusch-Pagan-Godfrey (P-value) 0.315

Source: Authors' calculations from Eviews

Figure 1: CUMSUM

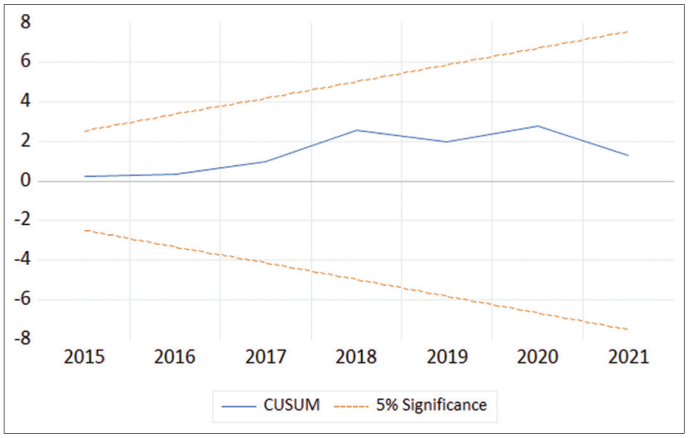
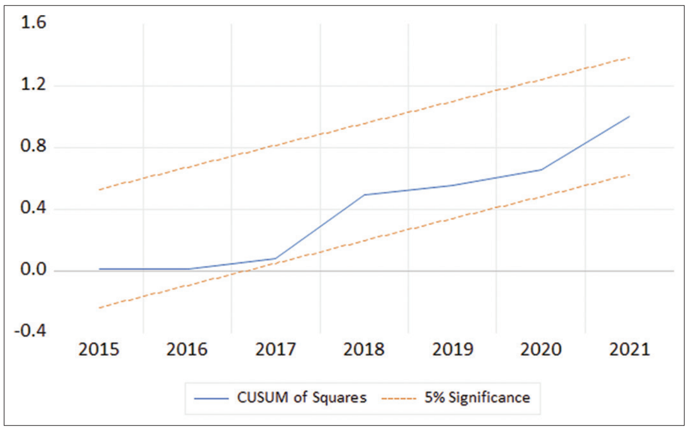


Figure 2: CUMSUM sum of squares



R square is 92%, Durbin Watson score is 2.44, the F Stat score is 5.20 and probability scores indicate model fitness.

Residual diagnostics with heteroskedasticity test of Breusch-Pagan-Godfrey, normality test with Jarque-Bera scores, and stability test using CUMSUM test and CUMSUM of Squares were conducted. The results of the above estimates are shown in Figures 1 and 2. Stability diagnostics are validated as the spread of the graph for CUMSUM and CUMSUM of Squares are within the upper and lower red lines. All the stability diagnostics tests are showing significant results, indicating no sign of heteroscedasticity, non-normality, serial correlation thereby ensuring stability.

5. DISCUSSION, CONCLUSION, POLICY IMPLICATIONS AND DIRECTION FOR FUTURE RESEARCH

Literatures examining the impact of inward FDI on carbon dioxide emission considering the current time periods are scanty, so the objective of this study is to identify the dynamic effect of inward FDI upon economic development, carbon dioxide emission and trade openness and this study can make a significant contribution to that direction and gains importance to systematically understand the dynamic influence of inward FDI on major macroeconomic indicators. Results of the ARDL model indicate that there is a strong cointegrating relationship between the independent and dependent variables. The long-run results are significant for GDP and Trade openness but insignificant in the case of carbon dioxide emission indicating the fact that an increase in inward FDI will always lead to an increase in carbon dioxide emission in the case of India. This result goes in sync with the study results of Alkhathlan and Javid, 2013; Karedla et al., 2021which indicated a negative relation between CO_2 emission and economic growth trade openness manufacturing for India.

As the development profile of India in all sectors of the economy is on the upscale, enhancement of trade and development is happening; at the same time, this phenomenon is causing more emissions. In the meantime, the Government of India announced net zero emissions by 2070 in 2021 and submitted its first Long-term Strategy for Low Carbon Development (LT-LEDS) in 2022 at COP 27. The findings of Aye and Edoja (2017) emphasise the need for transformation to low-carbon technologies aimed at reducing emissions for sustainable economic growth, which can include energy efficiency and switching away from non-renewable energy to renewable energy. This study recommends an examination of the dynamic relations at the firm level to understand better the impact and outcomes of inward FDI with foreign and domestic industries, as lax environmental laws is a significant reason for multinational companies to locate their polluting industries as per the study outcomes of Minisey and Tarek (2019), even though, this fact cannot be generalised.

Future studies can focus on industry-level and firm-level studies considering the energy consumption patterns with different emissions levels can give good insights about the details of more polluting industry sectors and also clean and no-so-clean firms. This will given a better evaluation of respective effect on emissions. Recollecting Grossman and Kurgers (1991), the environmental impact of trade also depends on the changes that have been forced into the intersectoral composition of economic activities and technologies used for producing goods and services. In the initial stages of development, nations give importance to generating more GDP than the environmental factors until a point arises where the environmental damages start showing detrimental effects. As the number of multinational companies' greenfield and brownfield FDI is increasing in developing countries, it is essential to calculate the implications of the Pollution Haven Hypothesis upon inward FDI to understand the net impact of capital flow-induced economic development (Dagar et al., 2022). Assessing the ecological footprint's economic complexity is essential to better understand environmental degradation (Alvarado et al., 2021). As India has multiple climate zones, efforts towards enhancing the use of alternative sources of energy by educating stimulus measures can create considerable implications in the long term. Governments must start focussing on current and future domestic developmental prospects when receiving foreign capital; at the same time, multinational and global entities must ensure that they are fulfilling the specific development requirements like local content requirements, in the investing countries by following fair and ethical business practices when undertaking investments abroad.

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APPENDICES

Appendix 1:

Variable Description	Variable representation	
Inward FDI	IFDI	Foreign direct investment, net inflows (% of GDP)
Carbon dioxide Emission	CO_2	CO_2 emissions (metric tons per capita)
Economic Growth	GDP	GDP Constant 2015 US$
Trade Openness	TOP	Exports added to imports and divided by GDP

Appendix 2: Unit Root Test, ADF and PP Test

Variables	ADF Test		Phillip Perron Test	
	At level	At first difference	At level	At First Difference
IFDI				
Constant	−0.927 (0.765)	−5.676 (0.000)	−0.705 (0.830)	−5.940 (0.00)
Constant & Linear	−3.126 (0.118)	−5.519 (0.000)	−3.104 (0.122)	−5.857 (0.00)
None	−0.120 (0.713)	−5.447 (0.000)	0.464 (0.809)	−5.429 (0.00)
CO_2				
Constant	1.066 (0.996)	−3.677 (0.00)	0.740 (0.991)	−3.673 (0.00)
Constant & Linear	−1.827 (0.666)	−3.722 (0.03)	−1.840 (0.660)	−3.753 (0.00)
None	6.548 (1.000)	−1.218 (0.199)	4.921 (1.00)	−1.814 (0.00)
GDP				
Constant	−4.598 (0.00	−5.669 (0.00)	−4.476 (0.00)	−14.480 (0.00)
Constant & Linear	−4.958 (0.00	−5.523 (0.00)	−5.522 (0.00)	−19.651 (0.00)
None	−0.091 (0.643)	−0.5.743 (0.000)	−0.369 (0.543)	−11.859 (0.00)
TOP				
Constant	−1.287 (0.622)	−4.338 (0.001)	−1.299 (0.617)	−4.346 (0.00)
Constant & Linear	−1.414 (0.836)	−4.296 (0.001)	−1.547 (0.790)	−4.296 (0.01)
None	−1.020 (0.915)	−4.038 (0.000)	0.908 (0.898)	−4.016 (0.00)

Source: Authors own calculation. t stats, p values are in parenthesis