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Cryptocurrency Returns Over a Decade: Breaks, Trend Breaks and Outliers

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Abstract: This study finds breaks, trend breaks, and outliers in the last decade returns of five cryptocurrencies Bitcoin, Ethereum, Litecoin, Tether USD, and Ripple that experienced frequent changes. The study uses the indicator saturation (IS) approach to simultaneously identify breaks, trend breaks, and outliers in these returns to gain a deeper understanding in their dynamics. The study found that monthly, weekly and daily breaks existed in these returns as well as trend breaks, and outliers mostly during the market peaks in 2017, 2018, 2020, and 2021 that can be attributed to a number of things, such as the global Covid-19 pandemic in 2020, the 2021 crypto crackdown in China, the 2020 price halving of Bitcoin, and the 2017–2018 initial coin offering (ICO) boom. These returns also have common break segments and outliers. The application of IS technique to cryptocurrencies and simultaneous detection of market breaks, trend breaks, and outliers makes this study unique. This study is limited to considering only returns of five digital coins. These results may help traders, investors, and financial analysts modify their tactics and risk-management techniques to deal with the complexity of the cryptocurrency market.

Keywords: breaks; trend breaks; outliers; cryptocurrency; indicator saturation.

JEL classification: C12; C58; G14.

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1. INTRODUCTION

Finding structural changes in the financial time series data has drawn a lot of attention in the literature. Structural changes in the prices of cryptocurrencies have drawn interest during the last ten years. Thus, its movements must be observed every ten years to record its behavior. A significant emphasis is being placed on adapting traditional approaches to the characteristics of the cryptocurrency market by following the historical evolution of breaks, trend breaks, and outliers in the market. From the beginning of cryptocurrency to the present, the ability to recognize outliers and breaks has changed in reaction to the environment, including technological improvements.

Conversely, analyzing past challenging periods allows for identifying both market instability and coinciding events. Cryptocurrency is a type of electronic cash that can be exchanged through a computer system and is run decentralized. In 2008, Bitcoin was created. A person or organization going by the name Satoshi Nakamoto released the Bitcoin whitepaper in 2008, titled Bitcoin: A Peer-to-Peer Electronic Cash System (Nakamoto, 2008). Since the financial crisis 2008, cryptocurrencies have attracted attention on a global scale and are regarded as a novel type of tradeable speculative asset. Since then, the cryptocurrency market has shown significant price fluctuations over time and the development of other coins. Since computer networks and open-source software govern cryptocurrencies, they are decentralized currencies that are not controlled by any authority. Price changes can greatly impact investors due to its structure. For example, 1 Bitcoin (BTC) cost $767 on January 1st, 2014. In 2015, 1 BTC was substantially cheaper, at $313. In 2017, the price of 1 BTC rose to $998. The price of one bitcoin increased in 2018, reaching $14,093. In 2019, the price of 1 BTC dropped to $3,692. The price of 1 BTC increased to $7,195 in 2020. In 2021, the price of 1 BTC significantly increased to $29,072. The price of 1 BTC increased significantly again in 2022, reaching $46,319 in value. In 2023, the price of 1 BTC fell to $16,540. Other cryptocurrencies released later mostly show similar price fluctuations. Figure no. 1 is an illustration of Bitcoin daily price fluctuations over the last 10 years, totaling 3143 days.

Figure no. 1 – Bitcoin Daily Prices

Throughout this study, we use the following definitions consistently. A structural break refers to a change in how a variable behaves over time, such as a spike in the money stock or a deviation from the prior pattern of relationships between observable variables (Castle and Hendry, 2019). On the other hand, outliers are referred to as data points that do not follow the trend of the other observations and deviate significantly from the fitted model (Brooks, 2019). A trend break is a discrete point in time period *t* when there is a noteworthy deviation or shift in a time series' underlying trend. The trend is expected to follow a given pattern or direction before to the defined date, but at the designated period, a structural change occurs, resulting in a new trend. Structural breaks and outliers are generally connected to financial crashes, wars, natural disasters, and attacks. Breaks in the financial market can be linked to important macroeconomic events (Andreou and Ghysels, 2002; Ahmed, 2018). Some studies have found breaks based on newspaper reports (Zarei *et al.*, 2015). For instance, breakpoints for the Asian Financial Crisis were specified for data between July 1997 and October 1998, while breakpoints for the Global Financial Crisis were set for observations between April 2007 and October 2009. Jiun (2019) divided the sample based on a recognized break date -the Malaysian general election. Even though some finance researchers use news reports of dates or known significant breaks and then specify dummy variables to control the effect of major breaks, relying on event identification using a more rigorous method is preferable to assuming the breaks from newspaper reports, as can be seen in the Dutta and Bouri (2022). So, the dates of breaks are not inferred from news stories but are instead quantified. The news article and known event dates, however, will be added as part of pre-analysis filtering step.

The pressing need to employ advanced methods and the availability of long historical data to identify breaks and outliers in cryptocurrency returns quickly is what motivated this research since it will help with risk reduction and decision-making in the volatile cryptocurrency market. Numerous studies on the detection of breaks and outliers in cryptocurrency have been conducted. These studies highlighted that significant fluctuations and structural breaks in price have occurred in the cryptocurrency market (Sahoo *et al.*, 2019; Evrim Mandaci and Cagli, 2022). Tan *et al.* (2022) detected the structural changes in the return, price, and squared return of the top 10 Cryptocurrencies. They demonstrated that structural changes are most frequently seen in the price series, followed by the squared return and return series, and highlighted that there is a "year-end" influence on the market due to cyclical price changes that occur at the start and end of the year. Canh *et al.* (2019) showed that structural breaks have become common in all well-known cryptocurrencies and that changes have moved from smaller to larger cryptocurrencies (in terms of market capitalization). According to Dutta and Bouri (2022) there is no actual evidence that there are outliers among the biggest cryptocurrencies, except for Bitcoin and considered the existence of some outlying observations in Bitcoin return series. Abdul Rashid and Ismail (2023) found that nonlinear and linear trend patterns were seen in every cryptocurrency closing price data sets. Abdul Rashid *et al.* (2023) also found that top five cryptocurrencies display the yearly phenomenon known as "crypto winter," in which the trend shifts downward after six months. The occurrence of speculative price bubbles and their subsequent bursting can result in economic fluctuations, potentially leading to a crisis (Mgadmi *et al.*, 2022).

Previous research, however, has only been able to identify outliers or breaks using different statistical change tests and has not been able to consider both changes at the same time. So, in literature, breaks are accounted for, trend breaks are not considered, and outliers are often removed from data. However, deleting too many data points in the case of too many outlier

observations increases the danger of the final regression model failing to reflect the link that the econometrician wishes to evaluate. Thus, there is a clear knowledge gap in the literature that exists regarding the dynamics of cryptocurrency market breaks, trend breaks and outliers, which is to find an all-encompassing detection methodology that does not place restrictions on the number of breaks, trend breaks, and outliers in this domain to accomplish a simultaneous identification of breaks, outliers, and trends throughout the history of the digital currency market. This calls for examining the whole historical record of digital assets and utilizing advanced techniques like the indicator saturation approach, which have not yet been used but present an unrealized potential for an in-depth understanding of the whole spectrum of breaks, trend breaks, and outliers in this changing financial landscape. This study builds upon the fact that breaks and outliers simultaneously affect the behaviour of the market. So, the Indicator Saturation Approach developed by Hendry (1999) is used in which allows the simultaneous detecting of breaks, trend breaks, and outliers without trimming or removing some observations. IS approach has different types of tests, and it was considered in other studies. According to Castle and Hendry (2022), there are a variety of Indicator saturation estimators (ISEs). These include impulse indicator saturation (IIS) to tackle outliers, step indicator saturation (SIS) to tackle location shifts, and trend indicator saturation (TIS) to tackle for trend breaks. This study aims firstly by employing IS technique to jointly identify breaks, trend breaks, and outliers in the monthly, weekly, and daily returns of the five cryptocurrencies. Secondly, the study finds the common breaks and outliers among cryptocurrencies. The originality of this work is in its application of the indicator saturation technique to cryptocurrencies and jointly detection of breaks, trend breaks, and outliers. In order to achieve all of the aforementioned goals, the study will first convert the prices of each cryptocurrency into returns. It will next visualize and discuss the descriptives to determine whether breaks and outliers exist. Finally, the study will independently apply the indicator saturation approach to each cryptocurrency return. So, SIS is designed to capture these breaks, IIS is designed to capture these outliers and the Trend Indicators (TIS) records this transition by setting a variable to zero until the stated period t and then following the new trend after that.

The results revealed that, over a 10-year period, distinct patterns in outliers, breaks, and trend breaks emerged in the cryptocurrency market for BTC, ETH, LTC, USDT, and XRP. BTC has frequent outliers and disruptions on a daily and monthly basis, with a moderate occurrence weekly. ETH has a balanced distribution of outliers and breaks across daily, weekly, and monthly intervals, with a slight emphasis on weekly trend breaks. LTC has a notable number of daily outliers and breaks, with a higher incidence monthly and a relatively low occurrence of trend breaks. USDT has increased weekly and monthly outliers, moderate daily and weekly breaks, and minimal trend breaks. XRP has a high number of daily outliers, more frequent daily breaks and trend breaks, and a stable trend over weekly and monthly intervals. These findings emphasize the importance of understanding individual cryptocurrency dynamics for effective investment strategies. A balanced approach to policy is required if all historical cryptocurrency breaks, trend breaks and outliers are made public. This entails open disclosure, teaching investors about their patterns, setting risk management policies, working with regulators, encouraging technology development, and guaranteeing ongoing observation. All of these actions are intended to promote a cryptocurrency environment that is more robust, secure, and knowledgeable. The remaining sections of the paper are arranged as follows. The following section provides review of related literature, the methodology and a summary of the data, the results and discussion are then presented, and it ends with conclusion.

2. LITERATURE REVIEW

The detection and study of structural breaks and outliers is becoming more and more important as the cryptocurrency market ages and matures. Consequently, in this quickly evolving financial world, knowing the historical presence and impact of breaks and outliers is crucial for making well-informed decisions. A body of work analyzes these unusual events and their consequences. This literature investigates the approaches to identify structural breaks and outliers in the cryptocurrency market and other associated assets. The previous literature focused on important facets of cryptocurrency connectivity, its relationship to other assets, and the market's behavior during financial crises, given how complicated the cryptocurrency space is. The occurrence of breaks and outliers in cryptocurrency markets during periods of economic crisis provided insights into their behavior under stress. According to Jana and Sahu (2023b), equities and cryptocurrency prices fluctuate in response to various economic conditions. However, currently, most studies consider the COVID-19 pandemic a financial crisis. Fernandes *et al.* (2022) show that these cryptocurrencies demonstrated noticeably stable price dynamics when compared to the periods before and during COVID-19.

Kumar *et al.* (2022) investigated the dynamics of return and volatility connectivity among different cryptocurrencies during the COVID-19 pandemic. They found that volatility connectedness greatly rises throughout the COVID-19 era, and returns connectedness is highest across short-time horizons of one day to one week. James (2021) discovered that whereas cryptocurrencies display more collective dynamics and correlation across the board, stocks act more similarly along their trajectories and extremes and persist longer during anomalies. Sahoo and Sethi (2022) examined return and trading volume data for the top eight cryptocurrencies from August 8, 2015, to October 20, 2022, to investigate the predictability of the cryptocurrency market. Except for XRP, XMR, and DASH, they discovered sustained efficiency after the break. Sahoo *et al.* (2019) conducted a study on the price-volume relationship in the bitcoin market, examining the relationship between returns, return volatility, and trading volume. They stated that new trading volume knowledge causes price changes, and significant price increases drive traders to become more active.

Other studies were conducted to evaluate the distinctive features of cryptocurrencies by contrasting their properties and behavior with a range of conventional and alternative investing options. Jana and Sahu (2023a), who investigated the relationship between cryptocurrencies and the Indian stock market, found that cryptocurrencies do not significantly correlate with the stock market under stable economic conditions. However, Bitcoin, Ethereum, and Cardano show favorable connections during financial crises. Dogecoin, however, provides a haven in times of financial distress. Shahzad *et al.* (2022) compared Bitcoin, gold, and US VIX futures to BRICS stock market indices and considered if these assets are good hedges in high-stress situations like the COVID-19 pandemic. They found that gold and bitcoin are ineffective hedges against BRICS declines. However, Bitcoin, gold, and VIX futures offer diversification advantages for investors in the BRICS stock markets. Gold offers more consistent benefits in China and India, while VIX futures provide more benefits for South Africa, Russia, and Brazil.

In cryptocurrency research, the detection of breaks and outliers have been carried out to identify and comprehend the reasons behind breaks in the dynamic and frequently unpredictable behavior of digital asset markets. According to Kumar *et al.* (2022), the

structural shift is evident when examining cryptocurrencies simultaneously with traditional assets as well as when examining them independently. Charfeddine and Maouchi (2019) employed the Bai and Perron (2003) tests known as (BP) for structural breaks in the returns series and the iterative cumulative sum of squares (ICSS) algorithm tests in the volatility series to determine whether structural breaks existed in both series. They came to two significant empirical conclusions: first, the BP test results applied to the returns series provide strong evidence against the presence of structural breaks in the returns series mean; second, the results indicate the presence of at least three breaks in the cryptocurrency volatility series, except for the XRP price volatility series. Tan *et al.* (2022) adopted the structural change model proposed by Bai and Perron (2003) to investigate the number and location of change points in daily price, return, and volatility as measured by the squared return of the cryptocurrency market. According to the results, structural changes in the price series happen often, with the squared return and return series following suit. These changes were constantly noted between December 2017 and April 2018. Telli and Chen (2020) used the Bai-Perron methodology to test several structural cracks in the cryptocurrency markets. Their findings suggested that there are statistically significant structural variations in terms of volatility and returns and that the dynamics of the volatility and return series are distinct. Furthermore, they noticed a grouping of breakpoints between February and March 2017 and December 2017 and March 2018. Sahoo and Sethi (2022) used the Bai and Perron (2003) test and discovered that the break dates of all 13 cryptocurrencies match their real trend values, but LTC and Steller (XMR) did not exhibit any structural breaks.

In addition, numerous scholars have addressed the topic of the consequences of ignoring structural breaks. Aharon *et al.* (2023) found that investors' hedging tactics, risk exposure assessments, and derivatives valuations are all negatively impacted when structural breaks are disregarded in the cryptocurrency markets. Abakah *et al.* (2020) studied the persistence in the absolute and squared returns of twelve major cryptocurrencies using Bai and Perron (1998) fractional integration techniques and long-memory approaches and found a decrease in persistence in the cryptocurrency market after structural breaks were considered. Jiang *et al.* (2023) examined how structural breaks and the dual long memory property affected the persistence level of six significant cryptocurrency markets. They used the iterated cumulative sum of squares (ICSS) technique by Inclán and Tiao (1994), as well as the Bai and Perron (1998) structural break test and found that the conditional volatility of cryptocurrency markets is characterized by long memory and structural breaks. Omane-Adjepong *et al.* (2019) found that the measure of returns, volatility, and regime shift all had a significant impact on informational inefficiency and volatility persistence.

Mostly common multiple break tests used include Bai and Perron (1998, 2003) tests for mean level changes and iterative cumulative sum of squares (ICSS) for variance changes. Sansó and Aragó (2004) pointed out that ICSS has big size distortion for leptokurtic and platykurtic innovations. Gil-Alana (2008) extended the Bai and Perron tests to the fractional case. However, the BP test requires trimming, which means removing some portion of the sample at the beginning and end, which leads to a minimum break length. Trimming also makes it impossible to detect breaks near the start or end of the sample. However, the above test needs the user to employ an individual outlier or break test to find structural breaks or outliers. So, there are still gaps in the literature regarding the accurate and timely detection of past dynamics and shocks in the history of cryptocurrency market. In order to concurrently identify breaks, trend breaks, and outliers that occurred as the cryptocurrency market aged to

ten years, this study expands on the prior research on the market by applying the indicator saturation (IS) approach to a high frequency of roughly ten years of cryptocurrency returns. Because the IS technique is superior to earlier testing in its concurrent detection ability, this work is unique because it applies it to cryptocurrency returns. This aids in locating potential outliers and shifts in the market that occur under various financial situations. The indicator saturation technique of Hendry (1999) and its sub-tests were considered in the literature. The indicator saturation approach is a method that saturates the model with a full set of indicators to capture either a break, a trend break, or an outlier and then identifies statistically meaningful ones (Pretis *et al.*, 2015). Some variations of this strategy include the trend indicator saturation (TIS), step-impulse indicator (SIS) produced by Castle *et al.* (2015), and impulse indicator saturation (IIS) developed by Hendry (1999) and Santos *et al.* (2008).

The IS approach was also considered in other studies. Applying the impulse indicator saturation approach, Mohd Nasir and Ismail (2020) discovered that two elements that typically appear in data are outliers and structural breaks. Using the IIS and SIS techniques, Ismail and Nasir (2020) looked for outliers in the volatility of the Malaysian Shariah-compliant index return and discovered 47 of them. IIS was utilized by Russell *et al.* (2010) to pinpoint structural breaks in US inflation and generate precise and perceptive estimates of the Phillips curves in the US. In addition, IIS was also utilized by Reade and Volz (2011) to locate shifts and identify a very specific model for inflation in China. Pretis *et al.* (2015) used a least-squares approach based on (Bai and Perron, 1998) (BP) and the indicator saturation approach of Hendry (1999) to detect breaks. Ghouse *et al.* (2022) used IIS approach to identify structural breaks due to COVID-19 in the returns of Pakistan Islamic banks. Castle *et al.* (2021) used trend and step indicator saturation approaches (TIS and SIS) to detect trend and step shifts in long-run UK production functions. Pretis *et al.* (2015) applied IS approach using two of its types of Step indicator saturation (SIS) and trend indicator saturation (TIS) to evaluate climate models. This approach showed superiority among other change tests available. However, Castle *et al.* (2012) used US real interest rates to compare IIS and BP approaches and found that they give approximately similar results. Outlier detection via impulse indicator saturation is a popular method since it already outperforms existing outlier selection strategies such as least trimmed squares (LTS), M-estimator, and MM-estimator by (Johansen and Nielsen, 2008; Doornik, 2009).

3. METHODOLOGY

3.1 Indicator Saturation Approach

Historically, regression analysis investigated outliers and structural breaks by examining the statistical significance of a small set of associated indicator variables. However, recent general-to-specific (GETS) modeling developments allow for indicator testing at every observation in the estimation sample, including variables indicating outliers, structural breaks, or trend breaks and choosing them for inclusion in the final model. Moreover, the indicator saturation approach of Hendry (1999) saturates the model with a full set of indicators and identifies statistically meaningful ones. This technique has different types, including the impulse indicator saturation (IIS) of Hendry (1999) and Santos *et al.* (2008) used to detect outliers and the step-impulse indicator (SIS) of Castle *et al.* (2015) used to detect breaks, and Trend Indicator Saturation (TIS) used to detect trend breaks. The impulse indicator saturation

approach was first created to discover undetermined numbers of outliers with undefined magnitudes at unclear times in the sample (Hendry *et al.*, 2007). Doornik (2009) and Johansen and Nielsen (2008) demonstrated the impulse indicator saturation (IIS) as a robust estimator. The SIS method is a modified version of IIS techniques for multiple break detection.

The IIS and SIS methodologies provide a general procedure for examining model consistency and discovering structural breaks and outliers. Both IIS and SIS are generic tests for an unknown number of structural changes occurring at unknown periods, with unknown duration and amplitude, wherever in the sample (Hendry, 1999; Johansen and Nielsen, 2008). Ericsson and Reisman (2012) merged the two approaches (SIS and IIS). Doornik *et al.* (2013) demonstrate that combining SIS with IIS has no negative impacts when step dummies are present, but it may diminish the power for identifying the impulse indicator. Moreover, one strategy for detecting a trend break (TIS) would be to saturate the model with a number of trend indicators that produce a trend up until a specific observation and 0 subsequently for every observation (Castle and Hendry, 2019). IIS, SIS and TIS have been formulated their mean model y_t as general unrestricted model (GUM) by Pretis *et al.* (2018) as follows:

$$\text{IIS} \quad y_t = \mu + \sum_{j=1}^{n} \delta_j 1_{\{t=j\}} + \varepsilon_t \tag{1}$$

$$\text{SIS} \quad y_t = \mu + \sum_{j=2}^{n} \delta_j 1_{\{t\geq j\}} + \varepsilon_t \tag{2}$$

$$\text{TIS} \quad y_t = \mu + \sum_{j=1}^{n} \delta_j 1_{\{t>j\}}(t-j) + \varepsilon_t \tag{3}$$

The GUM provides the initial information set and serves as the model reduction process's starting point. Each equation y_t represents the return series of each cryptocurrency, μ stands for the intercept of the regression, δ_j stands for the magnitude of either a break, trend break or outlier, and the ε_t is the error term. The Impulse Indicators (IIS) in equation (1) include a dummy variable that is set to zero in all periods except one, which occurs at period t and takes on a value of one. The Step Indicators (SIS) in equation (2), on the other hand, use a step function variable that remains at zero until period t and then transitions to one. Finally, in equation (3), the Trend Indicators (TIS) provide a trend-break variable that begins at zero and continues until period t, after which it follows a distinct trend.

3.2 IS Application Procedure

The procedure by which the above three equations incorporate the indicators into the regression equation is presented in Table no. 1. We set each return series as a dependent variable on an intercept, and each equation of the IS technique then adds indicators equal to T observations as indicator variables (N). As the number of indicators (N) surely exceeds the number of observations $(N > T)$, the IS techniques will automatically employ blocks; each block contains 30 indicators to look for significant indicators. The blocks constructed and the indicators added when these tests were allowed to run are summarized in Table no. 1. For the three tests – IIS, SIS, and TIS – to discover outliers, breaks, and trend breaks simultaneously, we ran the three tests all at once. Therefore, results will be more accurate, and masking will be less of an issue. We choose to use the sample observations (T) to calculate the alpha value, or (1/T). Each alpha value in the sample is set to be very tight.

Table no. 1 – IS application framework

Returns	Daily		Weekly		Monthly	
	Indicators	Blocks	Indicators	Blocks	Indicators	Blocks
BTC	9423	105	1344	15	303	4
ETH	6162	69	876	10	195	3
LCT	9606	107	1368	16	309	4
USDT	6162	69	876	10	195	3
XRP	6162	69	876	10	195	3

Note: Table no. 1 outlines an indicator-based framework for financial returns of various cryptocurrencies (BTC, ETH, LCT, USDT, XRP) across daily, weekly, and monthly time frames. It also describes the number of indicators created in the regression model and the corresponding blocks into which these indicators were divided. For example, With 9423 indicators created by IIS, SIS and TIS together for BTC daily returns were divided into 105 blocks, 1344 indicators for weekly returns were divided into 15 blocks, and 303 indicators for monthly returns were divided into 4 blocks. Similar procedures were applied to the other coins.

3.3 Datasets

The data set includes the daily, weekly, and monthly closing prices of five different cryptocurrencies: Tether (USDT), Litecoin (LTC), Ripple (XRP), Ethereum (ETH), and Bitcoin (BTC). The data were retrieved from the yahoo financial website, *https://finance.yahoo.com/*. Table no. 2 gives further information and summarizes the duration of the data and its frequency.

Table no. 2 – Data duration and frequency

Cryptocurrency	Market. Cap.	Start Date	Data begins	Data ends	Frequency
Bitcoin (BTC)	518B	13 July 2010	22 Nov 2014	30 June 2023	3143D, 450W, 103M
Litecoin (LTC)	4B	28 April 2013	22 Sep 2014	30 June 2023	3205D, 458W, 105M
Ripple (XRP)	26B	04 August 2013	13 Nov 2017	30 June 2023	2056D, 294W, 67M
Ethereum (ETH)	196B	07 August 2015	13 Nov 2017	30 June 2023	2056D, 294W, 67M
Tether USD (USDT)	83B	25 February 2015	13 Nov 2017	30 June 2023	2056D, 294W, 67M

Note: D stands for daily, W for weekly and M for monthly.

These cryptocurrencies were chosen based on their ranking in terms of market capitalization or launch. So, for BTC, ETH and USDT were chosen because they are the market leaders in terms of total market capital, and XRP and LTC were chosen because they are the next-oldest cryptocurrencies after BTC. Bitcoin (BTC) is the first cryptocurrency that has ever existed. Of all cryptocurrencies, it has the highest market capitalization at $518 billion. Ethereum (ETH) - With a market capitalization of $196 billion, Ethereum is the second most valued cryptocurrency behind Bitcoin. Tether (USDT) is the third-largest cryptocurrency in the world by market cap, with $83 billion. While Litecoin (LTC) ranks fifteenth with $4 billion and Ripple (XRP) is fifth with $26 billion, both XRP and LTC are older than other ETH and USDT. The study took into account market capitalization and age when choosing cryptocurrencies, allowing for the identification of market leaders as well as an evaluation of how well these coins have weathered changes in the marketplace over time. By considering both established and emerging cryptocurrencies, the combination of market capitalization and age also aids in lowering risk. Information on the market capitalizations was obtained from Yahoo Finance as of September 2023. This study deals with returns by

converting each series into log-returns using the formula: $R_t = \ln\left(\frac{P_t}{P_{t-1}}\right) = \ln(P_t) - \ln(P_{t-1})$. Where R_t stands for returns, P_t is the current lag of the price at time t, and P_{t-1} is the previous lag price at time $t-1$. Figure no. 2 shows the plots of each cryptocurrency return.

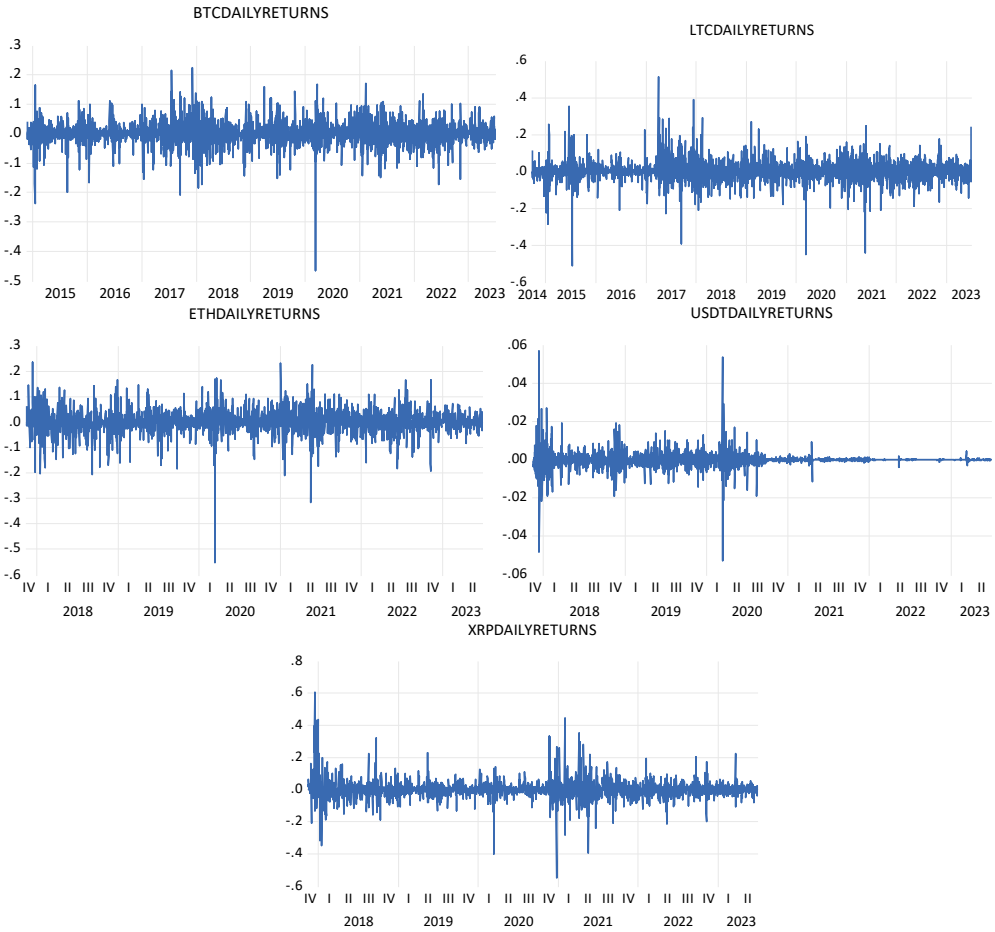

Figure no. 2 – Daily log returns of the five cryptocurrencies

Table no. 3 gives some descriptive information for the cryptocurrency daily log returns. The cryptocurrency market returns demonstrate the traditional features of financial data, namely that a large standard deviation predominates over a modest mean. The returns of LTC and XRP are the most volatile series, whilst the returns of USDT are the least volatile. Returns are also highly negatively skewed and have strong kurtosis, which makes them exceedingly out of the ordinary. According to the kurtosis, which ranges from 13.14 for ETH to 53.30 for USDT, an outlier exists.

Table no. 3 – Descriptive Statistics

Returns	Mean	Std. Dev	Skewness	Kurtosis
BTCDR	0.00	0.04	-0.789	14.2
LTCDR	0.00	0.06	0.103	15.85
ETHDR	0.00	0.05	-0.923	13.14
USDTDR	0.00	0.00	0.745	53.30
XRPDR	0.00	0.06	0.84	20.3

4. RESULTS AND DISCUSSIONS

This section presents the findings and discussions from our comprehensive analysis of breaks, trends, and outliers in the returns on cryptocurrencies over a 10-year period utilising the indicator saturation approach. We use a variety of tables to present our findings and explain them.

4.1 IIS Test Results

Table no. 4 – Outliers and their dates

Series	Alpha	Outlier Dates	Total
BTCDR	0.0003	1/13/2015(-), 1/14/2015(-), 1/15/2015(+), 8/18/2015(-), 1/15/2016(-), 1/11/2017(-), 7/17/2017 (+), 7/20/2017(+) , 9/14/2017(-), 9/15/2017(+), 12/06/2017(+), 12/07/2017(+), 1/16/2018(-), 2/05/2018(-), 4/02/2019(+), 6/27/2019(-), 7/16/2019(-), 10/25/2019(+), 3/12/2020(-), 3/19/2020(+), 1/21/2021(-), 2/08/2021(+), 5/12/2021(-), 5/19/2021(-), 6/13/2022(-)	25
ETHDR	0.0005	12/22/2017(-), 9/05/2018(-), 10/11/2018(-), 9/24/2019(-), 3/08/2020(-), 3/12/2020(-), 3/13/2020(+), 3/19/2020(+), 1/03/2021(+), 1/21/2021(-), 5/19/2021(-), 5/24/2021(+) , 6/21/2021(-)	13
LTCDR	0.0003	1/03/2015(-), 1/14/2015(-), 5/22/2015(+), 6/16/2015(+), 7/10/2015(-), 6/22/2016(-), 12/23/2016(+), 3/30/2017(+), 4/05/2017(+), 5/03/2017(+), 5/23/2017(+) , 9/14/2017(-), 12/08/2017(+) , 12/09/2017(+) , 12/11/2017(+), 12/12/2017(+), 1/16/2018(-), 2/14/2018(+), 2/08/2019(+), 4/02/2019(+), 3/12/2020(-), 1/11/2021(-), 5/12/2021(-), 5/19/2021(-), 5/24/2021(+), 6/21/2021(-), 9/07/2021(-), 6/30/2023(+)	28
USDTDR	0.0005	11/30/2017(+), 12/07/2017(+), 12/08/2017(-), 12/12/2017(+), 12/13/2017(-), 12/14/2017(-), 12/24/2017(-) , 12/30/2017(+), 1/16/2018(+), 1/17/2018(-), 1/19/2018(-), 2/08/2018(+) , 3/24/2018(+), 11/14/2018(-), 11/15/2018(+), 11/23/2018(-), 12/08/2018(+) , 6/28/2019(+), 3/12/2020(+), 3/13/2020(-), 3/17/2020(-), 3/19/2020(+) , 3/27/2020(+), 3/28/2020(-), 5/06/2020(+), 5/07/2020(-), 7/03/2020(-), 8/14/2020(-)	28
XRPDR	0.0005	12/12/2017(+), 12/13/2017(+), 12/14/2017(+), 12/21/2017(+), 12/29/2017(+), 1/03/2018(+), 1/08/2018(-), 1/16/2018(-), 8/17/2018(+), 9/20/2018(+), 9/21/2018(+), 5/14/2019(+), 3/12/2020(-), 11/21/2020(+), 11/23/2020(+), 12/23/2020(-), 12/24/2020(+), 1/07/2021(+), 1/30/2021(+), 2/01/2021(-), 4/10/2021(+) , 4/26/2021(+), 5/19/2021(-), 5/24/2021(+), 5/11/2022(-), 3/21/2023(+)	26
BTCWR	0.0022	12/18/2017(-), 1/29/2018(-), 11/19/2018(-), 3/09/2020(-)	4
ETHWR	0.0034	12/11/2017(+), 1/01/2018(+), 1/29/2018(-), 9/03/2018(-), 11/19/2018(-), 12/17/2018(+), 3/09/2020(-), 5/17/2021(-)	8
LTCWR	0.0022	1/19/2015(+), 3/27/2017(+), 5/01/2017(+), 5/17/2021(-)	4
USDTWR	0.0034	12/04/2017(+), 12/18/2017(+), 1/08/20189(+), 1/29/2018(+), 10/22/2018(+), 11/26/2018(+), 12/03/2018(+), 5/13/2019(+), 11/25/2019(-)	9

Series	Alpha	Outlier Dates	Total
XRPWR	0.0034	12/11/2017(+), 1/08/2018(-), 1/29/2018(-), 9/17/2018(+), 11/16/2020(+), 12/21/2020(-), 1/25/2021(+), 4/05/2021(+), 5/17/2021(-),	9
BTCMR	0.01	No	0
ETHMR	0.015	2018M03 (-)	1
LTCMR	0.01	2015M06(+), 2017M12(+)	2
USDTMR	0.015	2018M01(-), 2018M02(+), 2018M10(-), 2018M12(+), 2019M01(-), 2019M03(-), 2019M06(-), 2019M07(+)	8
XRPMR	0.015	2020M11(+), 2020M12(-), 2021M01(+), 2021M04(+)	4

Note: DR: daily returns, WR: weekly returns, and MR: monthly returns. The table contains daily outliers of the returns, weekly outliers, and monthly outliers. If no outliers were detected in a particular coin, we have written No—otherwise, the provided dates and total of outliers across frequencies.

Table no. 4 displays the results of the IIS approach on daily, weekly and monthly scale, including the outlier dates, total of outliers and alpha values. The sign in the bracket can determine whether the outlier is positive or negative. Positive outliers show that the value was much higher than most of the returns, whilst negative outliers show that the value was significantly lower than others. Regarding the daily returns, the cryptocurrencies LTC, USDT, and XRP each have 28 outliers, which is a significantly greater number. All five cryptocurrencies have a significant number of outliers. This shows that these coins went through fluctuations daily or occurrences that led to outlier values. In terms of weekly returns, ETH, USDT, and XRP have more outliers than BTC and LTC. This shows that, on a weekly basis, ETH, USDT, and XRP had more extreme values compared to BTC and LTC. In the monthly returns USDT cryptocurrency has the most outliers, followed by LTC. There are a small number of outliers for cryptocurrencies ETH and XRP but none for BTC. This implies that these cryptocurrencies perform differently each month, with some experiencing more extreme values than others. Overall, outliers tend to occur most frequently in daily returns. Compared to daily returns, the number of outliers for weekly returns is often smaller while monthly returns have the lowest occurrence of outliers. This suggests that monthly cryptocurrency performance is more likely to be consistent and to experience fewer extreme extremes. Furthermore, there are 169 outliers in total, which is a sizable number. 90 of them have values that are much greater than the rest of the returns, making them positive outliers. 79 of them, however, are negative outliers, with values that are far below the average of the returns. Positive and negative outliers are distributed in an even manner. This shows that extreme numbers can occur in either way, whether it's greater or lower than the expected range. 47% of these outliers coincide with market peaks in 2017, 2018, 2020, and 2021. The China crypto crackdown in 2021, the global covid pandemic, the halving of Bitcoin in 2020, and the initial coin offering (ICO) boom in 2017–2018 can all be blamed for that.

4.2 SIS Test Results

Table no. 5 – Daily Break Segments

SIS output								
Break Segments	**Sign**	**Size**	**Break Segments**	**Sign**	**Size**	**Break Segments**	**Sign**	**Size**
BTCDR			ETHDR			USDTDR		
11/22/2014-11/01/2015	+	344 days	11/13/2017-12/10/2017	+	29 days	11/13/2017-12/23/2017	+	40 days
11/02/2015-11/03/2015	+	2 days	12/11/2017-12/12/2017	+	2 days	12/24/2017-2/4/2018	-	42 days
11/4/2015-6/20/2016	-	229 days	12/13/2017-2/5/2018	-	54 days	2/5/2018-2/6/2018	-	Outlier
6/21/2016-6/22/2016	-	2 days	2/06/2018/11/18/2018	+	285 days	2/7/2018-2/9/2018	-	3 days

SIS output								
Break Segments	**Sign**	**Size**	**Break Segments**	**Sign**	**Size**	**Break Segments**	**Sign**	**Size**
BTCDR			ETHDR			USDTDR		
6/23/2016-1/4/2017	+	195 days	11/19/2018-11/20/2018	-	2 days	2/10/2018-11/18/2018	+	281 days
1/5/2017-1/06/2017	-	2 days	11/21/2018-5/20/2021	+	911 days	11/19/2018-11/20/2018	-	2 days
1/7/2017-12/6/2017	+	333 days	5/21/2021-6/9/2022	-	384 days	11/21/2018-11/23/2018	+	3 days
12/7/2017-12/16/2017	-	10 days	6/10/2022-6/13/2022	-	3 days	11/24/2018-6/30/2023	-	1,679 days
12/17/2017-11/18/2018	-	336 days	6/14/2022-11/07/2022	+	146 days			
11/19/2018-11/20/2018	-	2 days	11/8/2022-11/9/2022	-	2 days			
11/21/2018-11/7/2022	+	1,447 days	11/10/2022-6/30/2023	+	232 days			
11/8/2022-11/9/2022	-	2 days						
11/10/2022-6/30/2023	+	232 days						
LTCDR			XRPDR					
9/22/2014-1/23/2015	+	123 days	11/13/2017-1/07/2018	+	367 days			
1/24/2015-1/25/2015	+	2 days	1/08/2018-1/16/2018	-	8 days			
1/26/2015-7/04/2015	-	159 days	1/17/2018-1/18/2018	+	2 days			
7/5/2015-5/02/2017	+	667 days	1/19/2018-2/10/2018	-	22 days			
5/03/2017-5/07/2017	+	5 days	2/11/2018-11/23/2020	-	1,016 days			
5/08/2017-5/24/2017	-	16 days	11/24/2020-4/06/2021	+	133 days			
5/25/2017-5/26/2017	-	2 days	4/07/2021-4/08/2021	-	Outlier			
5/27/2017-6/15/2017	+	20 days	4/9/2021-4/13/2021	+	5 days			
6/16/2017-6/17/2017	+	2 days	4/14/2021-5/24/2021	-	40 days			
6/18/2017-5/20/2021	-	1,432 days	5/25/2021-6/20/2021	+	26 days			
5/21/2021-5/24/2021	-	4 days	6/21/2021-6/22/2021	-	2 days			
5/25/2021-6/30/2023	+	766 days	6/23/2021-6/30/2023	+	737 days			

Note: Here in this study, the term break segment refers to a discrete and continuous section of a dataset that is defined by breakpoints that have been found. Each break segment in our situation, for example, BTCDR, got 12 breakpoint dates ($m = 12$). Hence, we have ($m + 1 = 13$) break segments where the returns are divided into 13 segments by 12 breakpoints. These break segments aid in identifying and analyzing changes in patterns or trends during the observation period by highlighting times when the data's behavior departs noticeably from the surrounding intervals. The same idea applies to other segments of the other digital coins. In addition, an outlier is identified by SIS when it detects two consecutive step shifts with opposite signs, as it does in the dates highlighted in the USDTDR and XRPDR (Pretis *et al.*, 2018).

Table no. 6 – Weekly Break Segments

SIS Output					
Break Segments	**Sign**	**Size**	**Break Segments**	**Sign**	**Size**
BTCWR			LTCWR		
11/22/2017-4/23/2017	+	126 weeks	9/22/2014-6/14/2015	+	38 weeks
4/24/2017-6/11/2017	+	7 weeks	6/15/2015-7/05/2015	+	3 weeks
6/12/2017-7/16/2017	-	5 weeks	7/6/2015-12/03/2017	-	126 weeks
7/17/2017-8/13/2017	+	2 weeks	12/04/2017-12/17/2017	+	2 weeks
8/14/2017-11/12/2017	-	13 weeks	12/18/2017-5/9/2021	-	177 weeks
11/13/2017-12/17/2017	+	5 weeks	5/10/2021-6/30/2023	-	112 weeks
12/18/2017-5/9/2021	-	177 weeks			
5/10/2021-5/23/2021	-	2 weeks			
5/24/2021-6/30/2023	+	110 weeks			
USDTWR			XRPWR		
11/13/2017-12/10/2017	+	4 weeks	11/13/2017-12/17/2017	+	5 weeks
12/11/2017-2/4/2018	-	214 weeks	12/18/2017-1/7/2018	+	3 weeks
2/5/2018-6/30/2023	+	282 weeks	1/8/2018-6/30/2023	-	286 weeks

Table no. 7 – Monthly Break Segments

SIS Output					
Break Segments	**Sign**	**Size**	**Break Segments**	**Sign**	**Size**
BTCMR			ETHMR		
2014M12-2017M03	+	28 months	2017M12-2020M03	+	28 months
2017M04-2017M12	+	9 months	2020M04-2021M04	+	13 months
2018M01-2020M09	-	33 months	2021M05-2023M06	-	26 months
2020M10-2021M03	+	6 months			
2021M04-2023M06	-	27 months			
LTCMR			USDTMR		
2014M10-2017M02	+	28 months	2017M12-2018M10	+	12 months
2017M03-2017M08	+	6 months	2018M11-2019M04	+	6 months
2017M09-2023M06	-	70 months	2019M05-2023M06	-	49 months

The findings of the SIS technique are shown in Tables no. 5, no. 6 and no. 7. Table no. 5 shows daily break dates, break segments, segment signs, and segment sizes. A break segment is a certain timeframe in the cryptocurrency market that reflects a segment or period of similar behaviour. If the break segment is negative suggests that the cryptocurrency market's performance over the period in question declined or suffered. Segment size indicates the segment's duration in days. For instance, BTC's segment from 11/21/2018 to 11/7/2022, which covers 1,447 days, has a positive sign and is the longest segment during which BTC did not exhibit a fall. The longest segment break for ETH is comparable to BTC segments but is shorter at 911 days from 11/21/2018 to 5/20/2021. The longest break for LTC is from 6/18/2017 to 5/20/2021 with 1,432, yet there is a fall in LTC throughout this time. The longest break segment for XRP is 2/11/2018-11/23/2020 with 1,016 days, while the longest break segment for USDT is 11/24/2018-6/30/2023 with 1,679 days with a negative sign. The longest break segments for each cryptocurrency roughly fall in similar segments, showing that the market reacts similarly to each part. The average number of daily break segments detected among all cryptocurrencies is almost the same. However, they all have varying sizes. A similar analysis can be derived from the weekly and monthly break segments shown in Tables no. 6 and no. 7, but the weekly data for ETH did not show any breaks, and the monthly data for XRP did not show any breaks either. On average, the most extended break segments in weekly and monthly data are like daily break segments.

4.3 Common Outliers and Breaks

The daily and weekly outliers that at least three cryptocurrencies share exactly are shown in Table no. 8. Again, Table no. 8 demonstrates that the years 2017, 2018, 2020, and 2021 are among often occurring outliers, indicating that a shock to one cryptocurrency affects at least two others, either positively or negatively. The consistency with which these outliers arise across different cryptocurrencies is interesting, suggesting that there may be a pattern or common component that influences their values or market behavior. It is again interesting to note that cryptocurrencies with frequent outliers also seem to have approximately similar breaks. This implies that their market behavior may be related or correlated. Further investigation into these breaks and their effects on the prices of the cryptocurrencies may offer insightful information about the variables affecting their performance, see Table no. 9.

Table no. 8 – Common Outliers

Outlier date	BTCDR	ETHDR	LTCDR	USDTDR	XRPDR
12/12/2017	No	No	Yes (+)	Yes (+)	Yes (+)
12/13/2017	No	Yes (-)	No	Yes (-)	Yes (-)
1/16/2018	Yes (-)	No	Yes (-)	Yes (+)	Yes (-)
3/12/2020	Yes (-)	Yes (-)	Yes (-)	Yes (+)	Yes (-)
5/19/2021	Yes (-)	Yes (-)	Yes (-)	No	Yes (-)
5/24/2021	No	Yes (+)	Yes (+)	No	Yes (+)
Outlier date	**BTCWR**	**ETHWR**	**LTCWR**	**USDTWR**	**XRPWR**
1/29/2017	Yes (-)	Yes (-)	No	Yes (-)	Yes (-)
5/17/2021	No	Yes (-)	Yes (-)	No	Yes (-)

Note: Yes means share and sign shows whether positively or negatively.

Table no. 9 – Common Break Segments

Break segment	BTCDR	ETHDR	LTCDR	USDTDR	XRPDR
12/17/2017-1/18/2018	Yes	Yes	No	Yes	Yes
2/6/2018-11/18/2018	No	Yes	No	Yes	No
11/19/2018-11/20/2018	No	Yes	No	Yes	No
11/8/2022-11/9/2022	Yes	Yes	No	No	No
11/10/2022-6/30/2022	Yes	Yes	No	No	No
Outlier date	**BTCWR**	**ETHWR**	**LTCWR**	**USDTWR**	**XRPWR**
11/18/2017-12/17/2017	Yes	No	No	Yes	Yes
12/18/2017-5/9/2021	Yes	No	Yes	No	No
1/8/2018-6/30/2023	No	No	No	Yes	Yes
5/10/2021-6/30/2023	Yes	No	Yes	No	No
Outlier date	**BTCMR**	**ETHMR**	**LTCMR**	**USDTMR**	**XRPMR**
2014M9-2017M02	Yes	No	Yes	No	No
2017M04-2021M03	Yes	Yes	No	No	No
2021M04-2023M06	Yes	Yes	No	No	No

4.4 TIS Application Results

The trend break dates determined using the TIS technique are listed in Table no. 10, along with the appropriate alpha value and frequency. The symbol in the bracket indicates whether the trend break is positive or negative. The cryptocurrencies ETH and XRP exhibit a substantially higher number of 8 and 9 trends when it comes to daily returns. LTC and USDT exhibit smaller trends in terms of weekly returns, while others do not exhibit any weekly trends. The monthly returns of the cryptocurrencies show no trend.

Table no. 10 – Trend Break Dates

Series	Alpha	Trend Break Dates	Total
BTCDR	0.0003	7/13/2017 (-), 7/15/2017 (+), 7/17/2017 (-), 12/06/2017 (+), 12/23/2017 (-)	5
ETHDR	0.0005	1/14/2018(-), 1/16/2018(+), 1/20/2018(-), 1/21/2018(+), 1/27/2018(-), 2/06/2018(+), 5/21/2021(+), 5/25/2021(-)	8
LTCDR	0.0003	7/12/2015(-), 7/13/2015(+)	2
USDTDR	0.0005	12/20/2017(+), 12/24/2017(-), 1/18/2018(-), 1/30/2018(+), 2/03/2018(-)	5

Series	Alpha	Trend Break Dates	Total
XRPDR	0.0005	2/05/2018(+), 2/09/2018(-), 11/23/2020(-), 11/26/2020(+), 11/27/2020(-), 4/03/2021(+) , 4/05/2021(-), 5/20/2021(-), 5/25/2021(+)	9
BTCWR	0.0022	No	0
ETHWR	0.0034	No	0
LTCWR	0.0022	1/26/2015(+)	1
USDTWR	0.0034	12/11/2017(-), 2/05/2018(+)	2
XRPWR	0.0034	No	0

The study aligns with actual market events. However, due to varying data, important events may be questioned. The results indicate significant times in 2017, 2018, 2020, and 2021. In 2017, the market experienced BTC halving and planned BTC futures launches. In 2018, Bitcoin and other cryptocurrencies saw a significant price drop. This year also marks the beginning of crypto winter and the initial coin offering (ICO) boom in 2017–2018. In 2020 and 2021, the China crypto crackdown in 2021, the global Covid pandemic, and the halving of Bitcoin in 2020. BTC had its third halving, and prices increased further (Telli and Chen, 2020). Our examination of break, trend break and outlier dates in cryptocurrency markets offers insightful information about market behaviour and its effects. Making wise investment and trading decisions in the dynamic and often changing world of cryptocurrencies requires an understanding of the underlying dynamics behind these breaks.

5. CONCLUSION

In conclusion, this study has investigated the comprehensive detection of breaks, trend breaks, and outliers in historical cryptocurrency data, with a focus on five cryptocurrencies: Bitcoin, Ethereum, Litecoin, Tether USD, and Ripple over a period of 10 years. The findings showed that breaks, trend breaks, and outliers exist in the returns of these digital coins and that the frequency of these changes existed from monthly to weekly to daily. According to the tables, most of these changes happened in 2017, 2018, 2020, and 2021. It can be related to a variety of well-known occurrences, including the global Covid-19 pandemic in 2020, the Chinese crypto crackdown in 2021, the price halving of Bitcoin in 2020, and the rise in initial coin offerings (ICOs) in 2017–2018. Each of the five digital currencies exhibits roughly equal daily, weekly, or monthly returns changes that include both positive and negative shocks. The study also discovered that at least two or three cryptocurrencies have breaks and outliers in common, which indicate existence of common movement during those years. Using the indicator saturation test as a statistical tool for structural change identification, we successfully identified and date weekly, monthly, and daily breaks, trend breaks, and outliers within the cryptocurrency returns.

The study found that running IS estimators like IIS, SIS, and TIS individually can be flexible but running them concurrently increases accuracy, demonstrating the superiority of the IS approach over other tests. The capacity of the SIS method to locate outliers and the ability of the IIS method to identify breaks would both be reduced if all were performed simultaneously. Therefore, SIS is good at break detection, while IIS is good at outlier detection. Some researchers, like Pretis *et al.* (2018), Ghouse *et al.* (2022), and others, that used either SIS or IIS for break and outlier detection will find this to be beneficial. The indicator saturation approach's success in identifying these changes highlights the fact that it can be a useful tool for identifying various changes in financial time series data. For the breaks

detected, we have seen that most of the digital coins taken into consideration here exhibit a pattern of break segments throughout the history of the cryptocurrency market. This pattern seems to comprise longer and shorter segments that alternate, with the shorter ones typically lasting two days. The lengthier parts appear to have different particular durations, and their lengths do not exhibit an obvious arithmetic or geometric progression. Instead, the pattern is more erratic, alternating longer and shorter periods. If policymakers wanted to know what was causing the alternating patterns, they would have to keep a tight eye on the market. Policies should also be in place to control and lessen the risks brought on by changes in the market. This study offers practical insights for market participants, highlighting the importance of strong risk management, staying updated on regulations and security measures, and understanding the psychological aspects of market sentiment. The knowledge gained enhances the informed and resilient cryptocurrency market ecosystem, encouraging diversification and risk mitigation strategies among market participants. This study is limited by considering only five digital coins. However, future studies may consider more.

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Sovereign Credit Default Swap Market Volatility in BRICS Countries Before and During the COVID-19 Pandemic

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Abstract: SCDS (Sovereign Credit Default Swaps) are becoming more widely used as a country risk indicator after 2008 and stand out for providing real-time information rather than periodic reporting. The COVID-19 pandemic has led to economic disruptions and a decline in international trade. Understanding how the Pandemic affects SCDS return volatility in emerging economies like BRICS forms the motivation for our research. With this study, we aim to determine the impact of the COVID-19 Pandemic on SCDS return volatility in Brazil, Russia, India, China and South Africa, known as the BRICS countries. We used the Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model to analyze the data, which consisted of the daily closing price data for SCDS. The date of the first COVID-19 case in each country has been taken as the beginning of the COVID-19 Pandemic in each country. The results of the estimated GARCH models show that the volatility processes of the SCDS return series differ between periods. EGARCH model results indicate that shocks created by news in these countries during the Pandemic have a small and persistent effect on Brazil and Russia's SCDS return volatility, while they have a large and enduring effect on China and South Africa's SCDS return volatility. The findings will guide policymakers and portfolio managers in determining risk management models.

Keywords: SCDS; EGARCH; Volatility; BRICS; COVID-19.

JEL classification: E5; H81.

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1. INTRODUCTION

A credit default swap (CDS) is a credit derivative that can be used to insure against a corporate or government bond issuer's credit risk. SCDS is a type of CDS that can be used to protect investors against sovereign debt losses caused by credit events such as default or debt restructuring. The CDS market is still in its early stages but has already become an important component of the global credit market. CDS were introduced in the 1990s and became popular in the early 2000s, with the total value of outstanding CDS reaching $61.2 trillion by 2007 (Bank for International Settlements, 2022). CDS and Credit Derivatives started in 1996 after many financial institutions viewed them as useful tools for risk management. The 1997 Asian crises, the 1998 Russian bond default and the International Swaps and Derivatives Association (ISDA) regulations accelerated the emergence of credit derivatives (Ranciere, 2002). On a regional basis, Latin American countries account for approximately 50-60% of the Credit derivatives market, Eastern European countries 23-30% of the Credit derivatives market, and other countries 10-20% of the Credit derivatives market and the most liquid markets are; Argentina, Brazil, Mexico, Russia, Turkey, and South Africa (Ranciere, 2002). CDSs are issued in USD and other powerful currencies, such as the Euro (Brigo *et al.*, 2019).

S&P Global, a leading financial data and analytics provider, is well-known for its credit risk analysis expertise. They provide the iTraxx SovX indices, a family of sovereign CDS indices covering global markets, including the BRICS. The sovereign CDS indices were created to track the market's perception of credit risk via CDS contract pricing. The first iTraxx SovX indices were introduced in 2007. The iTraxx SovX Western Europe was the first index launched, followed by the iTraxx SovX CEEMEA (Central and Eastern Europe, Middle East and Africa) and the iTraxx SovX Asia ex-Japan (S&P Down Jones Indices, 2023).

CDS were widely used to mitigate the risks associated with mortgage-backed securities and fixed-income products, contributing to the 2008 financial crisis and the European sovereign debt crisis (Bhatnagar *et al.*, 2023). Before the global financial crisis, more money was invested in CDSs than in other financial instruments, such as stocks, with a market capitalization of $60.4 trillion in 2007 (The World Bank Data, 2022).

The price of sovereign CDS has traditionally been used to assess the risk of a sovereign credit event. If the price of a sovereign CDS rises, the market perceives a higher risk of default, while a price decrease indicates a lower risk. Furthermore, the academic and practitioner literature on CDS is growing, with researchers looking into the role of counterparty credit risk in determining par CDS spreads, how quickly new information is reflected in CDS pricing in comparison to other markets, a measure of investor perception of the country's credit risk, and much more (Amstad *et al.*, 2016; Fontana and Scheicher, 2016; Cevik and Öztürkkal, 2020; Bomfim, 2022).

CDS are among the most contentious derivative instruments as a result of their roles in the 2008 financial crisis and subsequent debt crises in Europe. CDS proponents believe that the CDS market enables bond market lenders to reduce credit concentrations and meet regulatory goals while maintaining customer relationships (Amstad *et al.*, 2016; Cevik and Öztürkkal, 2020). On the other hand, opponents frequently see the contracts as speculative and potentially destabilizing, citing their differences from standard insurance policies covering property (Tevfik Kartal, 2020; Bhatnagar *et al.*, 2022).

Due to the CDS market regulation and relative financial market stability until 2019, investors' interest in this market has generally decreased. However, although SCDS account

for a small portion of the sovereign debt market, their significance has grown rapidly since 2008, particularly in advanced economies (International Monetary Fund, 2013). The proportion of SCDS increased in the years following the global financial crisis, from less than 4% of notional amounts outstanding in the global CDS market in 2007 to around 14% in 2020 (Bomfim, 2022). CDS contracts issued on emerging-market government debt continue to dominate the SCDS market. Contracts referencing the sovereign debt of key emerging-market countries are frequently cited as among the most frequently negotiated in the global CDS market's sovereign sector (Bomfim, 2022).

The CDS market rose to $8.8 trillion in the first six months of 2020 and remained there until 2022 (Bank for International Settlements, 2022). This increase can be attributed partly to the uncertainty caused by COVID-19 when market participants used CDSs to adjust their risk exposures and infer changing market views on credit risk (Bank for International Settlements, 2022). Due to COVID-19, debt became more expensive because of capital outflows from emerging markets, an increase in the spreads on their SCDSs, and a decline in the value of their currencies (Daehler *et al.*, 2021).

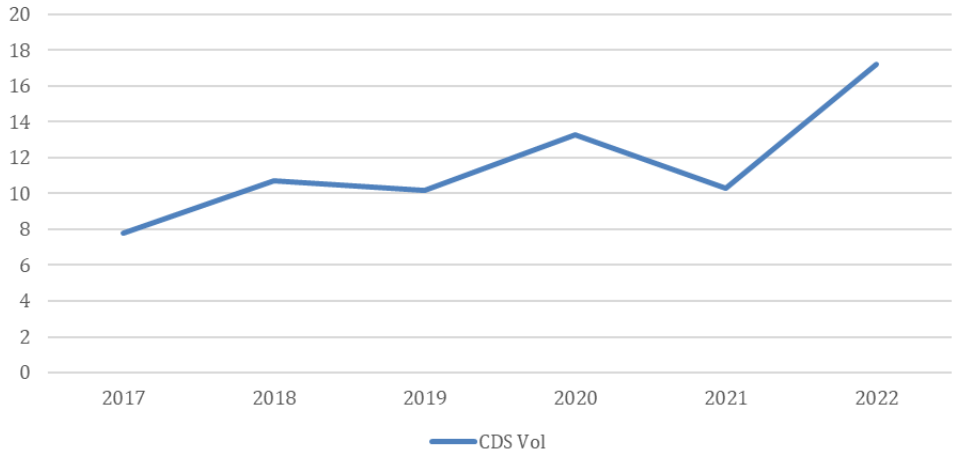

Figure no. 1 – CDS Volume (trillions of USD)
Source: adapted from Barnes (2022)

In Figure no. 1, we can note how the trading volume of CDS increased during the Pandemic period in 2020 and decreased the following year. We witnessed a sharp rise in 2022, maybe due to Russia's invasion of Ukraine and the rising regional and global geopolitical risks.

Although the United States, China, Japan, and Germany continue to be the world's largest economies in terms of nominal GDP, some rankings have shifted as a result of the Pandemic. India, the world's fifth-largest economy in 2019, slipped to sixth place behind the U.K. in 2020 (The World Bank Data, 2022). India was subjected to strict lockdowns during the COVID-19 pandemic as the country struggled to contain the coronavirus, and it took three years to return to fifth place in 2022. Brazil's economy fell from ninth to twelfth in 2020, making it the only country to fall out of the top ten and remain there in 2022 (The World Bank Data, 2022). South Korea entered the top ten since it was one of the earliest countries outside China to report cases of COVID-19 in early 2020 (The World Bank Data, 2022). This lends

credence to our study's motivation to investigate SCDS return volatility as a risk indicator in emerging economies such as the BRICS.

During 2020, the economic disruptions brought about by COVID-19 resulted in a decline in international trade. However, because global demand resumed, international trade rebounded in 2021 and increased further during 2022 (UNCTAD, 2023). As we see in Table no. 1, the exports in 2020 of almost all BRICS countries fell. On the other hand, China increased its exports by 3.84%, and other BRICS countries' exports fell by 11.86% (South Africa). Thus, we can conclude that the Pandemic negatively affected the BRICS countries, causing the rise of credit default problems in these countries.

Table no. 1 – Export yearly change by Country %

Country	*2017*	*2018*	*2019*	*2020*	*2021*
Brazil	4.91	4.05	-2.56	-1.84	5.79
Russia	5.01	5.55	0.73	-4.10	3.50
India	4.56	11.93	-3.39	-9.24	24.32
China	10.23	9.53	-1.02	3.84	30.19
South Africa	-0.27	2.74	-3.45	-11.86	9.99

Source: The World Bank Data (2022)

We can see the GDP Growth of the BRICS countries between 2019 and 2022. According to IMF data (International Monetary Fund, 2022), except for China, all of the BRICS countries' GDP fell (3.6% in Russia, 4.5% in Brazil, 7.5% in South Africa and 8.0% in India). However, the growth rate in China fell to 2.3% from 6.0% during the COVID-19 pandemic in 2020. Therefore, we can say that the COVID-19 pandemic had an adverse effect on all BRICS countries.

Table no. 2 – Real GDP Growth %

Country	*Estimate*		*Projections*	
	2019	*2020*	*2021*	*2022*
Brazil	1.4	–4.5	3.6	2.6
Russia	1.3	–3.6	3.0	3.9
India	4.2	–8.0	11.5	6.8
China	6.0	2.3	8.1	5.6
South Africa	0.2	–7.5	2.8	1.4

Source: IMF (2022)

These effects can be caused by problems in the supply chain, etc., because of the pandemic restrictions. There are many avenues: supply chains may be affected, the failure to receive necessary inputs from other countries, the closure of export markets, transportation challenges, currency fluctuations, the financial state of a country before the Pandemic and the political status of a country.

There is no official definition of an emerging market, but the IMF defines one based on systemic presence, market access, and income level. The IMF defined 20 emerging market countries in 2020, accounting for 34% of global nominal GDP in U.S. dollars and 46% in purchasing-power-parity terms (Duttagupta and Pazarbasiogly, 2021). Brazil, Russia, India, China, and South Africa (BRICS) have long been among the world's fastest-growing emerging market economies, owing to low labour costs, favourable demographics, and

abundant natural resources during a global commodities boom (Duttagupta and Pazarbasiogly, 2021). BRICS is a club of emerging powers attempting to increase political and economic integration in response to new global challenges. In this study, we do not examine BRICS as an institution but rather each country's potential, as Brazil, Russia, India, China, and South Africa account for around 25% of the global GDP, 40% of the world's population, and 12% of global trade in 2021 (The World Bank Data, 2022).

With this study, we aimed to determine the impact of the COVID-19 Pandemic on SCDS return volatility in Brazil, Russia, India, China and South Africa, namely because, as noted above, Emerging countries are more vulnerable to some risks than developed markets. We look at the volatility of sovereign CDS as an indicator of the country's economic stability/instability and ranking. The more volatile the BRICS countries' CDS prices are, the less stable their economies are and the lower their ranking.

In the literature, very few studies examine the impact of the Covid-19 pandemic on SCDS prices. This study distinguishes itself from the existing literature by revealing the effect of the Pandemic on SCDS return volatility and the persistence of volatility. The study predicts the impact of the Pandemic on SCDS return volatility using EGARCH models. As one of the first studies conducted on the volatility of BRICS SCDS returns, this study uniquely contributes to the literature.

Our findings contribute to SCSD perception as a market sentiment indicator towards specific reference entities and credit risk in general. Moreover, COVID-19 has recently triggered another crisis; thus, this study complements the literature on CDS in the context of COVID-19 with meaningful empirical relationships that SCSD return volatility has with a country's economic stability.

Our findings indicate that the shocks caused by news in countries have varying effects on SCDS return volatility both before and during the pandemic period. However, it is observed that the persistence of SCDS return volatility is longer during the Pandemic than in the pre-pandemic period across all countries. In addition, the increases in volatility in SCDS returns and the long duration of volatility can be interpreted as increased risks for countries during the pandemic period.

Understanding the effect of a pandemic on the volatility of sovereign credit default swaps is important for policymakers since this can help determine models for managing a country's expected credit risk exposure. Furthermore, because SCDS return volatility can be used as a reliable indicator of investors' views on credit risk exposure, this study has practical implications for investors interested in emerging markets.

2. LITERATURE REVIEW

So far, researchers and practitioners have focused on the primary applications of credit default swaps from the perspective of those who participate in the credit derivatives market (Wigan, 2009; Grima *et al.*, 2020; Srivastava and Dashottar, 2020; Wu *et al.*, 2020). Less obvious but potentially very significant is the growing use of pricing data from credit default swaps by market participants and non-participants alike as indicators of market sentiment toward specific reference entities and credit risk in general. In the literature, the number of studies examining the impact of the Covid-19 pandemic on SCDS is limited. However, a substantial body of literature investigates the relationship between CDS prices and different financial instruments.

A study by Cevik and Öztürkkal (2020) shows the impact of infectious diseases on the evolution of sovereign CDS spreads. After controlling for macroeconomic and institutional factors, they found that infectious-disease outbreaks have no discernible effect on CDS spread. However, their granular analysis using high-frequency (daily) data indicated that the COVID-19 Pandemic significantly impacted market-implied sovereign default risk. This adverse effect was more pronounced in advanced economies.

This analysis shows that more stringent domestic containment measures help lower sovereign CDS spreads. The macro-fiscal cost of efforts to curb the spread of the disease could undermine creditworthiness, eventually pushing the cost of borrowing higher and decreasing economic stability (Cevik and Öztürkkal, 2020). Cevik and Öztürkkal (2020) support the findings of Apergis *et al.* (2022), who research global and local COVID-19 indicators and examine how the Pandemic measured by these indicators affects U.S. corporate CDS spreads. The results provide strong evidence for the significant impact of the severity of the Pandemic on U.S. corporate CDS spreads. COVID-19 has driven up CDS prices, and the magnitude and significance of this increase have been heterogeneous across sectors. Specifically, banking, travel, leisure, transportation, airlines, and restaurants were the worst affected sectors, while media, technology, telecommunications, pharmaceutical, information, and data technology firms were not affected by the Pandemic. Hasan *et al.* (2023) have found similar results in their study. Hasan *et al.* (2023) investigated the response of global corporate CDS spreads to the COVID-19 pandemic for 655 companies operating in different industries in 27 countries. The study demonstrates an increase in corporate CDS spreads due to the Pandemic, which is more pronounced for larger companies with higher leverage and closer to the default threshold.

Fender *et al.* (2012) analyzed the CDS premiums of emerging countries using a GARCH(1,1) model. The models were estimated for two separate periods to observe the impact of the global financial crisis. The findings indicate that global and regional risks have a more significant influence on the CDS premiums of emerging countries than their own dynamics, and during the crisis period, the impact of external factors on CDS premiums is more crucial.

According to Amstad *et al.* (2016), global investors differentiate between economies by focusing on sovereign risk, as reflected in monthly returns on CDSs. By dividing their sample into two periods and extracting risk factors from CDS returns, they found an "old normal" in which a single global risk factor drove half of the variation in returns and a new normal in which that risk factor became even more dominant. They noted that tests for breaks in the time series of these returns suggested a new norm and highlighted that the way countries loaded on this factor did not depend on economic fundamentals in both the old and new normal.

Raimbourg and Salvadè (2021) analyzed the evolution of CDS spread and CDS volatility around European sovereign rating announcements over the period 2008 to 2013. They show that the effect of the announcement differs depending on the issuer's credit quality (Investment Grade versus Speculative). An investment grade country's downgrading and negative credit watch stabilize the market as volatility decreases right after its release. By contrast, the announcements regarding speculative grade countries trigger an increase in both CDS spread and volatility. In doing this, they also show that these announcements not only affect the CDS of the country but spill over to the German CDS.

A study providing a thorough investigation of the lead-lag connection between stock indices and sovereign credit default swap (CDS) returns for 14 European countries and the U.S. over the period 2004–2016 was carried out by Ballester and González-Urteaga (2020). They used a rolling VAR framework to analyze the connection process over time, covering

both crisis and non-crisis periods. Examine the connection between stock market volatility and CDS returns. They found that a connection between the credit and equity markets exists and that it is a time variable that seems related to financial crises. Furthermore, the authors observed that stock market returns anticipate sovereign CDS returns, and sovereign CDSs anticipate equity return conditional volatility, completing a market connectedness circle. They further noted that the contribution percentages in terms of returns are more intense in the U.S. than in Europe. The opposite result is found with respect to volatilities, highlighting the greater impact in Eurozone countries compared to non-Eurozone countries.

Vurur and Özen (2020) examined the effect of the COVID-19 Pandemic on the relationship between CDS premiums and the main stock market indices of England, Germany, France, Italy, and Spain. The study's findings showed that the relationship between CDS premiums and stock market indices increased significantly after the Pandemic.

A comparison of the market pricing of the euro area government bonds and the corresponding CDSs was carried out by Fontana and Scheicher (2016). They specifically analyzed the "basis", defined as the difference between the premium on the CDS and the credit spread on the underlying bond, using weekly data for a period that contained several episodes of sovereign market distress. Their observations show a complex relationship between the derivatives market and the underlying cash market characterized by sizable deviations from the no-arbitrage relationship. They highlight that short-selling frictions explain the persistence of positive basis deviations. In contrast, funding frictions explain the persistence of negative basis deviations. These are observed in countries with weak public finances.

Tevfik Kartal (2020) examines how the sovereign CDS spreads of Turkey behaved during the COVID-19 pandemic times by considering that CDS spreads reflect countries' riskiness, vulnerability, financial stability, and macroeconomic stability. Most emerging countries' CDS spreads have increased with the emergence of the COVID-19 Pandemic. This study focuses on two periods, 'before COVID-19' and 'COVID-19 pandemic times', applying the Multivariate Adaptive Regression Splines (MARS) method to daily data of six independent variables and six COVID-19 situations. His findings reveal that (i) influential factors on Turkey's CDS spreads are the BIST100 index, VIX index, MSCI Turkey index, and USD/TL foreign exchange rates for the period which is before the COVID-19 pandemic times; (ii) MSCI emerging market index, number of new deaths from COVID-19, USD/TL foreign exchange rates, the weighted average cost of funds, number of new cases from COVID-19, and VIX index effect on Turkey's CDS spreads during the COVID-19 pandemic times, respectively; (iii) on the other hand, number of cumulative cases, number of cumulative deaths, and measures do not affect Turkey's CDS spreads in any period. Taking precautions to decrease the negative effects on Turkey's CDS spreads while considering the importance of the number of deaths from the COVID-19 Pandemic is very important. Hence, he suggests Turkey could stimulate foreign portfolio investment inflows by decreasing CDS spreads.

Kandemir *et al.* (2022) research also demonstrated the predictive power of CSD premiums as risk indicators. They examined the interaction between the changes in Turkey's CDS premiums and the BIST 100 index, exchange rates, and bond rates. The interaction between the CDS and BIST 100 index, exchange rates, and bond interest rates were analyzed via cDCC-EGARCH and causality in variance. As a result of the analysis, it can be seen that the effect of shocks created by increases for CDS, USD/TL, EU/TL, and bond interest series is more and more significant than shocks created by decreases. According to the variance causality analysis results, a unidirectional causality relationship was found between exchange

rates and interest rates on CDS premiums. A causality relationship was determined from CDS premiums to the BIST 100 index. It is possible to predict the volatility in CDS premiums from the first lag by monitoring exchange rates and bond rate volatility.

An investigation, using the Toda Yamamoto causality test on daily closing data, of the relationship between the VIX index and the BRICS countries' stock market, carried out by Gürsoy (2020), demonstrated that the VIX index is in bilateral causality with the Russian (RTSI) and South African (INVSAF40) stock markets as of the dates of 02.24.2011 and 06.01.2020. On the other hand, it is determined that the price movements in the VIX index have a unilateral causality relationship with the India (BSESN) and China (SSEC) indices. However, it has been seen that the VIX index does not have a unilateral or bilateral causal relationship with the Brazilian (BOVESPA) stock market. These findings corroborate our previous findings on the leverage effect within BRICS countries. The variation in the significance of SCDS as risk indicators depending on domestic factors explains the study's different results for different countries. This is consistent with Kocsis and Monostori (2016) findings, who used a dynamic hierarchical factor model to aggregate information on fundamental economic indicators to investigate the determinants of sovereign CDS spreads on a sample of Eastern European data. SCDS spreads were regressed on forecasts of factors. They found that domestic fundamentals explain more of SCDS spread variance than global factors, largely due to their ability to explain differences in sovereign risk across countries. The effects on SCDS spreads are time-varying, and in terms of economic significance, the factor of institutional-political strength stands out.

An investigation on volatility transmission from commodities to sovereign CDS spreads of emerging and frontier markets carried out by Bouri *et al.* (2017), using daily data for seventeen emerging and six frontier countries, highlights significant volatility spillover from commodity markets to sovereign CDS spreads of emerging and frontier markets. They found that this effect is strong for most countries and that the results differ by country and over time.

Pu and Zhang (2012) examined the global impact of the 2010 German short sale ban on sovereign credit default swap (CDS) spreads, volatility, and liquidity across 54 countries. They found that CDS spreads continued rising after the ban in the debt crisis region, which suggests that the short-selling ban cannot suppress soaring borrowing costs in these countries and that the ban helps stabilize the CDS market by reducing CDS volatility. They further noted that the reduction in CDS volatility is greater in the eurozone than in the non-eurozone.

3. SAMPLE

We used a dummy variable to measure the impact of the COVID-19 Pandemic on SCDS return volatility. In addition, we compared SCDS return volatilities in terms of the pre-pandemic and pandemic periods using the 5-year CSD price data of the five BRICS countries, divided into two buckets: "before the COVID-19 pandemic outbreak period" and "during the COVID-19 pandemic outbreak period". The dataset used in this study consisted of daily closing price data from January 2, 2018, to February 28, 2022, for BRGV5YUSAC (Brazil), RUGV5YUSAC (Russia), INGV5YUSAC (India), CNGV5YUSAC (China), and ZAGV5YUSAC (South Africa) CDS. This data was collected from the Thomson Reuters Eikon System and the Bloomberg database.

We focused on the 5-year SCDS contracts in this study rather than other maturities because they are the most commonly traded contracts. During the sample period, each 5-year contract traded at least once daily in each chosen country.

A dummy variable was included to measure the impact of the COVID-19 Pandemic on SCDS return volatility. The dummy variable COVID-19 assumes a value of 0 for the pre-pandemic period and 1 for the pandemic period. The date of the first COVID-19 case in each country has been accepted as the beginning of the COVID-19 Pandemic. The first case dates in the countries were determined from the Worldometers database. The first case dates were 26.02.2020 for Brazil, 31.01.2020 for Russia, 30.01.2020 for India, 31.12.2019 for China and 05.03.2020 for South Africa. As seen in Table no. 3, the study was evaluated considering three periods.

Table no. 3 – Data Periods

Country	*Term*	*Date*	*Observations*
Brazil	All Term	02.01.2018-28.02.2022	1051
	Pre-Pandemic	02.01.2018-25.02.2020	541
	Pandemic	26.02.2020-28.02.2022	510
Russa	All Term	02.01.2018-23.02.2022	1048
	Pre-Pandemic	02.01.2018-30.01.2020	524
	Pandemic	31.01.2020-23.02.2022	524
India	All Term	02.01.2018-28.02.2022	728
	Pre-Pandemic	02.01.2018-29.01.2020	422
	Pandemic	30.01.2020-28.02.2022	306
China	All Term	02.01.2018-28.02.2022	1050
	Pre-Pandemic	02.01.2018-28.02.2020	503
	Pandemic	02.01.2020-28.02.2022	547
South Africa	All Term	02.01.2018-28.02.2022	1054
	Pre-Pandemic	02.01.2018-04.03.2020	547
	Pandemic	05.03.2020-28.02.2022	507

While the World Health Organization (WHO) announced the Pandemic on 11 March 2020, we preferred to use the data when the first COVID-19 case was announced in each country. This is because we believe that local markets have been affected mostly by local factors, and we also believe that a country that has not seen a COVID-19 case could have some advantages over a country that has had COVID-19 cases. Additionally, since there was a large amount of missing data in the Indian data, it was not included in the analysis.

In addition, in the study, SCDS return volatilities were compared in terms of pre-pandemic and pandemic periods, which were created considering these dates.

SCDS returns are calculated using the formula:

$$R_t = \ln (P_t/P_{t-1}) \quad (1)$$

The CDS return series of the countries are shown in Figure no. 2.

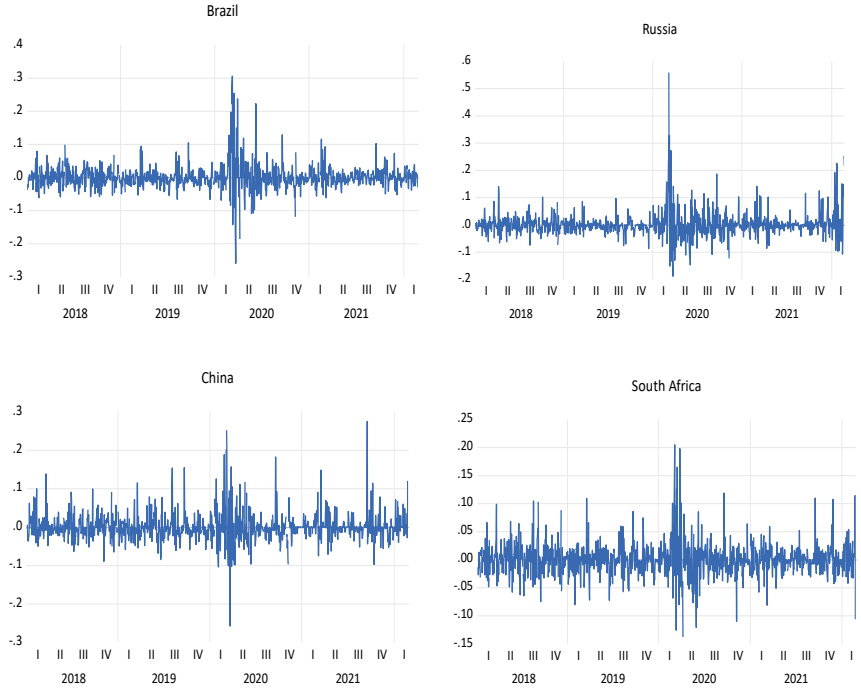

Figure no. 2 – CDS Return of BRICS Countries
Source: authors' compilation

The figures show that at the beginning of the Pandemic, the fluctuations in the SCDS returns of the countries were more intense. The Figures of India do not provide the full data set information since some time intervals are missing. In Table no. 4, descriptive statistics of countries' SCDS returns are provided for the whole period, consisting of a combination of the pre-pandemic and pandemic periods. Data availability for each country's CDS prices vary due to several reasons, such as holidays, market closures, or incomplete data reporting.

Table no. 4 – Descriptive Statistics

SCDS Return Series	Term	Mean	Std.Dev.	Skewness	Kurtosis	Jarque-Bera	Observations
Brazil	All Term	0.000984	0.037539	1.859236	20.91727	14663.89***	1051
	Pre-Pandemic	-0.000428	0.025418	0.654115	4.730601	106.0911***	541
	Pandemic	0.002482	0.047086	1.767547	16.80276	4314.025***	510
Russia	All Term	0.002151	0.045636	3.029882	30.87537	35534.06***	1048
	Pre-Pandemic	-0.000135	0.025694	0.883710	7.139504	442.3273***	524
	Pandemic	0.005104	0.059090	2.601185	21.23273	7849.024***	524
China	All Term	0.000930	0.037415	1.341697	13.46091	5102.621***	1050
	Pre-Pandemic	-0.000442	0.030378	1.241562	7.224680	504.2902***	504
	Pandemic	0.002198	0.042888	1.263961	13.23647	2529.247***	546
South Africa	All Term	0.000783	0.030207	0.976425	9.990274	2313.423***	1054
	Pre-Pandemic	0.000788	0.026333	0.500844	5.107839	124.1318***	547
	Pandemic	0.000778	0.033921	1.183007	11.08618	1499.543***	507

Note: *** indicates statistical significance at the 1 percent level.
Source: Prepared by the Authors

When we examine the standard deviations of the SCDS return series, the standard deviations of Brazil, Russia, China and South Africa have increased in the pandemic period compared to the pre-pandemic period. This result shows that SCDS returns have more volatility during the pandemic period. It is seen that only the standard deviation of the India SCDS return series decreased during the pandemic period. It can be said that this is because there is a lot of missing data in the India data set.

According to the Jarque-Bera test statistics, the countries' SCDS return series do not exhibit a normal distribution. The stationarities of the series were investigated with the Augmented Dickey-Fuller (ADF) unit root test developed by Dickey and Fuller (1979), and the results are given in Table no. 5. According to the ADF unit root test results, it was determined that the series were stationary at the level.

Table no. 5 – Unit Root Test

SCDS Return Series	Term	ADF Test Statistic	Critical Values %1	%5	%10	Stability Level
Brazil	All Term	-18.87267***	-3.436366	-2.864084	-2.568176	I(0)
	Pre-Pandemic	-20.65689***	-3.442231	-2.866673	-2.569564	I(0)
	Pandemic	-19.93250***	-3.442970	-2.866999	-2.569739	I(0)
	All Term	-6.521523***	-3.436493	-2.864140	-2.568206	I(0)
Russia	Pre-Pandemic	-20.74927***	-3.442625	-2.866847	-2.569657	I(0)
	Pandemic	-4.884846***	-3.443072	-2.867044	-2.569763	I(0)
	All Term	-8.888055***	-3.439192	-2.865332	-2.568846	I(0)
China	Pre-Pandemic	-11.34313***	-3.443175	-2.867089	-2.569787	I(0)
	Pandemic	-5.696384***	-3.442413	-2.866753	-2.569607	I(0)
	All Term	-7.406008***	-3.436425	-2.864111	-2.568190	I(0)
South Africa	Pre-Pandemic	-22.71878***	-3.442098	-2.866614	-2.569533	I(0)
	Pandemic	-6.627301***	-3.443388	-2.867183	-2.569837	I(0)

Note: ** and *** indicate statistical significance at the 5 and 1 percent levels, respectively.
Source: Authors computed

4. METHODOLOGY

The study modelled the volatility of SCDS return values in BRICS countries with the GARCH model. To be able to model the volatility of time series data, it is necessary to initially investigate whether there is an ARCH effect (volatility) in the series. The ARCH LM test will determine the presence of volatility in the series. The ARCH-LM test is tested by estimating the autoregressive moving average (ARMA) model. Once it is established that there is an ARCH effect in the series, general autoregressive conditional heteroskedasticity (GARCH) models will be employed to model the volatility.

4.1 ARMA Model

The autoregressive moving average (ARMA) model, proposed by Box and Jenkins (1976) and widely known as the Box-Jenkins method (Gujarati, 2003), is employed for forecasting univariate time series data. The autoregressive moving average model is a forward-looking prediction model for fixed (discrete or interrupted) and stationary time series consisting of observation values obtained at equal time intervals. These models are developed based on the assumption that events over time are stochastic in nature and that the time series related to these events constitutes a stochastic process (Enders, 2015). Autoregressive moving

average (ARMA) models combine autoregressive (A.R.) and moving average (M.A.) models. The observation value at any given time period of a time series is expressed as a linear combination of a specific number of preceding observation values and the error term. The ARMA model includes a component with p terms from the A.R. model and q terms from the M.A. model, written as ARMA(p,q). The ARMA(p,q) model is expressed as follows (Gujarati, 2003; Brooks, 2008):

$$y_t=\varphi_0+\varphi_1 y_{t-1}+\varphi_2 y_{t-2}+\cdots+\varphi_p y_{t-p}+u_t-\theta_1 u_{t-1}-\cdots-\theta_q u_{t-q} \quad (2)$$

here, p and q indicate the degree of the model. and φ and θ refer to the model's parameters.

4.2 GARCH Model

The Autoregressive Conditional Heteroskedasticity (ARCH) model developed by Engle (1982) allows for a better understanding of the dynamic properties of financial time series and for predicting heteroskedasticity over time. Later, Bollerslev (1986) developed the GARCH (Generalized ARCH) model based on the weighting of past error squares. The GARCH (p,q) model is the model in which variance is explained depending on past variances of past volatility and dependent variables. The GARCH (p,q) model is as follows (Enders, 2015).

$$h_t= \omega + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} \quad (3)$$

GARCH models contain some restrictions on α_i parameters. In these models q>0, p≥0, $\alpha_0>0$, $\alpha_i\geq 0$ (i=1,2,3,….,q) and $\beta_i\geq 0$ (i=1,2,3,…,p) conditions should be met. In addition, in addition to these constraints, $\alpha_i + \beta_i < 1$ should be. Providing this constraint indicates that the process has a static structure. $\alpha_i + \beta_i \geq 1$ does not statistically estimate volatility (Engle, 2002).

In equation (3), α_i and β_i are the coefficients of ARCH and GARCH terms, respectively. Large values of the ARCH and GARCH parameters influence conditional volatility differently. A high ARCH parameter implies that the effects of a shock are more pronounced in the subsequent period. In contrast, a high GARCH parameter indicates that the effects of a shock persist for a long time (Enders, 2004, p. 134). Therefore, the large ARCH value will increase volatility in the short term, and the large GARCH value will increase volatility in the long term (Nazlioglu *et al.*, 2013).

4.2.1 EGARCH Model

The models known as ARCH/GARCH suffer from a significant limitation, as they assume that positive and negative shocks in financial markets have the same effect on the volatility of financial assets. Furthermore, these models only focus on the magnitude of volatility, neglecting the sign of volatility. However, it is frequently observed in financial markets that negative news (negative shocks) tends to impact volatility more than positive news of the same magnitude (positive shocks). This phenomenon, expressed as the leverage effect, cannot be detected by ARCH/GARCH models. Therefore, to address this limitation and provide a more suitable analysis of asymmetry in the volatility of time series data, the Exponential-GARCH

(Exponential Generalized Autoregressive Conditional Heteroskedasticity) model was developed by Nelson (1991). One of the most important features of this model is its ability to model asymmetric effects by eliminating the non-negativity constraint introduced in GARCH models, primarily due to the logarithmic nature of the conditional variance. Nelson (1991) proposed the EGARCH model, which allows for a more nuanced understanding of the asymmetric impact on time series volatility. The model is expressed as follows:

$$\log(h_t) = \omega + \sum_{j=1}^{p} \beta_j \log(h_{t-j}) + \sum_{i=1}^{q} \alpha_i \frac{|u_{t-i}|}{\sqrt{h_{t-i}}} + \sum_{i=1}^{q} \gamma_i \frac{u_{t-i}}{\sqrt{h_{t-i}}} \quad (4)$$

In the model, h_t shows the conditional variance, h_{t-j} shows the values of the conditional variance going back to the j periods, u_{t-j} shows the values of the error terms going back to the i periods. ω, β_j, α_i, and γ_i are EGARCH model parameters. α_i, γ_i, and β_j measure innovation, asymmetry, and persistence, respectively. The presence of asymmetric volatility in the EGARCH model depends on the statistically significant γi parameter. The γ_i parameter shows both the leverage effect and the asymmetry of the series. In the model, if $\gamma_i = 0$, it means that a positive shock and a negative shock have the same effect on volatility. If $\gamma_i \neq 0$, it indicates the presence of an asymmetric effect in the series. If $-1 < \gamma_i < 0$, a negative shock increases volatility more than a positive shock (Brooks, 2008).

4.2.2 EGARCH Model with Regressors

This EGARCH model with additional regressors is used in this article to estimate the impact of the COVID-19 Pandemic on SCDS return volatilities. The EGARCH model has been extended by including a dummy variable for the COVID-19 period.

$$\log(h_t) = \omega + \sum_{j=1}^{p} \beta_j \log(h_{t-j}) + \sum_{i=1}^{q} \alpha_i \frac{|u_{t-i}|}{\sqrt{h_{t-i}}} + \sum_{i=1}^{q} \gamma_i \frac{u_{t-i}}{\sqrt{h_{t-i}}} + \delta_1 COVID_t \quad (5)$$

In the equation, if the coefficient δ_1 is negative and significant, it indicates a relationship between COVID-19 and the decrease in SCDS return volatility. If the coefficient δ_1 is positive and significant, it will indicate a relationship between the increase in COVID-19 and SCDS return volatility.

5. ANALYSIS AND RESULTS

It is necessary to determine whether the SCDS return series is heteroskedastic to model its volatility. First, the Autoregressive Moving Average (ARMA) model structure, which is the series' linear stationary stochastic model, must be determined. Table no. 2 shows the most appropriate ARMA models for the series based on Akaike Information Criteria (AIC), Schwartz Information Criteria (SCI), and Log Likelihood ratio. Second, autocorrelation and ARCH LM tests were run to determine the heteroscedasticity status of the series, and the results are shown in Table no. 6.

Table no. 6 – ARMA Models of Developing Countries

SCDS Return Series	Term	AIC	SIC	LogL	$Q^2(10)$	ARCH LM(10)
Brazil	All Term ARMA(2,4)	-3.785319	-3.747584	1997.185	1539.3***	60.10038***
	Pre-Pandemic ARMA(2,1)	-4.513272	-4.473592	1225.840	45.718***	3.962663***
	Pandemic ARMA(2,4)	-3.289661	-3.223239	846.8637	727.07***	33.15081***
Russia	All Term ARMA(1,2)	-3.383787	-3.360148	1778.104	330.77***	21.35982***
	Pre-Pandemic ARMA(1,0)	-4.484607	-4.460209	1177.967	39.359***	3.874172***
	Pandemic ARMA(3,4)	-2.895434	-2.822241	767.6038	127.41***	7.390298***
China	All Term ARMA(3,2)	-3.762597	-3.729553	1982.363	309.90***	19.48894***
	Pre-Pandemic ARMA(3,3)	-4.165746	-4.098721	1057.768	10.659**	2.149714**
	Pandemic ARMA(4,3)	-3.499405	-3.428483	964.3377	183.93***	11.83709***
South Africa	All Term ARMA(3,1)	-4.166806	-4.138569	2201.907	470.73***	25.48141***
	Pre-Pandemic ARMA(1,0)	-4.427541	-4.403933	1213.932	19.684**	1.851277**
	Pandemic ARMA(0,0)	-3.927571	-3.919230	996.6392	275.98***	13.39672***

Note: ** and *** indicate statistical significance at the 5 and 1 percent levels, respectively.
Source: Authors computed

Ljung-Box Q^2 statistics and ARCH LM test results were evaluated up to the 10th lag. It was observed that there was no heteroscedasticity in India's all-term, pre-pandemic and pandemic periods. This can be attributed to the deficiencies in India's SCDS return data (Zaidi and Rupeika-Apoga, 2021). As a result, developing a reliable model for India is impossible. The fact that the Q^2 and ARCH LM values of other countries' SCDS return series are statistically significant at the 1% significance level indicates heteroscedasticity, and the series' volatility can be estimated.

The EGARCH model was used to estimate the countries' SCDS return series volatility. EGARCH models were applied to the residual series obtained from ARMA models. For the most suitable estimation of the EGARCH model, it is essential for its parameters to be statistically significant. Among the estimated models, the one with lower values for the Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) and a higher likelihood ratio (L.R.) is selected as the most appropriate model. The suitable EGARCH model results for the countries' SCDS return series are presented in Table no. 7.

In the EGARCH models, the coefficient of the constant term and the ARCH and GARCH parameters are statistically significant for all return series. Large values of the ARCH and GARCH parameters influence conditional volatility in different ways. A high ARCH parameter implies that the effects of a shock are more pronounced in the subsequent period. In contrast, a high GARCH parameter implies that the effects of a shock are more persistent (Enders, 2004, p. 134). Therefore, the large ARCH value will increase volatility in the short term, and the large GARCH value will increase volatility in the long term. Within the scope

of GARCH models, in addition to calculating the persistence of shocks, the half-life of shocks can also be computed. In this context, the formula ln (0.5)/ln (βj) has been used to calculate the half-life of shocks (Özdemir *et al.*, 2021). The leverage parameter (γ) measures whether the impact of positive and negative shocks on return volatilities is asymmetric.

Table no. 7 – EGARCH Models

	Brazil EGARCH(3,3)	**Russia EGARCH(3,1)**	**China EGARCH(3,1)**	**South Africa EGARCH(3,3)**
$\boldsymbol{\omega}$	-1.897570	-0.597149	-1.257527	-0.440998
	(0.0000)	(0.0000)	(0.0000)	(0.0078)
$\boldsymbol{\alpha_1}$	0.263111	0.258059	0.371192	0.189855
	(0.0000)	(0.0000)	(0.0000)	(0.0001)
$\boldsymbol{\alpha_2}$	0.388039	-	-	0.131642
	(0.0000)			(0.0339)
$\boldsymbol{\alpha_3}$	0.229753	-	-	-0.206368
	(0.0000)			(0.0000)
$\boldsymbol{\lambda}$	0.021147	0.084319	0.162010	0.078127
	(0.0000)	(0.0000)	(0.0000)	(0.0016)
$\boldsymbol{\beta_1}$	-0.349532	1.124184	0.148316	0.734336
	(0.0000)	(0.0000)	(0.0000)	(0.0001)
$\boldsymbol{\beta_2}$	0.227041	-0.805298	0.341326	0.609981
	(0.0000)	(0.0000)	(0.0000)	(0.0095)
$\boldsymbol{\beta_3}$	0.950525	0.617625	0.363111	-0.393880
	(0.0000)	(0.0000)	(0.0000)	(0.0109)
$\boldsymbol{\alpha_i}$	0.880903	0.258059	0.371192	0.115129
$\boldsymbol{\beta_j}$	0.828034	0.936511	0.852753	0.950437
Half-life	3.67	10.56	4.35	13.63
		Diagnostic Statistic		
AIC	-4.320801	-3.951058	-4.019506	-4.395725
SIC	-4.283065	-3.922692	-3.991183	-4.358075
LogL	2278.581	2076.354	2116.241	2324.547
Q^2(10)	2.1374	3.6218	2.2458	2.3799
	(0.995)	(0.963)	(0.994)	(0.993)
ARCH	0.195969	0.363257	0.231451	0.241267
LM(10)	(0.9966)	(0.9621)	(0.9932)	(0.9920)

Note: Q2 and ARCH LM tests were examined until the 10th lag. The ( ) values indicate the probability values.
Source: Authors computed

The leverage parameter is positive and significant for countries' CDS return volatilities. The positivity of the parameter implies that positive shocks have a greater impact on CDS return volatilities as compared to negative shocks. A high ARCH parameter suggests that the effects of a shock are more pronounced in the subsequent period. Shocks in country markets most significantly affect Brazil's CDS return volatility. A high GARCH parameter implies that the effects of a shock are more persistent. The CDS return volatilities of Russia and South Africa tend to be more persistent. To determine how long CDS return volatility lasts on a daily basis, the half-life (H.L.) has been calculated. In this context, the persistence of a shock on Brazil's CDS return is approximately 3.67 days, 10.58 days for Russia, 4.35 days for China, and 13.63 days for South Africa.

The EGARCH model has been extended by including a dummy variable for the COVID-19 period to determine the effect of the COVID-19 Pandemic on the volatility of the SCDS return series. Table no. 8 presents the results of the EGARCH models, which adds the coronavirus variable to the conditional variance equation.

The COVID-19 Pandemic positively and significantly affects CDS return volatilities in Brazil and Russia. The Pandemic increases the CDS return volatility by approximately 10% in Brazil and around 9% in Russia.

Table no. 8 – EGARCH Models with COVID-19 Variables

	Brazil EGARCH(3,3)	**Russia EGARCH(3,1)**	**China EGARCH(3,1)**	**South Africa EGARCH(3,3)**
ω	-2.404374	-0.865598	-1.270058	-0.489806
	(0.0000)	(0.0000)	(0.0000)	(0.0042)
α_1	0.356192	0.294465	0.373859	0.191399
	(0.0000)	(0.0000)	(0.0000)	(0.0001)
α_2	0.383510	-	-	0.125342
	(0.0000)			(0.0415)
α_3	0.179750	-	-	-0.192718
	(0.0000)			(0.0002)
λ	-0.035805	0.070973	0.157030	0.087671
	(0.0042)	(0.0001)	(0.0000)	(0.0010)
β_1	-0.274234	1.133660	0.133292	0.709619
	(0.0000)	(0.0000)	(0.0667)	(0.0001)
β_2	0.182396	-0.794217	0.341313	0.622528
	(0.0000)	(0.0000)	(0.0000)	(0.0063)
β_3	0.854654	0.568371	0.377833	-0.386791
	(0.0000)	(0.0000)	(0.0000)	(0.0105)
δ**(COVID)**	0.096404	0.088293	0.015890	0.011125
	(0.0087)	(0.0000)	(0.2082)	(0.1284)
α_i	0.919452	0.294465	0.373859	0.124023
β_j	0.762816	0.90781	0.852438	0.945356
Half-life	2.56	7.16	4.34	12,33
		Diagnostic Statistic		
AIC	-4.293511	-3.972371	-4.018012	-4.395262
SIC	-4.251058	-3.939277	-3.984968	-4.352906
LogL	2265.240	2088.523	2116.456	2325.303
Q^2(10)	2.6515	3.8688	2.2237	2.4479
	(0.988)	(0.953)	(0.994)	(0.992)
ARCH	0.244805	0.392814	0.228914	0.248220
LM(10)	(0.9915)	(0.9502)	(0.9935)	(0.9910)

Note: Q^2 and ARCH LM tests were examined until the 10th lag. The ( ) values indicate the probability values.
Source: Authors computed

According to the results of Table no. 8, the effect of the COVID-19 Pandemic on the SCDS return volatility could not be measured well by adding the dummy variable. For this reason, the analysis period was divided into two periods, the pre-pandemic period and the pandemic period, taking into account the dates of the COVID-19 cases in the countries. In these two periods, countries' SCDS return volatilities were measured with the EGARCH

model. Model results are given in Table no. 9 in comparison. In the EGARCH model, the volatility processes of the return series differ between periods.

Leverage parameters are positive and significant for both the Pandemic and other periods. This result indicates that during the pandemic period and the other periods, positive shocks have a greater impact on SCDS return volatilities compared to negative shocks. In China and South Africa, the impact of ARCH on SCDS returns during the Pandemic was smaller than in the pre-pandemic period. In addition, the GARCH coefficient in the pandemic period is quite high compared to the other period. These results show that the effects of the shocks experienced during the pandemic period on the SCDS returns are small and permanent for a long time. In Russia and China, the impact of ARCH on SCDS returns during the Pandemic was bigger than in the pre-pandemic period. However, the GARCH coefficient was similarly high in both the pandemic and other periods. These results show that the effects of the shocks experienced during the Pandemic on the SCDS returns are big and permanent for a long time. According to the half-life, the impact of shocks on volatility persists for a longer duration during the pandemic period. In other words, it has been determined that the effect of shocks created by news in countries on SCDS return volatility continued for an extended period during the pandemic period.

Table no. 9 – EGARCH Models for Pre-Pandemic and Pandemic Period

	Brazil		**Russia**		**China**		**South Africa**	
	Pre-Pandemic EGARCH(1,1)	Pandemic EGARCH(3,1)	Pre-Pandemic EGARCH(3,3)	Pandemic EGARCH(3,1)	Pre-Pandemic EGARCH(3,2)	Pandemic EGARCH(2,1)	Pre-Pandemic EGARCH(1,2)	Pandemic EGARCH(3,2)
ω	-2.582088	-0.256976	-5.280150	-0.564948	-0.839084	-0.988193	-0.914638	-1.011655
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0259)	(0.0000)	(0.0001)	(0.0000)
α_1	0.292068	0.151124	0.268011	0.258834	0.034698	0.408706	0.258341	0.166836
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0217)	(0.0000)	(0.0038)	(0.0000)
α_2	-	-	0.124174		-0.031285	-	-0.244968	0.177192
			(0.0027)		(0.0380)		(0.0054)	(0.0000)
α_3	-	-	0.228039		-	-	-	-
			(0.0016)					
λ	0.103154	0.036674	0.099555	0.135917	0.048129	0.180484	0.158666	0.031251
	(0.0168)	(0.0069)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0004)
β_1	0.681540	1.834041	0.750824	1.194681	1.970944	0.445454	0.876843	-0.948237
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
β_2	-	-1.699044	-0.971325	-0.912803	-1.937506	0.448759	-	0.877396
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)		(0.0000)
β_3	-	0.844698	0.568898	0.655994	0.849531	-	-	0.970835
		(0.0000)	(0.0000)	(0.0000)	(0.0000)			(0.0000)
α_i	0.292068	0.151124	0.620224	0.258834	0.003413	0.408706	0.013373	0.344028
β_j	0.681540	0.97970	0.348397	0.937872	0.882969	0,894213	0.876843	0.899994
Half-life	1,80	33.78	0.65	10.80	5.56	6.19	5.27	6.57
				Diagnostic Statistic				
AIC	-4.589881	-4.147772	-4.573737	-3.458736	-4.285161	-3.960813	-4.510287	-4.462879
SIC	-4.558136	-4.097955	-4.508676	-3.409940	-4.226514	-3.921412	-4.470941	-4.404498
LogL	1245.563	1063.682	1206.319	912.1887	1086.860	1086.302	1238.564	1138.340
Q^2(10)	5.0293	1.4332	3.7149	2.9142	5.3705	1.7627	2.4885	5.2586
	(0.899)	(0.999)	(0.959)	(0.983)	(0.865)	(0.998)	(0.991)	(0.873)
ARCH LM(10)	0.499336	0.136498	0.369722	0.247372	0.617730	0.180152	0.256937	0.580627
	(0.8907)	(0.9993)	(0.9594)	(0.9906)	(0.7992)	(0.9976)	(0.9896)	(0.8302)

Note: Q^2 and ARCH LM tests were examined until the 10th lag. The ( ) values indicate the probability values.
Source: Authors computed

Tables no. 7, no. 8 and no. 9 also include diagnostic test statistics for GARCH models. As a result of the predicted GARCH models, the ARCH-LM test was repeated to determine whether the ARCH effect in the residual series had been lost. The statistical values of the ARCH-LM test calculated up to the 10^{th} lag were statistically insignificant, and the conditional variance effect in the series disappeared. No autocorrelation issues were found in the model series when autocorrelation was examined using the Ljung-Box Q^2 test until the 10^{th} lag.

6. DISCUSSION

In this study, we investigated the role of SCDS return volatility as a risk indicator and whether it can be used as an early warning indicator of risk. COVID-19 is a natural event that disrupts the economic system's functioning and significantly negatively impacts assets, production factors, output, employment, or consumption, among other things (Grima *et al.*, 2021). During hazards such as a pandemic, emerging and developing economies suffer the most because their governments' access to international capital markets is limited, and their ability to respond to external shocks is limited (Daehler *et al.*, 2021).

During COVID-19, many countries' exposure to credit risk increased significantly, particularly in emerging markets, raising interest in reallocating credit risk and liquidity during times of stress (Grima *et al.*, 2021). SCDS has been identified as a solution for this, reviving interest in the market (Bomfim, 2022). On the other hand, because of the prospect of prolonged lockdowns and a slower GDP growth recovery, epidemiological deterioration can reduce confidence in sovereign credit markets (Daehler *et al.*, 2021).

As a result, we take a similar stance to Amstad *et al.* (2016) in this paper. They see the volatility of SCDS as an indication of the stability and ranking of the country's economy. They examined SCDS returns for 18 emerging markets and 10 advanced countries from January 2004 to December 2014, using monthly data from January 2004 to December 2014. The authors discovered that while global risk factors change whether SCDS spreads rise or fall over time, the extent to which these spreads rise or fall varies by country. Amstad *et al.* (2016) found that SCDS returns after the 2008 financial crisis moved over time largely to reflect the movements of a single global risk factor, with variation across sovereigns reflecting the designation of "emerging market" for the most part.SCDS are considered an important risk indicator in financial markets. Both investors and policymakers benefit heavily from SCDSs in their decision-making processes (Amstad *et al.*, 2016; Bomfim, 2022). An increasing SCDS premium indicates negative volatility and increased risks in financial markets (Fontana and Scheicher, 2016). As a result, estimating the volatility of a country's SCDS returns is critical.

In the study, the change in the SCDS return volatility of the BRICS countries was examined by adding the dummy variable created by first considering the COVID-19 case dates in the model and the volatility of the SCDS return values. The estimation was carried out before and during the COVID-19 Pandemic, and the persistence of the volatility between the periods was compared. The SCDS return volatility of countries was estimated using EGARCH models.

When the COVID-19 variable was added to the EGARCH model, it was seen that the COVID-19 pandemic only had a statistically significant and positive effect on Russia's and Brazil's SCDS return volatility. Considering the COVID-19 pandemic, it was observed that shocks arising from news increased the volatility of Brazil's SCDS returns. However, it was determined that the persistence period of volatility in returns was short, lasting only 2.5 days

before disappearing. In Russia's case, the shocks' impact on SCDS return volatility was less pronounced, but the persistence period of volatility lasted for 7 days before dissipating.

The data period was divided into the pre-pandemic and pandemic periods, and SCDS return volatility processes were compared. In the GARCH models of the Brazilian SCDS returns, the coefficient of the ARCH effect decreased from 0.292 to 0.151, while the GARCH coefficient increased from 0.681 to 0.979. These results show that the effect of the news on Brazilian SCDS yield volatility decreased, but the duration of its effect on volatility increased during the pandemic period.

In the GARCH models of the Russia SCDS return, the coefficient of the ARCH effect decreased from 0.620 to 0.258, while the GARCH coefficient increased from 0.348 to 0.937. These results show that the effect of the news on Brazilian SCDS yield volatility decreased, but the duration of its effect on volatility increased during the pandemic period.

In the GARCH models of Chinese SCDS returns, while the coefficient of the ARCH effect increased from 0.003 to 0.408, there was a very slight increase in the GARCH coefficient from 0.882 to 0.894. In the GARCH models of South African SCDS returns, the coefficient of the ARCH effect increased from 0.013 to 0.344, while the GARCH coefficient showed a very slight increase from 0.876 to 0.899. These results indicate that news increased the volatility of Chinese and South African SCDS returns and extended the impact duration during the pandemic period.

Half-life measure is higher during the pandemic period. This indicates that the impact of news on SCDS return volatilities lasts longer. For Brazil, the persistence of a shock on CDS returns has increased from approximately 1.8 days to 33.7 days. For Russia, it has increased from 0.65 days to 10.8 days. In the case of China, it has changed from 5.56 days to 6.19 days, and for South Africa, it has increased from 5.27 days to 6.57 days.

This study's findings are consistent with Tevfik Kartal (2020), Apergis *et al.* (2022), and Hasan *et al.* (2023) studies. Tevfik Kartal (2020) examines how the sovereign CDS spreads of Turkey behaved during the COVID-19 pandemic times by considering that CDS spreads reflect countries' riskiness, vulnerability, financial stability, and macroeconomic stability. Most emerging countries' CDS spreads have increased with the emergence of the COVID-19 Pandemic.

Apergis *et al.* (2022), global and local COVID-19 indicators, examine how the Pandemic measured by these indicators affects U.S. corporate CDS spreads. The results provide strong evidence that the Pandemic has increased CDS prices. Hasan *et al.* (2023) investigated the response of global corporate CDS spreads to the COVID-19 pandemic for 655 companies operating in different industries in 27 countries. The study has demonstrated increased corporate CDS spreads due to the Pandemic.

7. CONCLUDING REMARKS

Although we did our best to capture as much data as possible, our study has some limitations Since some countries, especially BRIC countries, do not provide information on a timely basis, and often, the reliability of the information might be questionable. First, our findings do not fully cover the BRICS due to data issues in India. Second, the inclusion of other countries in the discussion and future research on the use of SCDS as a risk indicator would improve opportunities for international comparison and benchmarking. Third, COVID-19 capturing the COVID-19 recovery period and risk indicator behaviour would be interesting. Fourth, the authors define the COVID-19 Pandemic as the first date that COVID-

19 cases were publicly reported in a country. However, it is important to acknowledge the potential limitations and uncertainties associated with these sources of information, especially in countries where there may be data transparency or reliability issues. Traders are not going to wait until a country makes a formal announcement. Traders will form their own assessment of the scale of a pandemic in a country and the economic consequences for the country.

However, our research answers how international investors differentiate between different economies when entering or exiting emerging markets. Our research shows that SCDS-based indexes make it easier for investors and market observers to obtain exposure to or simply track a specific credit market sector. Furthermore, they aid in comprehending how global investor behaviour changes during crises such as the 2008 global financial crisis or the COVID-19 Pandemic. According to the literature review, prices in the credit default swap market tend to incorporate information faster than prices in the corporate bond market because it is sometimes easier to enter into swap positions than to buy or sell certain corporate bonds and loans. Although whether the information is reflected first in credit derivatives or cash markets remains an empirical question Bomfim (2022), investors and regulators have begun to pay closer attention to credit default swap signals.

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Flexicurity in the EU28 Countries: A Multiyear Composite Indicator Proposal

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Abstract: This study computes a flexicurity index for the EU28 countries for 2001-2019 following the European Commission's four components of flexicurity model. The index allows the ex-post assessment of flexicurity efforts and efficiency. Following the computation of the index, we compare its values against the theoretical flexicurity typologies and against other empirical flexicurity groupings to assess their (dis)similarities. Even though Northern and Western countries generally have higher flexicurity scores than Southern and Eastern states, the study shows some countries deviate from their theoretical performance. Thus, some of the Continental and Mediterranean countries have flexicurity values like those of the Nordic group. Moreover, the flexicurity regimes are not static as the theoretical typology suggests: while Denmark and France are always in the top performers' group, other countries change their performance throughout the 2001-2019 period. The flexicurity index correlates highly with empirical country groupings in the literature. The highest correlation is with country groupings using the European Commission's four components of flexicurity model, followed by the Golden Danish Triangle, and lastly, the Wilthagen and Tros' flexicurity matrix. In the end, we compare EU countries' performance in the flexicurity index scores with their performance in selected employment and unemployment rates, labor productivity, and poverty rates. Results suggest that higher flexicurity performance correlates generally with better labor market and social outcomes, the highest correlations being in the case of labor productivity rates.

Keywords: flexicurity; EU policy; labor markets; composite indicators.

JEL classification: J08; J88; C43.

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1. INTRODUCTION

In the early and mid-2000s, the Danish and Dutch success stories inspire policymakers across EU to quickly embrace flexicurity, viewing it as a miraculous policy that fosters employment growth and social inclusion. Therefore, to attain the *Europe 2020*'s goals, in 2007, the European Commission includes flexicurity in its social policy agenda (Muffels and Wilthagen, 2013). The strategy targets increased employment, productivity, and social cohesion by 2020 (European Commission, 2010). Thus, one of its targets is to reach a 75% employment rate for people aged 20-64 by 2020. However, in 2020, the employment rate is only 71.7%. Additionally, the strategy targets a decrease of 20 million people at-risk of poverty[1] by 2020 compared to 2010. Even though the at-risk of poverty rate decreases in the ten years, the change is 8 million people[2] only, instead of 20 million as previously aimed.

Concerning flexicurity, the policy instrument supposed to foster reaching these goals, there are several attempts at benchmarking EU countries' flexicurity efforts for policy advice. These include developing country groupings (Dominguez-Torreiro and Casubolo, 2017), scoreboards (EMCO, 2009), and composite indicators (Manca *et al.*, 2010). However, the European Commission discontinued the development of all these monitoring tools[3]. There is no mention of flexicurity being redefined or ceased. Still, the most recent measures related to flexicurity are the *European pillar for social rights* (2017) and *A new skills agenda* (2016); performance evaluation reports and country recommendations do not go beyond 2015. Moreover, these policy evaluations rely on the theoretical flexicurity clusters (GHK, 2013), draw on a new flexicurity analytical framework (De Pedraza Garcia *et al.*, 2018), or provide general discussions on the policy efforts taken by each Member State (Peer review on flexicurity, 2014 and related documents). Overall, communication challenges akin to those identified in the *Lisbon strategy* by Saltelli *et al.* (2011) are also seen in the context of flexicurity, with the absence of a standardized benchmark and ongoing uncertainty impeding clarity, trust, and adequate research. Thus, the question remains: was flexicurity effective in reaching its proposed outcomes?

Absent an established flexicurity benchmark, this question is challenging to address. One cannot analyze whether countries that successfully integrated flexicurity as their labor market policy are better at employment or poverty rates because it is not clear which are those countries. Therefore, this paper aims at:

(1) Creating a flexicurity index by extending Manca *et al.* (2010)'s four flexicurity subindices for the EU28 countries during 2001-2019 to have a clear benchmark for future analyses.

(2) Comparing the flexicurity index scores with the theoretical flexicurity regimes described by Muffels and Wilthagen (2013) to understand if countries fall into the theoretical typology throughout the analyzed period.

(3) Comparing country performance in the flexicurity index scores with other flexicurity country groupings in the literature for the overlapping country-time sample to understand how (dis)similar they are to each other.

(4) Comparing EU countries' performance in the flexicurity index scores with their performance in selected employment and unemployment rates, labor productivity, and at-risk of poverty rates to understand whether higher flexicurity countries also perform better in flexicurity-related outcomes.

Hence, the main contribution of this paper is the creation of a flexicurity index to benchmark the EU28 countries' flexicurity efforts during the 2001-2019 period. The index follows the European Commission (2007)'s four components of flexicurity model. To this aim, we compute a flexicurity composite indicator by aggregating the Manca *et al.* (2010)'s four subindices[4]: flexible contractual arrangements (FCA), modern social security systems (MSSS), active labor market policies (ALMP), and lifelong learning strategies (LLL). This approach is seen in the recent works of Ferent-Pipas and Lazar (2023) and Nikulin and Gawrycka (2021). Ferent-Pipas and Lazar (2023) compute a flexicurity composite indicator for the EU27 countries for 2005, 2010, and 2015, while Nikulin and Gawrycka (2021) compute it for the Central and Eastern European (CEE) countries, except for Lithuania, for the years 2007 and 2013. The construction of the index brings more clarity and facilitates the analysis of the other three aims of this paper.

Following the construction of the index, a second contribution of this paper stems from its comparison with the theoretical flexicurity regimes. Muffels and Luijkx (2008) and later on, Muffels and Wilthagen (2013) amend the Espring-Andersen's policy regimes typology to describe how European countries perform in relation to flexibility and security from a theoretical perspective. Several empirical studies (e.g., Hastings and Heyes, 2018) find countries that do not fit this theoretical typology. Instead of one- or two-yearly snapshots, the flexicurity index computed here allows for a comparative analysis at different points in time. Performing such a comparison brings understanding on whether referring to the theoretical country grouping in policy recommendations is a valid practice, and if so, under which assumptions. Based on Hastings and Heyes (2018)'s previous results we expect flexicurity scores to show countries that perform differently than their theoretical regime in some years of analysis.

A third contribution of the paper comes from comparing the flexicurity index scores with other empirical country groupings. To this aim, we identify five studies[5] that classify countries according to their flexicurity regime based on quantitative data and methods. Even though these studies have commonalities in their grouping of countries, some dissimilarities appear. Such an example is the case of Portugal, which is classified as either a top, average, or bottom performer in flexicurity, depending on the study. One explanation for this diverse categorization is the difference between studies in the variables used to describe flexicurity. However, the five studies differ in their country and time sample, impeding a straightforward comparison of the country groupings. Hastings and Heyes (2018) find that some countries changed their performance in flexicurity in 2011 compared to 2006, the two years analyzed by their study. This suggests that the differences between the five studies could stem not only from the variables used to describe flexicurity but also from the difference in time and country sample. Thus, the availability of the flexicurity index for each of the periods analyzed by the five identified studies allows comparing it with each one of the country groupings. Such a comparison could shed some light on whether the dissimilarities between the different groupings come exclusively from the variables used or if the studies' different time frames also explain the dissimilar results.

Lastly, the paper assesses the correlation between the EU28 countries' flexicurity scores and their performance in twelve labor market variables related to employment, productivity, and poverty. The variables are listed in the European Commission (2007) as flexicurity outcomes. This brief descriptive analysis brings some assumptions about the relationship between labor market outcomes and flexicurity, opening the way to future more detailed causational studies. The remainder of the paper is structured as follows. Section 2 describes

the theoretical flexicurity typologies and the flexicurity frameworks used in empirical classifications. Next, the construction of the composite indicator – framework, data, methodology, and robustness analysis – is presented at length in Section 3. The flexicurity index scores are compared to the theoretical and other empirical flexicurity regimes in Section 4. Section 5 provides the correlation analysis between the flexicurity index scores and the results in desired labor market outcomes. Lastly, Section 6 summarizes the findings of this study, and Section 7 concludes and discusses some policy implications of the results.

2. FLEXICURITY FRAMEWORKS

Muffels and Luijkx (2008) provide an account of how the EU14 countries perform in relation to flexicurity from a theoretical standpoint. This framework is later extended by Muffels and Wilthagen (2013) to encompass certain Eastern countries (see Figure no. 1). Thus, they name a "flexicurity cluster" formed by the Nordic countries and an "inflexicurity cluster" including the Mediterranean-Southern states and some Eastern ones. Two "trade-off clusters" define the Anglo-Saxon and the Continental regimes. Literature refers to these five country clusters as the "theoretical flexicurity regimes," "theoretical clusters," "theoretical typologies," or "natural clusters" (e.g., Hastings and Heyes, 2018). This paper adopts the same naming convention.

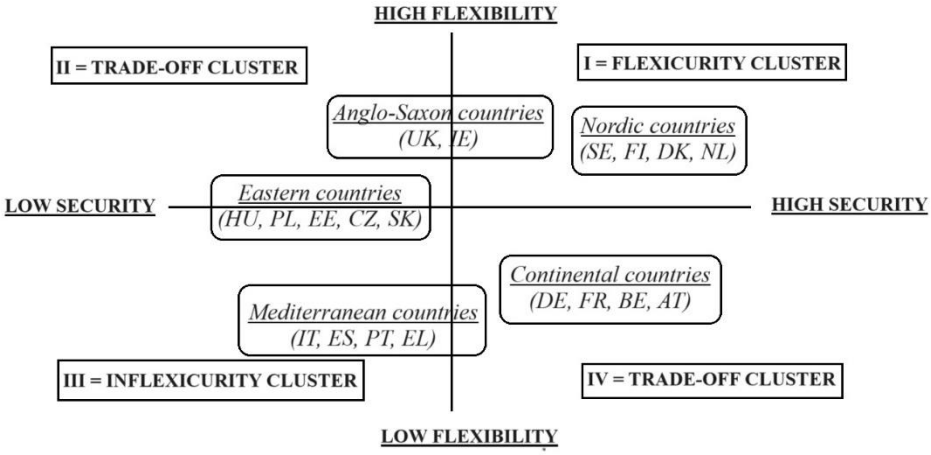


Figure no. 1 – The theoretical country grouping of flexicurity regimes
Source: Muffels and Wilthagen (2013)

To continue, several studies focus on identifying an empirical classification of European countries in relation to flexicurity. These studies are diverse in the flexicurity definition employed, the country sample, and the timeframe considered. Chung (2012) points out the existence of three main flexicurity frameworks used to classify country regimes in the literature, namely: the Wilthagen and Tros (2004) *flexicurity matrix*, the *Danish Golden Triangle* (Madsen, 2004), and the *European Commission's four components of flexicurity model (European Commission, 2007)*.

Firstly, Wilthagen and Tros (2004) flexicurity matrix differentiates between four forms of flexibility that allow for quick adjustments to economic conditions and enhance competition and productivity: numerical-external, numerical-internal, functional, and the flexibility of wage. The matrix also distinguishes four forms of security that improve social inclusion and labor market participation: job, employment, income, and combination security. Country groupings following Wilthagen and Tros (2004) flexicurity matrix include: Muffels and Luijkx (2008) that study the EU15 countries except for Sweden and utilize mixed data from 1994-2001; Auer (2010) that studies the EU15 countries excluding Luxembourg, and using mixed data from the mid-2000s; and lastly, Muffels and Wilthagen (2013) that study the EU25 countries along with Norway and Island, employing mixed data from the years 2005-2006.

Secondly, the Danish Golden Triangle flexicurity model has three components: flexible labor markets, generous welfare schemes, and active labor market policies (ALMP). Country groupings following the Golden Triangle model include: Chung (2012), which groups 17 European countries based on mixed data from 2005, 2007, and 2008; and Noja (2018), which clusters the CEE countries based on 2015 data. Lastly, the European Commission's four components of flexicurity model defines flexicurity as the combination of: flexible contractual arrangements, modern social security systems, active labor market policies, and lifelong learning strategies. Empirical works following the European Commission's four principles of flexicurity model include the development of composite indicators and cluster analysis. Thus, Manca *et al.* (2010) develop four composite indicators for the 22-27 EU countries for 2005[6]. Further on, Nikulin and Gawrycka (2021) recompute and aggregate these four indicators into one flexicurity index for the CEE countries for 2007 and 2013. Similarly, Ferent-Pipas and Lazar (2023) construct a flexicurity index for the EU27 countries in 2005, 2010, and 2015. Adopting the same flexicurity definition, Hastings and Heyes (2018) cluster 19 European countries in 2006 and 2011.

Chung (2012) notes that the three research frameworks put different weights on distinct aspects of flexicurity. For example, the active labor market policies and the lifelong learning strategies form a single dimension in the case of the Danish Golden Triangle model. However, the European Commission's four components of flexicurity model considers them as two distinct dimensions of flexicurity. Thus, it is expected that different researchers following different frameworks, obtain different results. However, Chung (2012) claims this is not a problem but a call for researchers to acknowledge the flexicurity definition adopted, in this way highlighting their study's underlying assumptions. The flexicurity index constructed in this paper follows the European Commission's four components of flexicurity model. Therefore, it assumes equal weights for flexibility, security, active labor market policies, and lifelong learning strategies. Moreover, as described in the 'Data and methods' section, the index's composition uses the taxonomy put forward by the European Commission (2007). This research approach is also seen in the previous works of Ferent-Pipas and Lazar (2023), and Nikulin and Gawrycka (2021).

3. DATA AND METHODS

3.1 Flexicurity index

Table no. 1 displays the structure of the flexicurity index following the taxonomy from European Commission (2007) and Manca *et al.* (2010). To compute the index, data for the years 2001 to 2019 are sourced from the European Commission's databases: DG Eurostat,

DG Employment, Social Affairs, and Inclusion, and DG Economic and Financial Affairs; and from the Organization for Economic Co-operation and Development's (OECD) statistics (for more details on data sources, see Annex A). Further on, the construction of the composite indicator involves data treatment, normalization, weighting, and aggregation, as described by Nardo *et al.* (2008) and Becker *et al.* (2019). Lastly, we introduce robustness checks based on the methodological directions of Saisana *et al.* (2005) and Nardo *et al.* (2008).

Table no. 1 – Flexicurity components – hierarchical structure

Index: Flexicurity | *subindex weight inside the flexicurity index: ¼*
Subindex 1: **flexible and reliable contractual arrangements (FCA)** [dimension weight inside FCA subindex: ⅓] Dimension 1: external flexibility Dimension 2: internal flexibility Dimension 3: combined flexibility
Subindex 2: **modern social security systems (MSSS)** [dimension weight inside MSSS subindex: ¼] Dimension 1: overall expenditure and coverage of unemployment benefits Dimension 2: amount and duration of unemployment benefits Dimension 3: financial incentives to take up a job Dimension 4: childcare services
Subindex 3: **active labor market policies (ALMP)** [dimension weight inside ALMP subindex: ⅓] Dimension 1: ALMP expenditure as percentage of gross domestic product Dimension 2: ALMP expenditure per participant Dimension 3: ALMP expenditure per person wanting to work
Subindex 4: **lifelong learning (LLL)** [dimension weight inside LLL subindex: ¼] Dimension 1: provision of continuing vocational training Dimension 2: participation in continuing vocational training Dimension 3: investment in continuing vocational training Dimension 4: participation in lifelong learning schemes

Note: basic variables composing each dimension are presented in Annex A.
Source: based on Manca *et al.* (2010)

To begin with, the first step in data treatment is detecting outliers. To do so, we start by signaling variables whose absolute skewness and kurtosis values exceed 2 and 3.5, respectively, as recommended by Becker *et al.* (2019). For each identified distribution[7], an assessment is made to determine whether the outlier is genuine or the result of a reporting/exporting error. Such errors are found by carefully examining the original time series. For example, a value about ten times greater/lower than the rest of the values in the series could indicate that the period was misplaced. By contrary, if all values of the same country are much greater/lower than the rest of the countries, this could be evidence of a genuine skewed distribution. Other ways of identifying reporting errors include ensuring that all countries report using the same measurement unit and cross-checking with other data sources for the same variable, if available. For current variables, the presence of outlying values is not attributed to any reporting or exporting error but to countries that perform

significantly better than the rest. We want to acknowledge these atypical statistical units in the index score and, as such, refrain from treating these outliers (Becker *et al.*, 2019).

Next, we use the same normalization scheme as Manca *et al.* (2010), that is min-max scaling:

$$x_{min-max_i} = \frac{x_i - min(x)}{max(x) - min(x)} \cdot 100$$

where: $x_{min-max_i}$= the min-max scaled value of x_i; $min\ (x)$ = the lowest value of variable *x*; $max\ (x)$ = the highest value of variable *x*.

Subsequently, following the weights and polarities set forth by Manca *et al.* (2010), we aggregate the min-maxed variables into dimensions and further into the four subindices. Prior to aggregating the dimensions into subindices, we test them for correlation (Table A5). Nardo *et al.* (2008) show that this is common practice to avoid double counting of variables when using equal weights and to minimize the number of variables to increase the index's transparency. However, they argue that relating correlation to the weighting scheme can prove dangerous, unless motivated by the relation of the highly correlated measures to the phenomenon captured by the index.

First, the correlations between the dimensions of the FCA subindex suggest that countries with high external and internal flexibility tend to achieve lower levels of combined flexibility. This is true for all of the 2001-2019 period in the case of internal flexibility. External flexibility, on the other hand, is negatively correlated with combined flexibility only in 2001, 2002, 2006, 2007, and 2011. The strength of the correlation between internal and combined flexibility increases in the last five years of analysis. Second, the 'Financial incentives to take up a job' dimension of the MSSS indicator is negatively (low or moderate) correlated with the other dimensions. This suggests that high levels of security might disincentivize citizens to take up a job. While generally the correlations among dimensions are lower or at similar levels as in 2005-2007 (when initially computed by Manca *et al.* (2010)), the correlation between 'Childcare services' and 'Amount and duration of individual unemployment benefits' increases continuously, until doubling in 2019. This is not a concern in the construction of the MSSS subindex since the two dimensions represent two very different faces of social security systems.

Third, all ALMP dimensions correlate positively, suggesting that a higher share of GDP directed towards ALMP spending also translates into greater spending per participant. The strength of these correlations is moderate or high. Except for the correlation between the first and the third dimension, the other correlations decrease in the next years compared to 2005-2007. In 2006, the correlation between 'Expenditure as percentage of GDP' and 'Spending/participants per person wanting to work' is 0.73. It decreases to 0.65 in 2007 and then increases to 0.89 in 2015, after which it starts decreasing again. Forth and last, all the LLL's dimensions correlate positively. The strength of these correlations is at similar levels to 2005. Therefore, this correlation analysis shows that in case of FCA and MSSS, countries have dissimilar behaviors in different dimensions, while in case of ALMP and LLL, they have similar performance across dimensions. Similar to Nikulin and Gawrycka (2021), we decide not to revise the weights based on correlation analysis.

Finally, each subindex undergoes min-max scaling and the flexicurity index is computed as:

$$Flexicurity\ Index_i = \frac{FCA_i + MSSS_i + ALMP_i + LLL_i}{4}$$

where: $Flexicurity\ Index_i$ = the flexicurity index score of country *i*; FCA_i = the flexible contractual arrangements subindex score of country *i*; $MSSS_i$ = the modern social security systems subindex score of country *i*; $ALMP_i$ = the active labor market policies subindex score of country *i*; and LLL_i = the lifelong learning subindex score of country *i*.

Final flexicurity index scores are presented in Table no. 2.

Table no. 2 – Flexicurity scores rounded – EU28 countries. 2001 to 2019

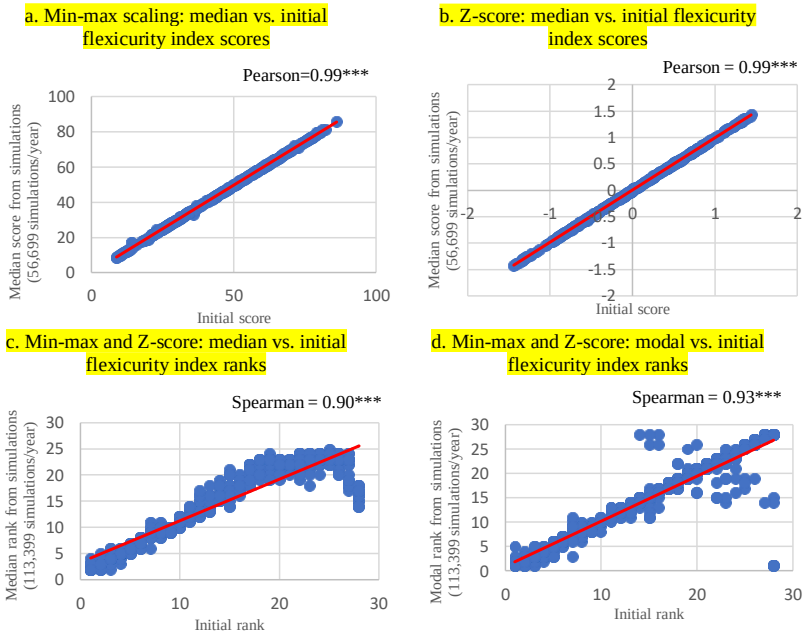
Year / Country	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
BE	65	64	62	62	61	64	68	71	75	70	69	70	69	69	66	70	69	69	69
BG	29	29	28	28	28	28	27	27	26	25	27	31	32	32	31	33	33	34	34
CZ	31	32	32	33	32	33	34	36	37	37	37	38	42	41	43	45	43	47	46
DK	77	78	78	79	76	86	77	79	80	80	81	80	80	79	79	77	77	76	80
DE	60	62	61	61	61	57	53	54	61	58	55	51	52	52	51	53	54	54	53
EE	36	36	35	35	34	36	37	37	46	42	39	33	32	31	31	34	37	49	48
IE	65	66	65	66	67	66	67	70	75	73	68	67	65	65	62	65	62	58	57
EL	31	31	31	29	26	27	28	29	35	29	27	25	22	22	20	24	23	23	28
ES	55	55	55	54	57	56	60	61	64	63	60	59	48	48	46	47	48	48	46
FR	76	76	77	76	77	78	79	80	82	80	77	77	77	78	76	78	77	75	76
HR	13	13	12	12	12	12	12	11	10	10	9	9	10	9	11	12	11	12	13
IT	45	44	44	42	43	40	42	43	47	43	43	43	44	46	50	55	52	46	43
CY	37	36	36	35	34	36	37	39	41	39	38	36	35	31	29	30	30	31	30
LV	21	22	21	22	22	21	19	20	22	22	19	18	20	21	22	26	28	29	28
LT	17	18	10	10	13	16	23	14	13	13	14	24	26	26	22	26	27	28	26
LU	57	59	67	67	74	72	75	67	62	61	60	63	63	62	59	66	68	65	64
HU	25	27	27	27	21	26	26	23	26	28	27	24	24	27	25	29	32	30	30
MT	47	46	45	44	44	39	42	47	45	44	44	45	47	47	42	46	47	45	45
NL	76	74	72	71	70	70	69	73	75	69	68	66	65	64	62	66	68	71	71
AT	52	53	54	49	51	53	51	51	56	53	51	50	51	52	51	54	52	51	50
PL	21	22	21	23	23	23	24	27	29	28	22	22	23	26	23	25	25	26	26
PT	60	58	53	53	54	58	58	62	69	67	63	61	60	60	57	57	57	58	56
RO	34	34	33	33	32	32	31	29	30	31	27	28	26	25	26	26	25	24	23
SL	42	43	43	44	44	44	41	40	47	44	43	43	44	43	41	44	42	42	38
SK	25	25	26	31	33	34	34	34	37	34	31	31	30	30	29	33	33	34	33
FI	59	59	60	61	61	61	60	61	63	60	59	59	60	60	60	62	61	60	60
SE	78	77	75	72	69	68	64	63	64	60	58	58	59	58	56	61	60	58	58
UK	51	52	52	52	52	49	48	49	51	48	48	48	49	49	48	50	49	50	48

Note: Year $= \overline{1,19}$ stands for Year $= \overline{2001,2019}$

3.2 Robustness analysis

Following the recommendations of Nardo *et al.* (2008), at this stage, we reconstruct the index: (1) excluding one variable per subindex at a time and (2) using Z-score instead of min-max scaling. The FCA subindex is composed of 17 variables. When excluding one variable at a time, we obtain 17 different FCA score simulations. Considering the variant that includes all variables, there are 18 possible scenarios. Similarly, the MSSS generates 21 possible score simulations; the ALMP generates 15 simulations; and lastly, for the LLL, we obtain 10 score simulations. All the possible combinations between the four subindices generate 56,700 possible flexicurity score simulations for each year in the sample, including the initial score. Subsequently, we Z-score the variables and recompute the flexicurity index scores. We repeat the inclusion-exclusion of variables simulations in this case. Finally, we rank countries based on all generated scenarios. Since there are two scaling methods, each with 56,700 simulations, this renders 113,400 alternative rankings each year, including the initial rank.

To assess the robustness of the flexicurity index scores and country ranks to these two methodological changes, we first compare initial scores and ranks against median and modal ones (e.g., Saisana *et al.*, 2005; Manca *et al.*, 2010). The robustness of the flexicurity index scores to the exclusion of variables is assessed in Figures no. 2a and 2b. First, Figure no. 2a presents the correlation between the initial flexicurity scores using min-max scaling and the median scores from the other 56,699 possible score simulations/year. Second, Figure no. 2b shows the correlation between initial and additional scores for Z-scoring. In both cases, the correlation between the median score and the initial one is 0.99, suggesting that the indicators' selection induces low variability in the flexicurity scores.



Note: *** represents statistical significance at 1% significance threshold.

Figure no. 2 – Initial Flexicurity scores/ranks against median/modal scores/ranks from simulations

To continue, to assess the robustness of the flexicurity scores to both the exclusion of variables and to the change in the scaling method, we compare country ranks across simulations. By providing a common scale, the ranks enable comparisons between the min-maxed flexicurity index and its Z-scored counterpart. Figures no. 2c and 2d plot the initial rank in the flexicurity index against the median and modal rank from the alternative simulations. Both correlate highly with the initial rank (0.90 and 0.93, respectively), suggesting that no deliberate bias is introduced in the index by either the choice of variables or the scaling method (e.g., Saisana and Saltelli, 2006).

Lastly, starting from the average shift in ranking formula of Nardo *et al.* (2008) (see Equation 1), we derive a more general average rank shift measure across all years, countries, and simulations (see Equations 2 through 4). On average, in the same year, a country shifts 2.75 ranks in ranking from the original ranking due to the choice of variables and the scaling method used. There are no well-defined thresholds or rules of thumb to justify this shift appropriate for a reliable composite indicator. Defining such thresholds at this point would be difficult since the measure is affected by the number and type of robustness checks undertaken by the researcher. However, given the increasing complexity of social and economic policies and the increased popularity of composite indicators as measurement tools, we consider it necessary for the end user (policy regulator, public) to acknowledge the possible deviation of a country from its original rank. In the present case, the upcoming analyses will mostly refer to the index scores and countries' positions in terms of quartiles while paying attention to scores close to each other. Thus, a less than 10% shift in ranking may have a negligible impact, if any, on the conclusions of this study.

$$\overline{R_S} = \frac{1}{M}\sum_{c=1}^{M}\left|Rank_{ref}(CI_c) - Rank(CI_c)\right| \quad (1)$$

$$\overline{R_{Country}} = \frac{1}{S}\sum_{i=1}^{S}\left|Rank_{ref}(CI) - Rank(CI_i)\right| \quad (2)$$

$$\overline{R_{Year}} = \frac{1}{M}\sum_{i=1}^{M}\overline{R_{Country_i}} \quad (3)$$

$$\overline{R_{Total}} = \frac{1}{Y}\sum_{i=1}^{Y}\overline{R_{Year_i}} \quad (4)$$

where: $\overline{R_S}$ = average shift in ranking; $Rank_{ref}(CI_c)$ or $Rank_{ref}(CI)$ = original rank given to the country by the original version of the index; $Rank(CI_c)$ = uncertainty output; M = number of countries; $\overline{R_{Country}}$ = country average shift in ranking in one year across all scenarios; $Rank(CI_i)$ = rank given to the country by the i[th] scenario of the index; S = number of scenarios; $\overline{R_{Year}}$= yearly average shift in ranking across all countries and all scenarios; $\overline{R_{Total}}$= average shift in ranking across all years, countries and scenarios; Y= number of years.

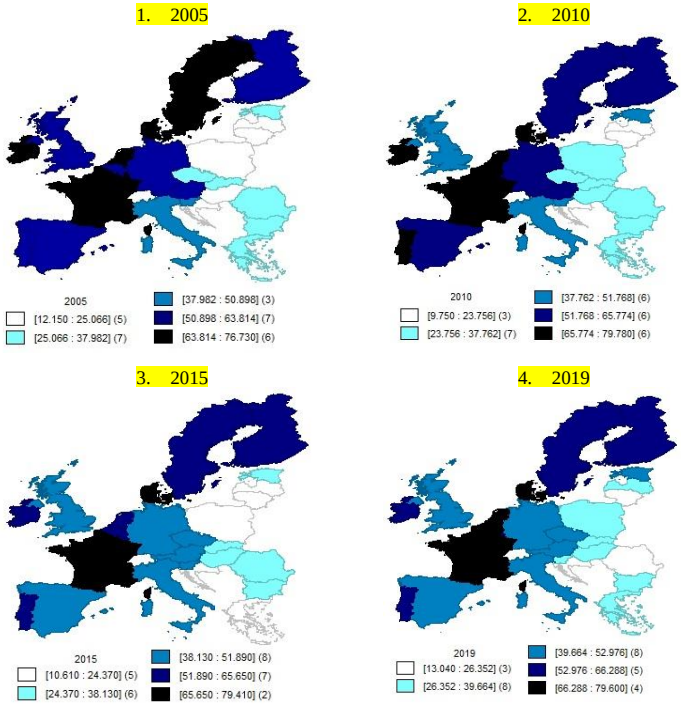
In the end, given that the correlation between the first and third dimension of ALMP increases in the years following Manca *et al.* (2010)'s computations and the rest of

correlations are moderate and high, we recompute the ALMP sub-index with equal weights for all variables (1/14). By doing this, we assume that all dimensions show the same face of ALMP. Further on, we recompute the flexicurity index with the new ALMP values. The new flexicurity index is highly correlated with the initial one (0.99), suggesting that the change in weights for the ALMP does not introduce deliberate bias in the index.

4. FLEXICURITY SCORES VERSUS OTHER FRAMEWORKS

4.1 Flexicurity scores and the theoretical flexicurity regimes

Figure no. 3 shows the spatial distribution of the flexicurity index scores. For space reasons, we only present the maps for 2005, 2010, 2015, and 2019. First, the figure shows the change in time of the EU28 countries' relative performance. For example, Portugal improves its performance in 2010 compared to 2005 (Figures no. 3a and 3b) and deteriorates in 2015 (Figure no. 3c). Spain also has lower scores in 2015 and 2019 than in the previous periods. Among Nordic countries, Denmark is always top performing, while Norway slightly decreases its performance in 2010 compared to 2005 (Figures no. 3a and 3b). Among Eastern countries, Romania has lower scores in 2019 compared to the previous snapshots. Lastly, the Anglo-Saxon countries have a lower performance in 2015 and 2019 compared to 2010 and 2005.



Note: Due to space limitations and to the large number of maps, this paper presents just these four snapshots. Visual representations of other periods can be easily produced based on the flexicurity scores in Table no. 2 or provided by the authors upon request.

Figure no. 3 – Flexicurity scores across the EU28 – Equal intervals maps for 2005, 2010, 2015, and 2019

As described at length in Section 2, the theoretical classification depicted by Muffels and Wilthagen (2013) suggests a spatial distribution of the flexicurity regimes. Thus, Southern countries (Italy, Spain, Portugal, and Greece) are inflexicure; Central countries (Germany, France, Belgium, Austria, and Luxembourg) are in the trade-off area; and the Northern ones (Sweden, Finland, Denmark, and the Netherlands) are flexicure. Also, Eastern countries (Hungary, Poland, Estonia, Czechia, and Slovakia) are inflexicure or closer to inflexicurity than their Western counterparts. A brief visual inspection (see Figures no. 3) suggests that Eastern countries have lower flexicurity scores than Western ones. However, the North-South distribution is not as apparent. Southern countries do not have a homogenous performance: Greece has low flexicurity values in all the years; Italy is an average flexicurity performer; and Spain and Portugal have average and top flexicurity scores. Exemptions from the theoretical typology are also seen in the case of France and Ireland, which are top performers similar to Denmark and the Nordic countries.

To test whether the spatial distribution assumption holds in the case of the flexicurity scores for the 2001-2019 sample, we run a linear regression of the following form for each year:

$$Flexicurity_i = \beta_0 + \beta_1 \cdot Latitude_i + \beta_2 \cdot Longitude_i + \varepsilon_i$$

where: $Flexicurity_i$ is the flexicurity score of country i; $Latitude_i$ and $Longitude_i$ are the latitude and the longitude coordinates of the central points of country i; and ε_i is the error term.

Table no. 3 presents the regression results for each year.

Table no. 3 - Regression results. Dependent variable: Flexicurity scores

Year	Intercept	Latitude	Longitude
2001	28.792 (0.147)	0.665 (0.101)	-1.126*** (0.000)
2002	27.310 (0.160)	0.697* (0.081)	-1.119*** (0.000)
2003	27.973 (0.168)	0.673 (0.105)	-1.126*** (0.000)
2004	25.963 (0.181)	0.715* (0.074)	-1.130*** (0.000)
2005	26.934 (0.162)	0.706* (0.075)	-1.178*** (0.000)
2006	24.989 (0.205)	0.748* (0.067)	-1.154*** (0.000)
2007	31.520* (0.090)	0.619 (0.101)	-1.172*** (0.000)
2008	36.955* (0.060)	0.538 (0.171)	-1.242*** (0.000)
2009	38.603* (0.54)	0.569 (0.155)	-1.282*** (0.000)
2010	38.069** (0.045)	0.526 (0.163)	-1.242*** (0.000)
2011	36.516 (0.056)	0.515 (0.177)	-1.212*** (0.000)
2012	35.306 (0.055)	0.529 (0.151)	-1.190*** (0.000)
2013	29.719 (0.104)	0.623* (0.094)	-1.128*** (0.000)
2014	29.168* (0.100)	0.633* (0.080)	-1.133*** (0.000)
2015	25.772 (0.138)	0.667 (0.062)	-1.099*** (0.000)
2016	27.040 (0.118)	0.694* (0.051)	-1.089*** (0.000)
2017	25.490 (0.137)	0.716** (0.044)	-1.055*** (0.000)
2018	21.183 (0.200)	0.787** (0.024)	-0.990*** (0.000)
2019	20.386 (0.232)	0.787** (0.029)	-0.964*** (0.000)

Note: ***, **, * represent statistical significance at 1%, 5% and 10%, respectively. P-values are reported in parentheses.

Firstly, latitude is positive, though not always statistically significant. These results suggest that, like the theoretical typology, the flexicurity scores generally increase from South to North – flexicurity countries are generally more Northern Europe, while Southern Europe

is inflexicure. However, the lack of or low statistical significance suggests that the difference between North and South is not as apparent every year. Secondly, in line with the theoretical typology and the expectations from Figure no. 3, the longitude is negative and statistically significant, suggesting that Eastern countries have lower flexicurity scores than Western ones.

4.2 Flexicurity scores and other empirical country groupings

We further discuss the flexicurity index scores and compare them with the similar time analysis of:

- Muffels and Luijkx (2008), Auer (2010) (*Wilthagen and Tros' flexicurity matrix*)
- Chung (2012), Noja (2018) (*Danish Golden Triangle*)
- Hastings and Heyes (2018) (*European Commission's four components of flexicurity*).

The study provides a descriptive comparison and an ANOVA analysis between the flexicurity index scores and each country classification. This might come as a non-orthodox approach since: (1) except for Hastings and Heyes (2018), all the other studies follow a different flexicurity framework than the one used in computing the flexicurity index; (2) the data used in the other studies does not always belong to one specific year; and (3) the sample size for the ANOVA analyses ranges between 10 to 18 countries. Therefore, the results of the following comparisons should be treated with caution. However, given the lack of previous comparative studies, these results could provide a descriptive starting point for future more elaborated research. It proposes a different way of looking at and reconciling the differences between distinct flexicurity frameworks.

4.2.1 Flexicurity scores in the early 2000s

To begin with, in 2001, the top 25% performers in the EU28 flexicurity scores are Belgium, Denmark, Ireland, France, the Netherlands, Sweden, and Germany. Germany is closely followed by Portugal, at less than 0.5 points. These results resemble Muffels and Luijkx (2008) country grouping. They use 1994-2001 data from the European Community Household Panel and focus only on respondents that are men. First, their findings suggest that Belgium, Denmark, Ireland, the Netherlands, Portugal, Austria, and the United Kingdom create the flexicurity cluster[8]. Auer and Chatani (2011) suggest that establishing clear borders and delimiting clusters when countries are close to borders is challenging. As such, the sample size and the border selection could explain the differences between the flexicurity scores and Muffels and Luijkx (2008) country grouping in the placement of Portugal, Germany, and Austria. While Germany and Portugal have close results in the flexicurity index scores, Muffels and Luijkx (2008) place Portugal in a flexicurity cluster and Germany in a trade-off cluster with a moderately low flexibility close to the flexicurity cluster's border. Similarly, Austria is placed in the flexicurity cluster, having a moderately high performance in both flexibility and security dimensions. In the case of our flexicurity index, Austria has an average performance placing in the third quartile.

To continue, the behavior of Mediterranean countries differs from the theoretical typology in both the flexicurity index scores and in the study of Muffels and Luijkx (2008). In contrast to the theoretical clusters, these countries do not show a similar performance. Thus, Greece and Italy are bottom performers and are greatly outperformed by Spain and Portugal.

Table no. 4 shows the ANOVA results between the 2001 flexicurity index scores and the Muffels and Luijkx (2008) country classification. The two frameworks have a medium-strength correlation (0.65). In addition to differences in the flexicurity framework used, the time dimension of the data used could also explain the differences in the two classifications. The flexicurity indicator relies on 2001 data only, while Muffels and Luijkx (2008) classification uses mixed data from 1994 to 2001. Moreover, Muffels and Luijkx (2008) data represent only men, while the flexicurity index accounts for the entire workforce.

Table no. 4 – ANOVA results: Flexicurity index scores and other country groupings

Study	Year study	Year flexicurity index	Sample size	ANOVA F-statistic (p-value)	Eta
Flexicurity framework: *Wilthagen and Tros' flexicurity matrix*					
Muffels and Luijkx (2008)	1994-2001	2001	14	2.377 (0.131)	0.65
Auer (2010)	Mid-2000s	Average 2004-2006	14	3.120* (0.075)	0.7
Flexicurity framework: *Danish Golden Triangle*					
Chung (2012)	2005-2008	2005	16	3.464** (0.046)	0.75
Noja (2018)	2015	2015	10	5.578** (0.036)	0.78
Flexicurity framework: *European Commission's four components of flexicurity*					
Hastings and Heyes (2018)	2006	2006	18	11.91*** (0.000)	0.91
Hastings and Heyes (2018)	2011	2011	18	7.682*** (0.003)	0.79

Note: ***, **, * represent statistical significance at 1%, 5% and 10%, respectively. P-values are reported in parentheses.

4.2.2 Flexicurity scores in the mid and late-2000s

The flexicurity index scores show that in the mid-2000s, Luxembourg, Slovakia, and Slovenia improve their performance while Germany and Greece deteriorate theirs. Otherwise, countries remain in the same performance quartile as in the early 2000s. We compare the flexicurity index scores with the country groupings of Auer (2010), Chung (2012), and Hastings and Heyes (2018). Among them, the study of Hastings and Heyes (2018) follows the *European Commission's four components of flexicurity* model. In 2006, they find that the Netherlands, Denmark, Belgium, France, Germany, Norway[9], Sweden, Austria, and Finland form a similar top-performing cluster. In 2006, the top 25% flexicurity index scores are those of the Netherlands, Denmark, Belgium, France, Sweden, Ireland, and Luxembourg[10]. They are followed by Austria, Germany, Finland, Portugal, Spain, and the United Kingdom, countries that are the top 50% performers. Further on, Hastings and Heyes (2018) group Slovakia, Czechia, Hungary, Italy, and Greece in a similar moderately low-performing cluster. The flexicurity index showcases them as the bottom 50% of countries. Lastly, Poland achieves a lower performance in the flexicurity index and forms a distinct group in Hastings and Heyes (2018) – an inflexible labor market with low spending on social security. Therefore, there is a general concordance between the 2006 flexicurity index scores and the Hastings and Heyes (2018) country grouping, the two frameworks being highly correlated – 0.91 (see Table no. 4).

Using mixed data from 2005, 2007, and 2008, Chung (2012) performs a flexicurity cluster analysis of 16 EU countries, following the *Danish Golden Triangle* flexicurity framework. Her country grouping correlates highly (0.75) with the 2005 flexicurity index scores (see Table no. 4). In 2005, the highest flexicurity scores are those of France, Denmark, the Netherlands, Sweden, Ireland, and Belgium. In 2007 and 2008, Sweden, Ireland, and Belgium exchange

positions, but otherwise, the hierarchy remains similar. Conversely, Chung (2012) clusters Denmark, Finland, the Netherlands, and Sweden as countries with high or medium to high performance in all the *Danish Golden Triangle*'s dimensions. France, Ireland, and Belgium, on the other hand, are grouped as countries with medium or medium to high performance. Further on, among the common sample, Poland, Greece, Czechia, and Italy are bottom performers in the flexicurity index in all three years. Except for Czechia, Chung (2012) classifies them as bottom performers in two or three of the *Danish Golden Triangle*'s dimensions.

Lastly, Auer (2010) provides a country grouping of flexicurity regimes for 14 EU countries for the mid-2000s. The study does not use data from one specific year to construct the country grouping. Therefore, as in the case of Muffels and Luijkx (2008) and Chung (2012), the difference in the time interval of the dataset poses one more challenge in comparing the two frameworks. Even so, there is a strong correlation (0.7) between Auer (2010) country grouping and the 2004-2006 average flexicurity index scores (see Table no. 4). They disagree in the performance of Spain and Portugal. Auer (2010) places the two countries in the same group as Italy and Greece, while the flexicurity index considers Spain and Portugal better performers than the other two Mediterranean countries. Using the same dataset as Auer (2010), Auer and Chatani (2011) also place Spain in a distinct cluster. Auer (2010) assigns Belgium, France, and Germany to the trade-off cluster of high security and low flexibility. However, all the countries are close to the flexicurity border. Conversely, the performance of these three continental countries in the flexicurity index is similar to the Nordic countries' performance.

To sum up, for the mid-2000s, the flexicurity index scores correlate highest with the country grouping of Hastings and Heyes (2018). Their study uses the same flexicurity framework as the index, data from one year, and a sample of 18 EU countries. In comparison, the correlations between the flexicurity index scores and the country groupings of Chung (2012) and Auer (2010) are lower but still moderately high. These studies are dissimilar to the flexicurity index in the adopted definition. Also, they use data from mixed years and have lower country sample sizes.

4.2.3 Flexicurity scores in the early and mid-2010s

There are two studies classifying EU countries' flexicurity regimes in the mid-2010s. First, Hastings and Heyes (2018) use data from 2011 and follow the *European Commission's four components of flexicurity* model. Second, Noja (2018) uses data from 2015 and clusters Central and Eastern European (CEE) countries based on the *Danish Golden Triangle*.

To begin with, the bottom 50% of countries (Slovakia, Czechia, Hungary, Italy, and Greece) remain unchanged in 2011 compared to 2006 in both the flexicurity index and in Hastings and Heyes (2018)'s cluster analysis. At the other end, the highest 50% flexicurity scores are those of Denmark, France, Belgium, the Netherlands, Ireland, Portugal, Spain, Luxembourg, Finland, Sweden, Germany, Austria, and the United Kingdom. In Hastings and Heyes (2018), Portugal and Spain form a distinct cluster along with Poland. Also, the United Kingdom remains an outlier. The similarity between the two frameworks decreases from 2006 but remains at a high 0.79 (see Table no. 4).

To continue, the flexicurity scores of the year 2015 are highly correlated (0.78) with the CEE clustering of Noja (2018) (see Table no. 4). Best CEE performers in the flexicurity index were Czechia and Slovenia. In Noja (2018), they perform high in security and have average performance in the rest of dimensions. Lowest flexicurity scores are those of Poland,

Lithuania and Latvia, countries that cluster together in the low security – medium to low flexibility and ALMP in the case of Noja (2018). Even though Hastings and Heyes (2018) and Noja (2018) follow different flexicurity definitions and focus on different country samples, their correlation to the flexicurity index is similar.

5. FLEXICURITY INDEX SCORES AND LABOR MARKET PERFORMANCE

European Commission (2007) sets the following flexicurity outcomes: the total employment rate, the employment rates of women and older workers, the youth and long-term unemployment rates, the labor productivity, and the at-risk of poverty rates (see variable definition and availability in Table B1). This section examines the correlation between the flexicurity index scores and these labor market outcomes. Besides a correlation analysis, we compare the labor market performance of the EU countries that scored highest in the flexicurity index (top 25% countries) with the lowest scores (bottom 25% countries). For simplicity, we split the 2001-2019 sample into five periods (four 5-year periods and one 4-year period). This last exercise is similar to the one performed by Auer (2010) for 2000-2005, except that instead of comparing 5-year averages, we compare median values. This avoids outliers impacting the mean measurement. Furthermore, while Auer (2010) compares the five flexicurity countries with the other 10 in his sample, we contrast the highest with lowest flexicurity scores' achievers, similar to Madsen *et al.* (2013). In line with the same authors, we present the scores obtained by each country in addition to the group's median score. This approach enables us to identify group heterogeneities, if any.

To begin with, the employment rates and the flexicurity scores are positively correlated (see Table no. 5a or Figure no. B1). When comparing top flexicurity performers to bottom ones in the employment rates, the highest difference is in the case of older workers: in the 2001-2005 period, the median employment rate of people aged 55-64 years is 1.65 times greater in high flexicurity countries compared to the low flexicurity ones (see Table no. 5a). However, this gap decreases to 1.11 and 1.12 times in the subsequent periods. It then increases to 1.28 times in 2016-2019 (Table no. 5b). The sharp decrease in 2006-2010 from 2001-2005, followed by a minor increase in 2016-2019, holds for the total employment rate and the employment rate of women. It's worth highlighting that Lithuania and Latvia stand out as the best performers in employment rates within the bottom 25% flexicurity group. They outperform the weakest rates in the top 25% flexicurity group, namely those of France, Ireland, Belgium, Luxembourg, and the Netherlands.

Further on, increased flexicurity scores are related to decreased youth and long-term unemployment rates (see Table no. 5a or Figure no. B1). However, France and Ireland (top flexicurity performers) have similar median values to Poland, Latvia, or Lithuania (bottom flexicurity performers). As seen in Table no. 5b, the relative difference between top and bottom flexicurity performers is significantly higher in 2006-2010 (-31%) and 2011-2015 (-37%) than in 2015-2019 (-17%). These two periods include the Global financial crisis of 2008-2009 and the European sovereign debt crisis of 2010-2013.

Table no. 5a – Median labor market outcomes for top and bottom flexicurity performers 2001-2005

Year	Countries		Median employment rate			Median unemployment rate		Median labor productivity	
			Total (20-64 years)	Women (20-64 years)	Older workers (55-64 years)	Youth (15-24 years)	Long-term	Per person employed	Per hour worked
Correlation with the flexicurity index			0.46***	0.36***	0.27***	-0.29***	-0.43***	0.81***	0.75***
2001-2005	Top 25%	Denmark	78.1	73.6	59.5	-	-	109.2	126.8
		France	69.2	63	36.3	22.3	28	120.2	132.3
		Ireland	70.8	59.8	49.2	-	-	140.8	126.1
		Netherlands	75.3	66.6	43.2	-	-	120.9	142.2
		Sweden	78.5	76.6	68.6	-	-	118.2	124.1
		Median	75.3	66.6	49.2	22.3	28	120.2	126.8
	Bottom 25%	Bulgaria	58.7	54.7	30.7	-	-	37	37.6
		Croatia	58.4	50.5	28	-	-	67.8	59.3
		Hungary	62	55.1	28.9	-	-	68.8	63.2
		Latvia	67.4	62.6	42.9	-	-	52.8	42.2
		Lithuania	69.6	65.3	46.7	-	-	55.7	49.1
		Poland	57.7	51.8	27.1	-	-	61.9	50.2
		Median	60.4	54.9	29.8	-	-	58.8	49.7
	Relative difference median		25%	21%	65%	-	-	104%	155%

Note: ***, ** represent statistical significance at 1% and 5%, respectively significance thresholds. For employment rates the sample is EU28 countries, 2001-2019. For unemployment rates the sample includes only the 2009-2019 period and excludes the UK. For productivity indicators the sample is EU28 without the UK, 2005-2019.

Table no. 5b – Median labor market outcomes for top and bottom flexicurity performers 2006-2019

Year	Countries		Median employment rate			Median unemployment rate		Median labor productivity	
			Total (20-64 years)	Women (20-64 years)	Older workers (55-64 years)	Youth (15-24 years)	Long-term	Per person employed	Per hour worked
2006-2010	Top 25%	Belgium	67.6	61	34.5	22.2	44	130.4	137.9
		Denmark	78.7	74.3	56	14.6	15.8	109.5	127.8
		France	69.5	64.9	38.2	23.5	27.4	117.9	128.2
		Ireland	73.4	63.3	53.1	26.3	39.1	138.3	126.7
		Netherlands	76.2	69.4	50	12	21.8	120.2	141.9
		Median	73.4	64.9	50	22.2	27.4	120.2	128.2
	Bottom 25%	Bulgaria	68.4	63.5	44.9	22.3	44.7	39.7	39.5
		Croatia	63.9	56.4	37.1	28.8	58.3	70.4	61.2
		Latvia	73.2	68.4	53.4	34.8	39.6	56.9	47.9
		Lithuania	71.3	68	51.2	32.7	33.3	62.5	54.5
		Poland	64.3	57.3	31.6	22.5	31.5	62.5	50.9
		Median	68.4	63.5	44.9	28.8	39.6	62.5	50.9
	Relative difference median		7%	2%	11%	-23%	-31%	92%	152%
2011-2015	Top 25%	Belgium	67.2	62.1	41.7	22.5	45.7	130.3	135.1
		Denmark	74.7	71.2	58.8	14.8	27.6	115	132.8
		France	69.4	65.5	45.6	25.8	28.9	116.4	125.5
		Ireland	66.5	61.3	51.2	26.7	59.5	143.3	140.9
		Netherlands	76.4	70.6	59.2	12.9	32.3	113.6	132.6
		Median	69.4	65.5	51.2	22.5	32.3	116.4	132.8

Year	Countries		Median employment rate			Median unemployment rate		Median labor productivity	
			Total (20-64 years)	Women (20-64 years)	Older workers (55-64 years)	Youth (15-24 years)	Long-term	Per person employed	Per hour worked
	Bottom 25%	Croatia	59.2	53.6	37.8	42.3	65.8	73.3	64.1
		Hungary	63	56.9	37.9	25.4	48	73.4	69.3
		Latvia	69.7	67.7	54.8	23.2	53.8	63.2	53.8
		Lithuania	69.9	68.6	53.4	21.9	45.1	73.2	63.6
		Median	66.4	62.3	45.7	24.3	50.9	73.3	63.9
	Relative difference median		5%	5%	12%	-7%	-37%	59%	108%
2016-2019	Top 25%	Belgium	69.1	64.6	49.3	17.7	45.7	129.5	133.7
		Denmark	77.1	73.6	68.7	11.4	22.4	115.9	136.3
		Finland	75.3	73.5	64	18.9	34.3	108.2	110.4
		France	71	67.2	51.8	22.8	31.1	115.4	124.3
		Luxembourg	71.8	67.8	40.2	16.2	31.5	167.5	181
		Netherlands	78.6	73.5	66.7	9.7	32.6	110.3	125.2
		Median	73.5	70.6	57.9	17	32.1	115.6	129.4
	Bottom 25%	Croatia	64.4	59.2	41.6	25.6	42	74.6	66.9
		Greece	58.7	48.6	39.7	42.9	64.3	72.4	57.8
		Lithuania	76.9	76.1	67.3	12.6	35.5	75.9	65.9
		Poland	71.6	64.3	48.6	13.4	29.6	75.9	61.4
		Median	68	61.8	45.1	19.5	38.7	75.3	63.6
	Relative difference median		8%	14%	28%	-13%	-17%	54%	103%

Next, labor productivity shows the strongest correlation with the flexicurity index scores: 0.81 and 0.75 in the case of labor productivity per employee and labor productivity per hour worked, respectively (see Table no. 5 or Figure no. B2). In the beginning period (2001-2005), the median labor productivity per hour worked is 2.55 times higher in the top 25% flexicurity countries than in the bottom group, while the median per person employed productivity is 2.04 times greater (see Table no. 5a). In the last analyzed period (2016-2019), the per-hour difference decreases to 2.03 times, and the per-person one to 1.54 times (see Table no. 5b).

To continue, in terms of poverty rates, we examine: the in-work at-risk of poverty rate (in-work AROP), the at-risk of poverty and social exclusion rate (AROPE), the at-risk of poverty rate, severe material and social deprivation rate (SMSD), and lastly, the share of population living in households with very low work intensity. Data on these indicators are available only from 2005 in case of AROP and in-work AROP, and from 2015 onwards in case of the rest. Except for the low work intensity variable, all poverty-related indicators are negatively correlated with the flexicurity index scores (see Table no. 6 or Figure no. B2). Nevertheless, Croatia, a bottom flexicurity performer seems to have similar poverty values to the ones of the top 25% flexicurity countries. Lastly, the gap in (in work) at-risk of poverty rates and severe material and social deprivation rates increases slightly in the 2016-2019 period from 2011-2015.

Table no. 6 – Median poverty rates for top and bottom flexicurity performers

Year	Countries		Median poverty rates				
			In-work AROP	AROPE	AROP	SMSD	Low Work Intensity
Correlation with the flexicurity index (sample: EU28 countries)			-0.32***	-0.48***	-0.50***	-0.48***	0.20***
2011-2015	Top 25%	Belgium	4.5	21.6	15.3	7.2	15
		Denmark	5.5	18.6	12.1	3.2	11.9
		France	7.8	18.4	13.7	6.8	8.3
		Ireland	5.4	25.4	16.2	9.4	18.8
		Netherlands	5	16.4	11	3.2	10
		Median	5.4	18.6	13.7	6.8	11.9
	Bottom 25%	Croatia	6	24.4	20	8.4	12.3
		Hungary	6.7	30.6	14.9	24.1	8.8
		Latvia	8.9	30	19.4	15.4	7.7
		Lithuania	9.1	29.4	19.2	14.6	9.1
		Median	7.8	29.7	19.3	15	9
	Relative difference median		-31%	-37%	-29%	-55%	33%
2016-2019	Top 25%	Belgium	4.9	21.3	15.7	6.9	13.8
		Denmark	5.7	17.5	12.5	3.6	10.3
		Finland	3	16.3	11.6	1.9	11.3
		France	7.4	18.3	13.5	6.7	7.6
		Luxembourg	11.2	19.7	16.6	1.8	6.7
		Netherlands	5.9	16.5	13.2	2.6	9.2
		Median	5.8	17.9	13.4	3.1	9.7
	Bottom 25%	Croatia	5.4	22.8	19.4	6.6	10
		Greece	12	31.3	19.4	17.2	14
		Lithuania	8.3	29.2	22.4	13.2	9.3
		Poland	9.8	18.5	15.2	4.9	5.8
		Median	9.1	26	19.4	9.9	9.6
	Relative difference median		-36%	-31%	-31%	-69%	1%

Note: AROP = At-risk of poverty rate; AROPE = At-risk of poverty and social exclusion rate; SMSD = Severe material and social deprivation rate (for full definitions and measurements see Annex - Table no. B1). ***, ** represent statistical significance at 1% and 5%, respectively significance thresholds. For AROP and in-work AROP the sample is EU28 countries, 2005-2019. For the other indicators the sample includes only the 2015-2019 period.

Finally, flexicurity scores show a positive low-strength correlation with people living in households with very low-work intensity (see Table no. 6). This correlation indicates that increased flexicurity scores correspond to an increased share of the population (aged 0-64) living in households where the adults (aged 18-64) worked 20% or less of their total work potential during the past year. The gap between the countries in the top compared to the bottom flexicurity quartiles decreases notably in the 2016–2019-time interval compared to 2011-2015: initially, the top flexicurity countries have 1.33 times greater median low work intensity rate; however, in 2016-2019, the median rate is almost similar to the one in the bottom flexicurity countries (only 1.01 times greater). To get some quick insights on the possible source of these results, we check the correlation between the low work intensity rate and the share of population part-time work because they could not find a full-time job. It is 0.52. We discuss some policy implications in the ending section of this article.

To sum up, the gap in labor market performance between top and bottom flexicurity performers tends to narrow from 2001 to 2019. The labor market productivity shows the highest correlation with the flexicurity index. All other selected labor market indicators show low or moderate correlations of expected signs: positive in the case of employment rates and negative in the case of unemployment and poverty rates. The low-work intensity rate is negatively correlated to flexicurity. All correlations are statistically significant at 1% or 5% significance thresholds and there is generally a more than 10% gap in labor market performance between top and bottom flexicurity countries. However, in some cases, bottom flexicurity countries match or outperform the values of top countries in selected labor market indicators.

6. FINDINGS AND DISCUSSIONS

This article aimed at constructing a flexicurity index, comparing its scores with the theoretical flexicurity typologies and with the other flexicurity country groupings in the literature, and lastly, producing a comparative analysis of performance in flexicurity index scores and selected labor market and social outcomes. In regard to the main aim of this paper, the flexicurity index is computed for the EU28 countries for the 2001-2019 period following the European Commission's four components of flexicurity model. Methodologically, the index is robust to the choice of variables and the standardization method used. In line with Hastings and Heyes (2018), the index scores show that the flexicurity regimes are dynamic, and countries change their typology over time.

To continue, when comparing the flexicurity index scores with the theoretical flexicurity typologies described by Muffels and Luijkx (2008) and Muffels and Wilthagen (2013), we find that for the entire analyzed period, Eastern countries have significantly lower flexicurity scores than their Western counterparts. This finding is in line with the theoretical framework. However, some dissimilarities arise further from the comparative analysis. First, some Continental countries (France and Belgium) scored similarly to the Nordic ones. Second, even though, not consistent for all the years, the Anglo-Saxon and the Iberian countries, particularly Ireland and Portugal, show similar flexicurity scores with the Nordic countries, as well. Thus, the flexicurity index agrees with Muffels and Luijkx (2008) and Hastings and Heyes (2018) in that Continental countries and Ireland are high flexicurity achievers instead of theoretical compromisers of either flexibility or security. They also agree that Portugal and Spain deviate from their theoretical Mediterranean cluster, characterized as inflexicure.

Further on, a comparative analysis shows that the flexicurity index scores share similarities with the other flexicurity country groupings proposed in the literature. Despite the methodological dissimilarities between the flexicurity index and the country groupings – the flexicurity definition, the choice of variables, and the methods - the five country groupings reviewed correlate moderately high (0.65-0.91) with the flexicurity index. It seems that the highest correlations are in the case of country groupings using the same flexicurity definition (European Commission's four components of flexicurity model), followed by the Danish Golden Triangle, and lastly, by the Wilthagen and Tros' flexicurity matrix. Moreover, the correlation is higher with country groupings that use data from one single year, instead of mixed years' data. These comparisons with previously validated country groupings strengthen the robustness of the index and suggest that it captures well the essence of flexicurity.

Lastly, regarding labor market performance, descriptive statistics show that, generally, countries that score highest in the flexicurity index also have better labor market performance.

Hence, the strongest correlation with the flexicurity index is in the case of labor market productivity. Even though lower, differences in median employment and unemployment rates still favor the high flexicurity countries. The labor market performance gap between high and low flexicurity countries is narrower in 2016-2019 compared to 2001-2005. To continue, high flexicurity achievers are better performers in the case of poverty rates as well. In this case, the gap does not change much throughout the analyzed period. Top flexicurity countries perform worse at low work intensity rates than the bottom flexicurity ones. However, the gap narrows to 1% in 2016-2019.

7. CONCLUSIONS AND POLICY IMPLICATIONS

The main contribution of this paper is providing a much-needed long-term flexicurity measure for the EU28 countries. Once more, the European Commission promoted a policy that attracted conversation around it but failed to deliver a coherent statistical discourse. This caused confusion and controversy around the subject. From 2007 to 2020, researchers focused more on critiquing the vagueness of the term (Calmfors, 2007), understanding the state and the future of the policy (Bekker, 2018), or explaining and defining the concept (Chung, 2012) than on assessing its strengths and its weaknesses - justified since flexicurity's main weakness is the poor communication of its definition. As a result, flexicurity was apparently abandoned without any conclusive remarks on its performance. Thus, we reinforce Saltelli *et al.* (2011) recommendations and stress the need for translating EU policy into indicators to enable continuous benchmarking and progress monitoring.

Therefore, promoting and monitoring a consistent EU-level measure increases the policy's visibility and fosters evidence-based policymaking. It facilitates a clear understanding of the policy's aims and bases changes and recommendations on statistical figures and estimations. These build trust in the EU's promoted policies and bring support from other actors. In addition to the active engagement of citizens and institutions in EU programs, having a coherent statistical framework allows researchers to contribute with their assessments, analyses, and policy recommendations. Moreover, while gathering data for constructing the flexicurity composite indicator, we struggled with identifying the data sources for the constituent variables. Even though the variables are agreed on and put forward in the European Commission (2007) and are afterward used by Manca *et al.* (2010), they are not part of an integrated database. They are not even in the same data portal, some variables being stored by Eurostat, others by other European Commission's Directorates. We thus end our recommendations for improved evidence-based policy making with having a single portal to store all EU data. Such a change gives researchers easy access to the data related to different EU policies, minimizing the time and effort spent in data gathering, and increasing their focus on the data analysis and research implications stages. This ultimately benefits the EU and its Member States since more research and of better quality can be dedicated to the EU policy.

The rest of this paper's objectives further strengthen these policy recommendations and bring additional implications, which we discuss next. First, the high correlation between a flexicurity indicator constructed based on the initial set of variables set by the European Commission (2007) and the other five country groupings in the existing literature suggests that a good enough measure for flexicurity benchmarking can be computed. Second, countries deviating from the theoretical flexicurity typologies indicate that the flexicurity index should be monitored and updated regularly to provide adequate policy advice. The same policy

implication results from countries changing performance in the flexicurity index over time. The use of the theoretical framework or of measures constructed for one point in time when analyzing the long-term performance or change in time of labor market outcomes inside the EU countries can provide misleading or confusing results. Moreover, having a long-term measure in place, changes in policy recommendations can be justified based on data.

Had there been a sound statistical framework already set in place by the European Commission, the research of other stakeholders could have focused more on the implications of flexicurity, generating a richer understanding of whether the last decade's flexicurity efforts attained their goals and whether externalities existed. This is beyond the scope and possibilities of this article. However, we can hint at some brief policy recommendations from the comparative analysis between flexicurity and labor market outcomes as a first use case of the flexicurity index. The analysis is correlational and not causational. Thus, further investigation is needed to understand whether flexicurity efforts enhance labor market and social outcomes or if countries that successfully adopted flexicurity had better labor market and social outcomes beforehand. Except for the low work intensity rate, all the analyzed variables are better off in the case of high flexicurity countries, suggesting that further causational investigation can unveil interesting results with important policy implications.

Therefore, it seems that flexicurity could have been a means to reach Europe 2020's goals of increased employment, productivity, and social cohesion. Among all, the high positive correlation between labor productivity and flexicurity strikes most, supporting the European Commission (2007) assumption that the costs of the flexicurity efforts are offset by the increased productivity rates. Even though, as described in the Introduction section, neither the employment nor the at-risk of poverty rate explicit targets were met, flexicurity may have contributed to getting closer to them. Reducing poverty among EU citizens remains a top priority in the Europe 2030 strategy. Had flexicurity been constantly monitored in previous years, it could have been part of the new strategy.

Since the retirement ages are similar or even higher in top flexicurity countries compared to bottom ones, the big difference in unemployment rates of older employees can be due to the better-performing insertion mechanisms of the high flexicurity countries. Also, the significantly better performance of top flexicurity countries in the two crisis periods could suggest that these mechanisms were subject to austerity measures in the case of low flexicurity countries. Should a causational relation be established, flexicurity efforts should increase in low-performant countries, particularly in the case of Croatia, Greece, or Poland, where are both the lowest flexicurity scores and the lowest employment rates of older people. Investments in effective reinsertion mechanisms for older people become more important in the context of an aging European population in a period of rapid social and technological change.

The positive correlation between the flexicurity index scores and the low work intensity rate opens an interesting and lengthy discussion. Some countries with low flexicurity scores, such as Croatia or Greece, have higher low-work intensity rates than the Netherlands, France, Luxembourg, or Denmark, but these are exemptions rather than the norm. An important policy question here is: should this be a concern, and if yes, under which circumstances? To begin with, the correlation is low. Moreover, it seems that the gap between high and low-flexicurity countries narrows significantly in the last years of the analysis. Therefore, had flexicurity remained a policy interest in the EU, the main recommendation forward would have been to continue to monitor the relation between flexicurity and the low-work intensity rate. It might be that the positive correlation becomes non-significant in the future due to the apparent decreasing rate of top flexicurity countries.

To continue, since flexicurity is also positively correlated with employment rates, higher low-work intensity rates in higher flexicurity countries could suggest that flexicurity eases people's access to jobs, but these jobs are not their full work time potential. This assumption is backed by the positive correlation between the low work intensity rate and the share of involuntary part-time employees. A first implication of this finding is that penalizing countries for the involuntary part-time rate in the flexicurity index should remain in the index's future versions.

Secondly, without social benefits, such an indication could lead to precarious living conditions. The (in-work) at-risk of poverty rates and the severe material and social deprivation rate are negatively correlated with the flexicurity scores. Since these rates are computed after social transfers, future research could investigate whether low work intensity rates are compensated by generous social benefits in the case of high flexicurity countries. Such research could clarify if flexicurity settings lead to increased employment rates at the expense of involuntary part-time and increased social benefits. If so, given the highly positive correlation of flexicurity with labor productivity, a last future research question is: do the increased productivity rates net out the incurred social benefits? Otherwise, the findings of this paper, facilitated by the flexicurity index, seem to encourage the integration of flexicurity for better labor market and social outcomes.

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ANNEXES

Annex A – Data and methods

Table no. A1 – Components of the Flexible Contractual Arrangements (FCA) subindex

	Variable	Source	Polarity	Weight
	Dimension 1: External flexibility			
	Data availability: 2001-2019			
1.1.	Fixed term contracts rate	Eurostat	+	1/18
1.2.	Involuntary fixed term contracts rate	Eurostat	-	1/18
1.3.	Self-employment rate	Eurostat	+	1/18
1.4.	Strictness of rules: regular contracts	OECD.Stat	-	1/18
1.5.	Strictness of rules: temporary contracts (versus regular contracts)	OECD.Stat	+	1/18
1.6.	Strictness of rules: collective dismissals	OECD.Stat	-	1/18
	Dimension 2: Internal flexibility			
	Data availability: 2001-2019; for (*) is 2014			
2.1.	Part-time work rate	Eurostat	+	1/15
2.2.	Involuntary part-time work rate	Eurostat	-	1/15
2.3.	Share of employees for whom overtime is main reason for actual hours worked being different from usual hours worked (*)	Eurostat	+	1/15
2.4.	Share of employees for whom variable hours is the main reason for actual hours worked being different from usual hours worked (*)	Eurostat	+	1/15
2.5	Irregular working times			
	2.5.1. Evening work rate	Eurostat	+	1/75
	2.5.2. Night work rate (*)	Eurostat	+	1/75
	2.5.3. Saturday work rate	Eurostat	+	1/75
	2.5.4. Sunday work rate	Eurostat	+	1/75
	2.5.5. Shift work rate	Eurostat	+	1/75
	Dimension 3: Combined flexibility			
	Data availability: 2001-2019			
3.1.	Inactivity due to lack of suitable care services for children and other dependents	Eurostat	-	1/6
3.2.	Part-time work due to lack of suitable care services for children and other dependents	Eurostat	-	1/6

Note: Dimension 2 is composed of five variables (part-time work, involuntary part-time work, overtime, variable working hours, and irregular working times), each receiving a 1/5 weight in the dimension (1/15 in the sub-index). Irregular working time is further composed of five measures: share of workers doing evening, night, Saturday, Sunday, and shift work. As such, each one of these five variables are weighted 1/25 in dimension 2 (1/75 in the FCA sub-index).

Source: based on Manca *et al.* (2010); Nikulin and Gawrycka (2021); Ferent-Pipas and Lazar (2023)

Table no. A2 – Components of the Modern Social Security Systems (MSSS) subindex

	Variable	Polarity	Weight
	Dimension 1: Overall spending and coverage of unemployment benefits		
	Data availability: 2001-2019		
	Data source: D.G. Employment, Social Affairs & Inclusion		
1.1.	Share of people wanting to work receiving out-of-work income support	+	1/12
1.2.	Expenditure on out-of-work income maintenance	+	1/12
1.3.	Expenditure on out-of-work income maintenance per person wanting to work	+	1/12
	Dimension 2: Financial incentives to take up a job		
	Data availability: 2001-2019		
	Data source: D.G. Economic and Financial Affairs		

	Variable	Polarity	Weight
2.1.	Unemployment trap (67% gross earnings of an average worker, single person)	-	1/20
2.2.	Unemployment trap (67% gross earnings of an average worker, one-earner couple with 2 children)	-	1/20
2.3.	Inactivity trap (67% gross earnings of an average worker, single person)	-	1/20
2.4.	Inactivity trap (67% gross earnings of an average worker, one-earner couple with 2 children)	-	1/20
2.5.	Inactivity trap (67% gross earnings of an average worker, two-earner couple with 2 children)	-	1/20
	Dimension 3: Amount and duration of individual unemployment benefits		
	Data availability: 2001-2019		
	Data source: D.G. Economic and Financial Affairs		
3.1.	Net replacement rate after 6 months (67% gross earnings of an average worker, single person)	+	1/24
3.2.	Net replacement rate after 12 months (67% gross earnings of an average worker, single person)	+	1/24
3.3.	Net replacement rate after 60 months (67% gross earnings of an average worker, single person)	+	1/24
3.4.	Net replacement rate after 6 months (67% gross earnings of an average worker, one-earner couple with 2 children)	+	1/24
3.5.	Net replacement rate after 12 months (67% gross earnings of an average worker, one-earner couple with 2 children)	+	1/24
3.6.	Net replacement rate after 60 months (67% gross earnings of an average worker, one-earner couple with 2 children)	+	1/24
	Dimension 4: Childcare services		
	Data availability: 2001-2019		
	Data source: D.G. Eurostat		
	... 1-29 hours per week		
4.1.	0 to 2 years	+	1/36
4.2.	3 years to compulsory school age	+	1/36
4.3.	Compulsory school age to 12 years	+	1/36
	... 30 hours or more per week		
4.4.	0 to 2 years	+	2/36
4.5.	3 years to compulsory school age	+	2/36
4.6.	Compulsory school age to 12 years	+	2/36

Note: Dimension 4 relates to combination security (work-life balance security). It makes a distinction between childcare services of 1-29 hours a week and those of 30 or more hours. Since the latter allow combining a full-time work schedule with family life, they are weighted double in the dimension.

Source: based on Manca *et al.* (2010); Nikulin and Gawrycka (2021); Ferent-Pipas and Lazar (2023)

Table no. A3 – Components of the Active Labor Market Policies (ALMP) subindex

	Variable	Polarity	Weight
	Dimension 1: Expenditure as percentage of GDP		
	Data availability: 2001-2019		
	Data source: D.G. Employment, Social Affairs & Inclusion		
1.1.	Expenditure on labor market services	+	1/18
1.2.	Expenditure on training services	+	1/18
1.3.	Expenditure on employment incentives	+	1/18
1.4.	Expenditure on supported employment and rehabilitation	+	1/18
1.5.	Expenditure on direct job creation	+	1/18
1.6.	Expenditure on start-up incentives	+	1/18
	Dimension 2: Spending per participant in millions of euros		
	Data availability: 2001-2019		
	Data source: D.G. Employment, Social Affairs & Inclusion		
2.1.	Spending per participant on training services	+	1/15

	Variable	Polarity	Weight
2.2.	Spending per participant on employment incentives	+	1/15
2.3.	Spending per participant on supported employment and rehabilitation	+	1/15
2.4	Spending per participant on direct job creation	+	1/15
2.5.	Spending per participant on start-up incentives	+	1/15
	Dimension 3: Spending/participants per person wanting to work		
	Data availability: 2001-2019		
	Data source: D.G. Employment, Social Affairs & Inclusion		
3.1.	Spending per person wanting to work on labor market services	+	1/9
3.2.	Spending per person wanting to work on training, employment incentives, supported employment and rehabilitation, direct job creation, and start-up incentives	+	1/9
3.3.	Share of participants receiving training, employment incentives, supported employment and rehabilitation, direct job creation, or start-up incentives over total number of persons wanting to work	+	1/9

Source: based on Manca *et al.* (2010); Nikulin and Gawrycka (2021); Ferent-Pipas and Lazar (2023)

Table no. A4 – Components of the Lifelong Learning (LLL) subindex

	Variable	Polarity	Weight
	Dimension 1: Percentage of firms providing continual vocational training		
	Data availability: 2005, 2010, 2015		
	Data source: D.G. Eurostat		
1.1.	Share of enterprises providing continual vocational training	+	1/7
	Dimension 2: Participation in continual vocational training		
	Data availability: 2005, 2010, 2015		
	Data source: D.G. Eurostat		
2.1.	Share of employees participating in continual vocational training		
	2.1.1. Men	+	1/14
	2.1.2. Women	+	1/14
2.2.	Hours in continual vocational training per employee	+	1/7
	Dimension 3: Investment in continual vocational training		
	Data availability: 2005, 2010, 2015		
	Data source: D.G. Eurostat		
3.1.	Share of cost with continual vocational training from total labor cost	+	1/7
3.2.	Direct cost of continual vocational training per employee	+	1/7
3.3.	Labor cost of participants in continual vocational training per employee	+	1/7
	Dimension 4: Participation in lifelong learning		
	Data availability: 2001-2019		
	Data source: D.G. Eurostat		
4.1.	Share of population aged 25-64 participating in education and training over the four weeks prior to the survey		
	4.1.1. Men	+	1/14
	4.1.2. Women	+	1/14

Note: Variables that refer to the total population receive a 1/7 weight. Variables that are gender disaggregated receive a 1/14 weight for each gender.

Source: based on Manca *et al.* (2010); Nikulin and Gawrycka (2021); Ferent-Pipas and Lazar (2023)

Table no. A5 - Pearson's correlation between dimensions

Flexible contractual arrangements			
	Dimension 1: External flexibility	*Dimension 2: Internal flexibility*	*Dimension 3: Combined flexibility*
Dimension 1: External flexibility	1	[0.12; 0.27]	[-0.13; 0.09]
Dimension 2: Internal flexibility	[0.12; 0.27]	1	[-0.42; -0.19]
Dimension 3: Combined flexibility	[-0.13; 0.09]	[-0.42; -0.19]	1

Modern social security systems				
	Dimension 1: Overall spending and coverage of unemployment benefits	*Dimension 2: Financial incentives to take up a job*	*Dimension 3: Amount and duration of individual unemployment benefits*	*Dimension 4: Childcare services*
Dimension 1: Overall spending and coverage of unemployment benefits	1	[-0.53; -0.3]	[0.37; 0.64]	[0.27; 0.43]
Dimension 2: Financial incentives to take up a job	[-0.53; -0.3]	1	[-0.57; -0.29]	[-0.46; -0.23]
Dimension 3: Amount and duration of individual unemployment benefits	[0.37; 0.64]	[-0.57; -0.29]	1	[0.08; 0.68]
Dimension 4: Childcare services	[0.27; 0.43]	[-0.46; -0.23]	[0.08; 0.68]	1

Active labor market policies			
	Dimension 1: Expenditure as percentage of GDP	*Dimension 2: Spending per participant in millions of euros*	*Dimension 3: Spending/participants per person wanting to work*
Dimension 1: Expenditure as percentage of GDP	1	[0.43; 0.71]	[0.64; 0.89]
Dimension 2: Spending per participant in millions of euros	[0.43; 0.71]	1	[0.46; 0.76]
Dimension 3: Spending/participants per person wanting to work	[0.64; 0.89]	[0.46; 0.76]	1

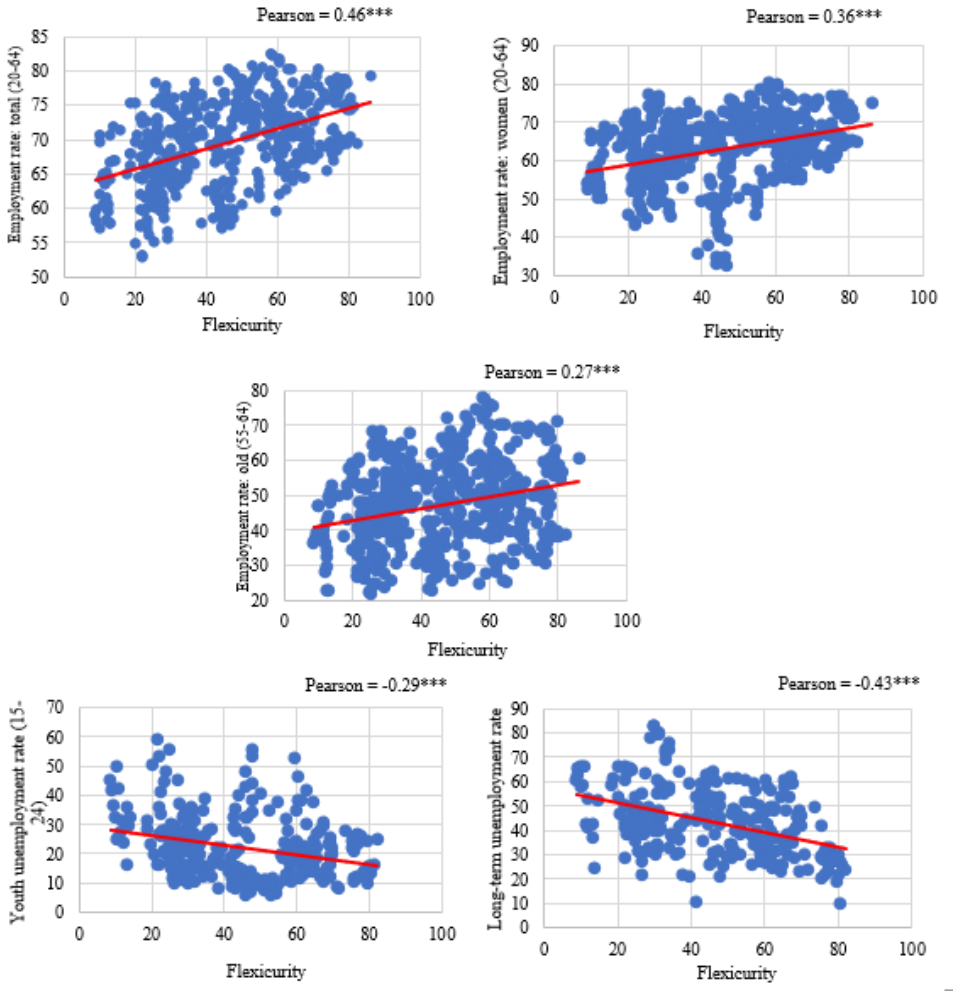
Lifelong learning				
	Dimension 1: Percentage of firms providing continual vocational training	*Dimension 2: Participation in continual vocational training*	*Dimension 3: Investment in continual vocational training*	*Dimension 4: Participation in lifelong learning*
Dimension 1: Percentage of firms providing continual vocational training	1	[0.71; 0.76]	[0.72; 0.8]	[0.68; 0.77]
Dimension 2: Participation in continual vocational training	[0.71; 0.76]	1	[0.8; 0.91]	[0.4; 0.51]
Dimension 3: Investment in continual vocational training	[0.72; 0.8]	[0.8; 0.91]	1	[0.4; 0.58]
Dimension 4: Participation in lifelong learning	[0.68; 0.77]	[0.4; 0.51]	[0.4; 0.58]	1

Note: In squared brackets are the minimum and the maximum Pearson's correlation coefficients during the 2001-2019. Yearly correlation values are available upon request

Annex B – Evaluating labor market performance

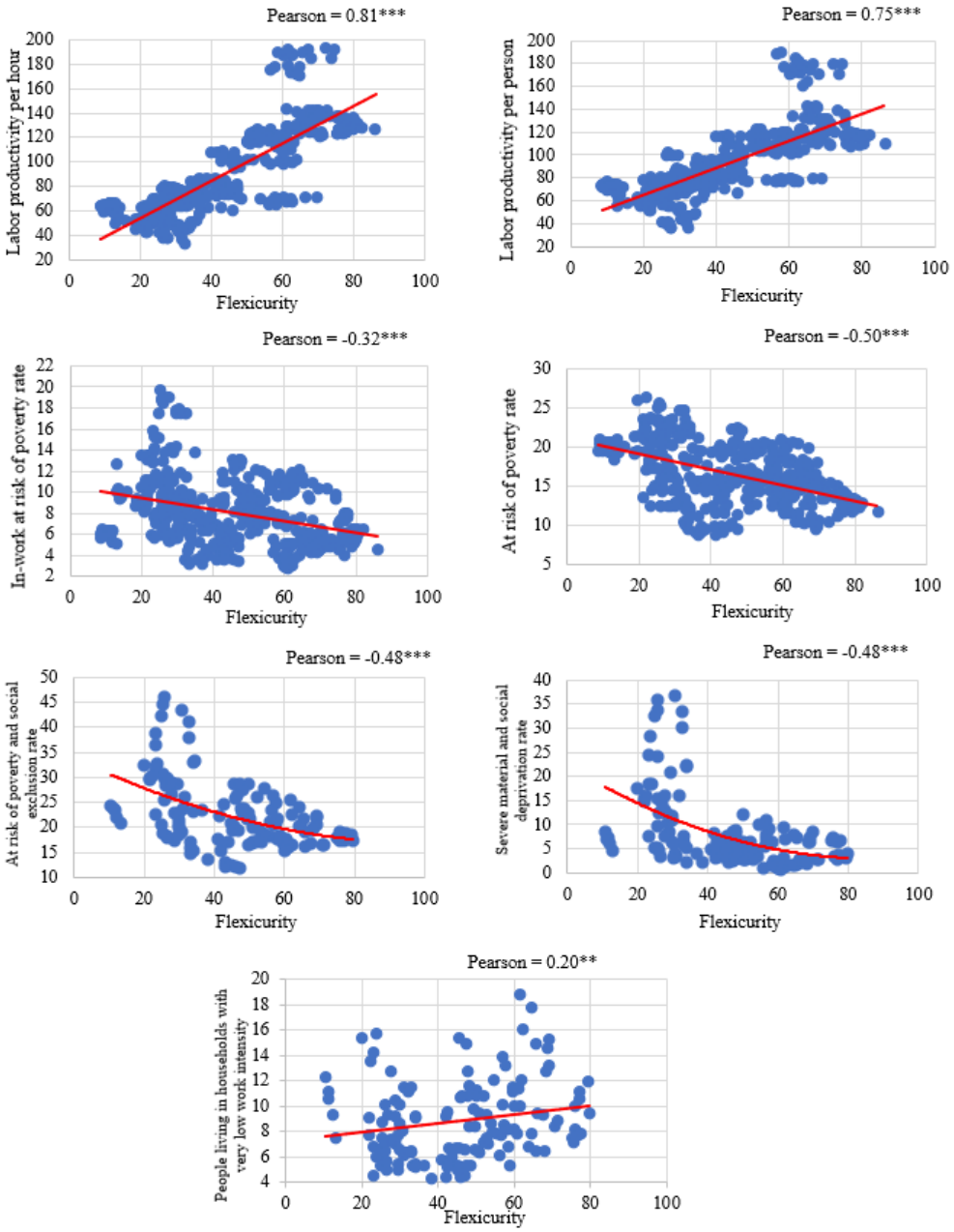
Table no. B1 – Labor market performance indicators

Variable	Measurement	Availability
Employment rate, total	% active population aged 20-64	2001-2019 (missing: Croatia 2001)
Employment rate, women	% active population aged 20-64	2001-2019 (missing: Croatia 2001)
Employment rate, older workers	% active population aged 55-64	2001-2019 (missing: Croatia 2001)
Youth unemployment rate	% active population aged 15-24	2009-2019 (UK missing completely)
Long-term unemployment rate	% unemployed population aged 20-64	2009-2019 (UK missing completely)
Labor productivity per person employed	% EU27 (from 2020) total (based on million purchasing power standards), current prices	2005-2019 (UK missing completely)
Labor productivity per hour worked	% EU27 (from 2020) total (based on million purchasing power standards), current prices	2005-2019 (UK missing completely)
In-work at-risk-of-poverty rate	Share of employed population aged 18 and over with an equivalized disposable income below 60 % of the national median equivalized disposable income (after social transfers)	2005-2019 (missing: Bulgaria, Croatia, and Portugal 2005; Croatia 2006; UK 2019)
People at risk of poverty or social exclusion (AROPE)	Share of population either at risk of poverty, or severely materially or socially deprived, or living in households with very low work intensity	2015-2019 (missing: UK2019)
At-risk-of-poverty rate (AROP)	Share of population with an equivalized disposable income below 60% of the national median equivalized disposable income (after social transfers)	2005-2019 (missing: Bulgaria, Croatia, and Portugal 2005; Croatia 2006; UK 2019)
Severe material and social deprivation rate (SMSD)	Share of population that cannot afford 7 or more of the following: i) pay rent or utility bills; ii) keep home adequately warm; iii) face unexpected expenses; iv) eat meat, fish or a protein equivalent every second day; v) a week holiday away from home; vi) have access to a car/van for personal use; vii) replace worn out furniture; viii) replace worn-out clothes with some new ones; ix) have two pairs of properly fitting shoes; x) spend a small amount of money each week on oneself; xi) have regular leisure activities; xii) get together with friends/family for a drink/meal at least once a month; and xiii) have an internet connection	2015-2019 (missing: UK 2019)
People living in households with very low work intensity	Share of population aged 0-64 living in households where the adults (aged 18-64) work 20% or less of their total work potential during the past year	2015-2019 (missing: UK 2019)



Note: *** represents statistical significance at 1% significance threshold. For employment rates the sample is EU28 countries, 2001-2019. For unemployment rates the sample includes only the 2009-2019 period and excludes the UK.

Figure no. B1 – Correlation between flexicurity index scores and employment and unemployment rates



Note: ***, ** represent statistical significance at 1% and 5%, respectively significance thresholds. For productivity indicators the sample is EU28 without the UK, 2005-2019. For AROP and in-work AROP the sample is EU28 countries, 2005-2019. For the other poverty rates the sample includes only the 2015-2019 period.

Figure no. B2 – Correlation between flexicurity index scores and labor productivity and poverty indicators

Notes

[1] People with an equivalized disposable income below 60 % of the national median equivalized disposable income (after social transfers).

[2] In 2010 there were 81 million people at-risk of poverty inside the EU27_2007 (2007-2013). In 2018 there were 85 million people at-risk of poverty inside the EU27_2007 (2007-2013). For 2019 and 2020, the at-risk poverty rate is computed only for EU27_2020 (72 and 73 million people, respectively).

[3] Manca *et al.* (2010) computed the flexicurity sub-indices for selected EU27 countries: FCA -2005 to 2008; MSSS -2005 to 2007; ALMP -2005 to 2007; LLL -2005.

[4] (EMCO, 2009) has been previously criticized by Dominguez-Torreiro and Casubolo (2017) and De Pedraza Garcia *et al.* (2018) mix input, process and output variables in creating their sub-indices.

[5] In the Web of Science collection, at the time of writing this paper.

[6] 2005 is the only year available for all four flexicurity components. Manca *et al.* (2010) computed and made available the scores for FCA for 2005-2008, MSSS for 2005-2007, and ALMP for 2004-2007. LLL is only available for 2005.

[7] This was the case of 7 variables, namely: LMP expenditure: cat.4, Employment incentives; LMP expenditure: cat.5, Supported employment and rehabilitation; LMP expenditure: cat.6, Direct job creation; LMP expenditure: cat.7, Start-up incentives; LMP services (cat 1): spending per person wanting to work; LMP measures (cat 2-7): spending per person wanting to work; and Expenditure on out-of-work income maintenance per person wanting to work.

[8] Sweden is not part of the empirical analysis of Muffels and Luijkx (2008).

[9] Norway is not part of our sample.

[10] Luxembourg is not part of Hastings and Heyes (2018) sample.

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DEA-Based Malmquist Productivity Indexes for Assessing Greek Tourism Regions

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Abstract: For this research project, a DEA-based Malmquist index model was built to evaluate the effectiveness and productivity of Greece's thirteen distinct tourist zones. The purpose of this article is to present a statistical analysis comparing the economic performance of different tourist locations in Greece. It does this by using a technique known as data envelopment analysis (DEA), which measures the Malmquist efficiency of the tourist sector in each of Greece's thirteen regions for the years 2017-2021. According to the findings of our study, the level of competitiveness enjoyed by a number of Greece's areas has not increased throughout the period under review. Our study approach and results give a reference for places in Greece that urgently need quick tourist growth to affect economic recovery. This need arises against the background of global climate change, the energy crisis, and the age that follows COVID-19.

Keywords: Malmquist productivity indexes; efficiency; tourism; Greek regions; regional analysis.

JEL classification: C43; R19; Z32.

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1. INTRODUCTION

The growth of tourism in Greece, which is one of the country's most important industries and has a strong multiplier impact on the economy (Brida *et al.*, 2016; Kolokontes *et al.*, 2018; Comerio and Strozzi, 2019; Nunkoo *et al.*, 2020) has been directly correlated with the country's recent economic success (Brida *et al.*, 2016; Comerio and Strozzi, 2019; Nunkoo *et al.*, 2020). The country's tourism sector had significant growth over the last ten years as a result of continued high levels of appeal as a vacation destination and major improvements in infrastructure that was directly related to tourism. Alongside the greater growth in worldwide tourism, the number of arriving visitors and travel revenues quadrupled throughout the period of 2010-2019 (Bank of Greece, 2019), thereby largely absorbing the extended recessionary shock caused by the post-debt Greek crises of 2010. The number of tourists that arrive is growing, the length of time they stay has not decreased much, the amount of money they spend each day has remained relatively stable, and the number of countries that generate a substantial amount of tourism is expanding. On the other hand, admissions continue to be at historically high levels, daily expenditure is low when compared to international norms, and the majority of demand is still directed toward the same heritage destinations (OECD, 2020b). On the other hand, the fact that the Greek economy is so heavily reliant on the travel and tourist industry makes it particularly susceptible to disruptions from the outside world, such as the pandemic problem that has been unfolding in recent years.

As a result of the COVID-19 epidemic and the significant disruption it brought to the economy of the whole world, the tourist industry is facing a number of new issues. Greece went through a severe economic downturn in the year 2020, which was substantially worse than the average for the OECD. This was mostly attributable to the country's high level of reliance on the tourist industry. The unusual demand-side shock that was induced by travel bans and containment efforts was a prominent feature of the coronavirus pandemic (Scott *et al.*, 2019). This extraordinary demand-side shock resulted in a precipitous and significant decrease in the number of tourists who visited the affected areas. According to the OECD's projections for 2020, travel revenues only amounted for 19% of the total service receipts, which meant that they only covered the trade deficit by 23%. It is important to highlight, however, that the year 2019 was a record-breaking year for tourism in Greece, as the nation was visited by 31.3 million visitors, which resulted in earnings of 18.2 billion euros from tourism. According to OECD (2020a), the unexpectedly large number of tourists who traveled to Greece during the peak summer months of 2021 was a major contributor to the robust recovery of GDP, which reached 8.3%. This new trend was quite like what occurred during the last economic crisis in Greece, when the country relied heavily on tourism to weather the storm and keep its economy afloat. Because of the large number of tourists who visited Greece in the first year after COVID-19, the country's gross domestic product (GDP) was able to recover from the negative effects of the event nearly completely (-9% in 2020). According to the projections for the year 2022, there will be a significant improvement. When compared to the same months of 2021, tourism-related income in 2022 was up 224.5% in June and 329.3% overall from January to June.

Tourism tends to become a competitive activity among areas, which are compelled to improve their performance in order to attract more visitors and boost their earnings (Pearce, 1997; Alavi and Yasin, 2000; Dwyer *et al.*, 2000; Ritchie and Crouch, 2000; Enright and Newton, 2004). Many people today view a tourist destination (such as a city, region, or site) not

as a collection of distinct natural, cultural, or environmental resources, but rather as an overall appealing product that is available in a specific area. This product is defined as a comprehensive and integrated portfolio of services provided by an area of interest that supplies holiday experiences that satisfies the requirements of the tourist (Ritchie and Crouch, 2001).

A tourism site thereby develops a compound bundle of tourist services based on the indigenous supply potential of the destination itself (Buhalis, 2000; Murphy *et al.*, 2000; Giaoutzi and Nijkamp, 2006; Gaki *et al.*, 2013; Giannakis and Bruggeman, 2017). It is crucial for the industry and the government to understand how and why competitiveness is shifting (Alavi and Yasin, 2000; Giaoutzi and Nijkamp, 2006). It is beneficial for the industry to understand where a country's competitive position is weakest and strongest (Kolokontes *et al.*, 2020). The flourishing growth of the tourist industry in Greece may be attributed to both the country's wonderful nature and the enormous demand for its products. In addition, the most successful companies have a significant impact on the industry by serving as a model for other businesses to follow. Therefore, conducting an analysis of the operational effectiveness of the tourism regions in Greece and gaining an understanding of the differences between the various types of tourism companies that operate in regions can provide the foundation for the improvement of those regions' operational efficiency as well as the development of additional small and medium-sized businesses (Chatzitheodoridis and Kontogeorgos, 2020).

By focusing on the competitiveness of tourist destinations and assessing regional competitiveness in terms of technical effectiveness and total factor productivity (TFP), the current research seeks to make a distinctive contribution to the existing body of tourism literature. This contribution revolves around a specific aspect: destination competitiveness. While the majority of tourism effectiveness studies typically consider statistical units like hotels and restaurants, our investigation is centered on territorial regions, also known as tourist destinations. This article employs major production theory methods to apply Data Envelopment Analysis (DEA), providing a performance measure for Greek tourist districts. Notably, the incorporation of the Malmquist index in our research enables the identification of primary contributors to variations in efficiency. This approach takes our inquiry a step further in evaluating the success of tourist locations. Utilizing a combination of the DEA model and the Malmquist index, the study conducts both static and dynamic analyses of operational efficiency values for tourism companies across thirteen regions in Greece from 2017 to 2021. The findings reveal operational weaknesses in these companies and offer recommendations for enhancing the operational effectiveness of Greek tourism regions.

Section 2 provides an in-depth exploration of the existing literature. Following this, Section 3 outlines the methodology for estimating efficiency and productivity changes. The findings and their discussion are then presented in Section 4, leading to the summarization of conclusions in the final Section.

2. LITERATURE REVIEW

Regarding the study of how effective the tourism industry is, researchers initially concentrated on the highly competitive hotel industry (Charnes *et al.*, 1978; Morey and Dittman, 1995; Barros, 2004; Chiang *et al.*, 2004; Barros, 2005; Barros and José Mascarenhas, 2005; Karakitsiou *et al.*, 2007) then extended to the branch industries such as travel agencies (Sun and Lu, 2005; Fuentes, 2011); and travel transportation Recent years have seen the development of a number of regional applications of frontier analysis in different areas of the

economy (Farrell, 1957; Macmillan, 1986; Charnes *et al.*, 1989; Martić and Savić, 2001; Susiluoto and Loikaanen, 2001; Zhu, 2002).

The efficiency of hotel companies has been a subject of extensive research, particularly through the application of Data Envelopment Analysis (DEA). Johns *et al.* (1997) pioneered DEA to monitor and benchmark productivity in a chain of 15 hotels, sparking subsequent applications globally. In Portugal, Barros (2005) assessed overall and technical efficiency in state-owned Pousadas de Portugal hotels. Barros and Santos (2006) used DEA to measure economic efficiency in 15 Portuguese hotels, proposing managerial enhancements. Oliveira *et al.* (2013) explored factors like star ratings and golf courses on hotel efficiency in Algarve. French hotel chains were evaluated by Perrigot *et al.* (2009), revealing plural form chains as more efficient. Botti *et al.* (2009) corroborated this using DEA with different inputs. Taiwanese hotel industry efficiency has seen extensive study. Tsaur (2001) analyzed 53 international tourist hotels. Hwang and Chang (2003) found international franchise-chains more efficient. Lovell (2003) and Huang *et al.* (2014) continued this exploration, applying DEA and Malmquist indices. Few studies focus on hotel and restaurant efficiency. Sanjeev (2007) measured the efficiency of 68 Indian establishments, revealing efficiency patterns within the largest and smallest companies using a variable return to scale framework. The literature on regional-level application of the DEA approach is limited. Pulina *et al.* (2010) examined hotel sector efficiency across 20 regions in Italy identifying Lombardy and Molise, Piedmont, and Umbria as the most efficient regions. Barros *et al.* (2011) employed a two-stage DEA to assess the competitiveness of French tourism regions, revealing significant efficiency variations. Toma (2014) utilized DEA to analyze the efficiency of the hotels and restaurants sector in all eight Romanian regions, employing two separate constant return to scale and variable returns to scale input-oriented analyses. The inputs considered were diverse, encompassing the number of employees and investments, while the output remained consistent—the turnover of the hotel and restaurant sector in each region. These studies collectively underscore the importance of examining efficiency at the regional level within the context of the hotel and tourism industry. The diverse methodologies employed and the varied geographical contexts considered contribute to a nuanced understanding of regional efficiency disparities and underscore the need for further exploration in this domain. As we move forward in this paper, we build upon this foundation to investigate and analyze the efficiency of tourist destinations, drawing upon both regional and sector-specific insights.

The majority of researchers make use of Data Envelopment Analysis (DEA) when conducting efficiency evaluations (Farrell, 1957; Morey and Dittman, 1995; Crouch and Ritchie, 1999; Ritchie and Crouch, 2000; Habibov and Fan, 2010; Oliveira *et al.*, 2013). Additionally, researchers have investigated the possibility of combining traditional DEA with other methods, such as the Malmquist index (Simar and Wilson, 1999; Zhu, 2002).

There is a lack of research on tourist provinces that have their own unique features, according to Giaoutzi and Nijkamp (2006). Existing studies have undertaken valuable investigations on the efficiency of tourism. The disparity that now exists between the rates of tourist development in the various areas of the country is rapidly spreading, and the issue is becoming more apparent. Considering the brisk economic expansion and policies that are beneficial to tourism, the provinces have taken a variety of steps to improve their ability to compete in the tourist industry. However, tourism, which is dependent on inputs of both capital and labor, can effectively drive regional economic development in the short term. However, in the long term, it will lead to the overexploitation of natural resources and an excess of human

resources (Mavrommati and Migdalas, 2005; Karakitsiou *et al.*, 2007; Chen *et al.*, 2018; Norio, 2021; Mavrommati *et al.*, 2022). Furthermore, even though it is becoming more widespread, the tourist industry is still plagued by poor development levels and unequal growth across areas. The primary objective of this research is to conduct a comprehensive evaluation of the operational efficiency exhibited by tourist destinations. This evaluation encompasses an in-depth analysis of the destinations' capacity to judiciously utilize the resources at their disposal. The central focus is on attracting a significant share of the overall demand from tourists while concurrently upholding a competitive stance relative to their most prominent rivals within the tourism industry. Through a nuanced examination, this study seeks to unravel the intricate dynamics that contribute to the effectiveness of tourist destinations in meeting the demands of the tourism market and positioning themselves strategically in a competitive landscape.

3. EFFICIENCY AND PRODUCTIVITY CHANGE ESTIMATES: METHODOLOGY

The study aims to contribute to the understanding of the economic performance of Greece's tourist zones over a specific time period, emphasizing the need for quick tourist growth to facilitate economic recovery. The broader context of global challenges, such as climate change and the aftermath of the COVID-19 pandemic, is also considered in framing the urgency of addressing tourism competitiveness in the highlighted regions. From a methodological viewpoint, this work estimates the regions' technical efficiency scores by using DEA and changes in productivity by using the Malmquist index. DEA's ability to handle multiple inputs and outputs, its non-parametric nature, and its flexibility in orientation make it well-suited for efficiency assessments in the complex and diverse landscape of the tourism sector. Researchers and practitioners in the tourism industry often choose DEA for its versatility and adaptability to the industry's multifaceted nature.

3.1 Data Envelopment Analysis (DEA)

The Decision-Making Units (DMUs) are the organizations or entities which are responsible for the translation of inputs into outputs. The DEA is based on a ratio of efficiency known as Outputs/Inputs. The purpose of the DEA is to achieve the highest possible ratio of efficiency for each DMU that is being taken into account (DMUo). The DEA approach lets researchers build a deterministic, non-parametric production frontier comparing the performance of several Decision-Making Units (DMUs), which in our case are the Greek regions (Eastern Macedonia and Thrace, Central Macedonia, Western Macedonia, Thessaly, Epirus, the Ionian Islands, Western Greece, Central Greece, Peloponnese, Attika, the Islands of Northern Aegean, the Islands of Southern Aegean and Crete).

The axial distance between each DMU in relation to the border is used as a basis for computing the scores for technical efficiency. We have used Farrell's (1957) output-oriented model and believed Variable Returns to scale (VRS) (Banker *et al.*, 1984). The purpose of the VRS hypothesis is to obtain pure technology efficiency (PTE), with the proviso that the effects of scale effectiveness on technology efficiency are not taken into consideration. Consequently, the formula for technology efficiency (TE) is pure technological efficiency (PTE) divided by scale efficiency (SE). Let's say there are r DMUs, and each of them has m inputs and n yields; the notation xj and yj will be used to denote the inputs and outputs, respectively.

$$\min \theta - \varepsilon \sum_{i=1}^{m} s_i^- + \varepsilon \sum_{z=1}^{n} s_z^+$$

s.t.

$$\sum_{j=1}^{r} x_{jj+}\, s_i^- = \theta \chi_0$$

$$\sum_{j=1}^{r} y_{jj} - s_z^+ = y_0$$

$$\sum_{j=1j}^{r} = 1$$

$$j \geq 0, s^-, s^+ \geq 0$$

ε is the Non-Archimedean infinitesimal, θ is the operational efficiency value of DMU, s−, s+ are slack variables. When θ = 1 and s_i^- = 0, s_z^+= 0, the DEA of this DMU is valid; when θ < 1, the DEA of this DMU is invalid.

3.2 Malmquist index

The Malmquist index (MPI) is a method (Malmquist, 1953) for assessing shifts in productivity and decomposing them into their main elements (Färe *et al.*, 1992; Färe *et al.*, 1994; Lambert, 1999; Alavi and Yasin, 2000; Lovell, 2003; Wendong *et al.*, 2012). This method has been utilized in a variety of fields, including, for instance, education, energy efficiency, tourism, and health care.

This index is used in the process of computing the ratio of outputs to inputs at various intervals (Färe *et al.*, 1992; Grosskopf, 2003). assuming that data on only one input (x) and output (y) are available for analysis throughout two different time periods (t and t+1). The MPI gives us the ability to evaluate, for each observed unit, how the actual production at period t (or t+1) compares to the potential production that might have been achieved in period t +1 (or t). In other words, we are able to assess two separate Malmquist indices due to the fact that we have two distinct technologies, namely, the technology that existed in period t and the technologies in period t+1. The following is the method that is used to determine the MPIs:

$$MPI^t = \frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)}$$

and

$$MPI^{t+1} = \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)}$$

Using the geometric mean of the alternative expression of MPI^t and MPI^{t+1}, we obtain:

$$MPI^{t,t+1}\,(x^t, y^t, x^{t+1}, y^{t+1}) =$$

$$\left[\frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})}, \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}} * \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)}$$

x^t stands for the input vector in period t; x^{t+1} stands for the input vector in t+1 period;
y^t stands for the output vector in period t; y^{t+1} stands for the output vector in t+1 period;
D^t stands for the function of distance in period t when the technology in period t is taken as the reference;
D^{t+1} stands for the function of distance in period t+1 when the technology in period t+1 is taken as the reference.

The Malmquist productivity index is now the $MPI^{t,\,t+1}$ value; this value is used for measuring the overall efficiency change. According to Malmquist (1953), increases in production are indicated by scores for the Malmquist index that are greater than 1. The Malmquist index is constructed using the components in the form of distance ratios. This first factor, which depicts changes in efficiency from time t to time t+1 and is known as Effectiveness Change or Increase in Efficiency (EFF), is an example of a component. The second factor is commonly referred to as Technological Change or Shift in Tech (TECH), and it is a representation of the transition of technology from the previous frontier to the new frontier that takes place between time t and time t+1. In specifically, the first component, which is denoted by the letter EFF, is a representation of a region's capability to get to the frontier in the time t using the inputs of period t+1. Therefore, this index demonstrates the capacity of a tourist zone to make use of the resources that will be accessible at time t+1, while assuming that the circumstances that existed at time t will remain the same (Wendong *et al.*, 2012). The technological change component, abbreviated as TECH, reflects an increase in regional production as measured relative to the frontier at time t as measured relative to the present situation. This component, for the sake of our research, indicates the capacity of a Greek tourist area to reorganize the operation of its business, that is, to exploit the inputs at time t+1 in a new manner, therefore either enhancing or deteriorating its position in regard to the border at time t. In light of the information presented above, the Total Factor Productivity (TFP) between time t and time t+1 may be recalculated by making use of the product of the change in efficiency and the change in technology. The Malmquist TFPCH index is decomposed into technological effectiveness (EFFCH) improvement and advancement in technology change (TECHCH) in the context of the VRS assumption. The first option may be broken down even further into two subcategories: pure technological efficiency improvement (PECH) and scale effectiveness change (SECH). That is:

$$MPI^{t,t+1} = TFP^{t,t+1} = EFF^{t,t+1} * TECH^{t,t+1} =$$

$$= PECH^{t,t+1} * SECH^{t,t+1} * TECHCH^{t,t+1}$$

If the score of the Malmquist TPF index is greater than one, it implies that the level of total factor productivity of the decision-making unit t+1 period is higher when compared to the level of productivity seen in the period that came before it. If the value of the Malmquist TFP index is 1, it shows that the total factor productivity has remained stable between the two time periods. If the value of the Malmquist total factor productivity index is less than one, this indicates that total component productivity has decreased.

3.3 Index Selection and Data Source

The assessment of the productive capacity of the tourist industry in Greece was carried out based on information gathered for all 13 of the country's regions during the course of a period of five years (2017–2021). The quality of the findings acquired via the application of the DEA analysis is dependent on the quality of the data, particularly in the case of the use of economic data. The Hellenic Statistical Authority, the Institute of Greek Tourism Confederation (INSETE), and the Research Institute for Tourism (RIT) all contributed data to this study, which we utilized. It is important to point out that all of the data comes from the official financial accounts of the tourist units. These statements have been prepared in compliance with the laws of both Greece and Europe, which means that they adhere to international accounting standards.

Eastern Macedonia and Thrace, Central Macedonia, Western Macedonia, Thessaly, Epirus, the Ionian Islands, Western Greece, Central Greece, Peloponnese, Attika, the Islands of Northern Aegean, the Islands of Southern Aegean, and Crete are the thirteen areas that makeup Greece. Crete is the largest island in the Aegean Sea. Each area was analyzed as if it were a DMU, which is the entity that is being assessed based on its capabilities to transform inputs into outputs. For the purpose of putting the DEA into practice, the following categories of inputs were chosen number of local units, number of personnel, and investments (total assets). The following categories of output were chosen revenues and net profits.

Land, capital, and labor force are the three elements that contribute most significantly to production in economics. The land is not considered to be one of the most essential requirements for the establishment of tourist businesses; hence, its presence is not reflected in the input variable index. The manner in which all of the assets are put to use will have a direct bearing on the progression of future development in the area. For the purpose of illustrating capital investment, this study uses the aggregate assets held by tourist businesses in each geographical area. The tourist business is one that relies heavily on human labor; the number of workers may more accurately represent the contribution of the operational activities that tourism enterprises engage in within an area. As a result, we have decided to use this statistic to reflect the region's total labor investment. As a result, in order to illustrate the company's development size and profitability, the paper chooses the primary business revenues and net profits of the tourist businesses as the output indexes assessing the operational efficiency. This is done by selecting the main business revenues and net profits of the tourism companies.

The selection of inputs and outputs is strategically aligned with the unique characteristics of the tourism industry in each region. The choice of 'number of local units' serves as a proxy for the industry's breadth and scale within a region, capturing the diversity and magnitude of establishments contributing to the overall tourism landscape. Simultaneously, the 'number of personnel' reflects the human capital and workforce deployed in the tourism sector, emphasizing the industry's labor-intensive nature and its contribution to regional employment. On the output side, 'Revenues' and 'net profits' have been selected as indicators of the tourism industry's financial performance. 'Revenues' provide insights into the overall economic activity generated by tourism-related businesses, offering a measure of the industry's contribution to the region's economic prosperity. 'Net profits,' on the other hand, signify the financial viability and profitability of these businesses, reflecting their efficiency in converting inputs into economic gains. By utilizing these specific inputs and outputs, our DEA analysis seeks to holistically capture the multifaceted nature of the tourism industry's

productive capacity in each region. This strategic selection aims to balance the quantitative representation of industry scale and workforce with a nuanced assessment of economic performance, providing a robust framework for evaluating efficiency and guiding regional tourism management decisions.

4. RESULTS AND DISCUSSION

Using the input-oriented and variable returns to scale DEA model, the study carried out a static analysis of 13 tourism regions' operational efficiency reported in 2017-2021. Limited by writing, the work extracts the data result for 2017, 2019, and 2021, as shown in Table no. 1. Scale Efficiency (SE) assesses how well a region is operating at its optimal scale, considering the difference between the existing scale and the scale needed to achieve the production frontier. A SE value of 1.00 indicates optimal scale, while values below 1.00 suggest potential inefficiencies in the size of operations relative to the optimal scale. Regions with lower SE might benefit from adjusting their scale of operations for improved productivity. Pure Technical Efficiency (PTE) measures a region's efficiency in using its resources for tourism without considering the scale of operations. It reflects how well a region converts inputs into outputs, irrespective of the scale. A PTE value of 1.00 implies optimal resource use at the current scale. Values below 1.00 suggest there is room for improvement in utilizing resources effectively. Improving PTE involves optimizing processes to achieve higher output with the existing resources.

Table no. 1 – The values of operating efficiency of Greek tourism regions

Region	2017			2019			2021		
	TE	PTE	SE	TE	PTE	SE	TE	PTE	SE
Eastern Macedonia & Trace	0,64	0,73	0,87	0,59	0,72	0,82	0,79	0,83	0,95
Central Macedonia	0,82	0,85	0,97	0,77	0,85	0,90	0,86	0,88	0,98
Western Macedonia	0,79	1,00	0,79	0,71	0,87	0,82	0,74	0,98	0,75
Thessaly	0,77	0,80	0,96	0,66	0,78	0,85	0,79	0,81	0,97
Epirus	0,81	0,90	0,90	0,86	0,95	0,90	0,88	0,95	0,93
Ionian Islands	0,95	0,96	0,99	0,94	0,96	0,98	0,99	1,00	0,99
Western Greece	0,90	0,93	0,97	0,80	0,84	0,95	0,95	0,96	0,99
Central Greece	0,74	0,82	0,90	0,80	0,86	0,93	0,96	1,00	0,96
Peloponnese	0,83	0,87	0,95	0,81	0,87	0,93	0,90	0,95	0,95
Attica	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
North Aegean	0,97	1,00	0,97	0,93	0,96	0,97	0,92	1,00	0,92
South Aegean	1,00	1,00	1,00	0,80	0,98	0,82	1,00	1,00	1,00
Crete	0,91	0,94	0,97	0,87	0,91	0,96	0,82	0,85	0,97
Mean	0,86	0,91	0,94	0,81	0,89	0,91	0,86	0,94	0,95
Mean (2017-2021)	0,85 (TE)	0,91 (PTE)	0,95 (SE)						

Source: authors' own work

Technology efficiency, often known as TE, is an essential component to consider when determining how effectively resources are allocated and used. According to the findings shown in Table no. 1, the average value of the technological efficiency of Greece's 13 tourist regions throughout the period 2017-2021 is 0.85. This finding suggests that when all potential causes of inefficiency are considered, the Greek regions as a whole have the potential to improve their inputs by up to 15% (given the amount of output they now produce). In 2017, the median combined effectiveness of the Greek regions was 0.86; in 2019, this mean value

dropped to 0.81; and in 2021, this mean value increased to 0.86, representing an improvement. In 2017, two areas, namely Attica and South Aegean, gained DEA effectiveness. This number decreased to one region in 2019 (Attica), and then increased again to two regions in 2021 (both Attica and South Aegean). In the variable model, Central Macedonia, Epirus, Peloponnese, and the North Aegean all achieve good efficiency, but their scale efficiency is quite poor. In 2019, the majority of areas experienced decreased overall efficiencies, mostly as a result of lower-scale efficiencies. In 2019, there was a decrease in both the efficiency of scale and the efficiency of pure technical processes, which led to a decrease in the overall efficiency of both of these areas combined. Based on these findings, it seems that the hotel and restaurant industries in these places are operating at a size that is inappropriate for their businesses. The challenge that these areas are facing is one that is related to the capacity of their production. Despite the fact that their overall technical efficiency ratings are quite near to those of the most efficient areas, Crete, Western Greece, and the Ionian Islands are all technically inefficient regions. In order to increase their performance, these three areas need to reduce the amount of input they get. The following locations all have relatively poor efficiency, according to all of the models. This indicates that they should improve their management methods as well as the capacity of their manufacturing facilities.

The analytical mean of the pure technical efficacy (PTE) of the enterprises operating in the 13 Greek tourist districts throughout the period 2017-2021 is 0.91, which places them very near to the effectiveness frontier. Only Attica was able to maintain a PTE value of during all of the years, which demonstrates that their leadership level and technological expertise are both high, as well as that they have appropriately distributed their invested resources. It is important to point out that Western Macedonia's PTE value has significantly decreased during 2017, going from 1 to 0.87 in the current year. A drop of this magnitude is most likely attributable to the region's robust development and the successful execution of critical investments. The area has to place a significant emphasis, as part of the ensuing growth, on the improvement of its capability management level. In addition, the values of PTE in the majority of the areas are lower than 0.9, which indicates that there is space for development. Scale efficiency (SE) is a metric that assesses the productivity efficiency of tourist zones as it relates to their scales. This metric also shows the difference between their existing scales and the scales that are needed to achieve the production frontier. The mean value for scale efficiency across all 13 Greek regions over the time period under consideration is 0.95. It should come as no surprise that the reduction in scale efficiency is the primary cause of the poor and deteriorating technological efficiency. According to the findings of the calculations, all of the other regions showed varying degrees of loss, with the exception of Attica and the South Aegean, which maintained the highest level of productivity throughout. In general, the vast majority of tourist destinations in Greece do not have an ideal fit between the degree of operating technology, the management level, and the magnitude of the inputs. Therefore, it is suggested that they increase the amount of work they put into making investments and enhance the effectiveness of the approach they use to make use of their cash. The DEAP2.1 program is used to compute and deconstruct the overall factor productivity shift index, and further assess the modifications in the efficiency. The particular results of the process are provided in Table no. 2, which are based on the data from tourism in Greek regions from 2017 to 2021.

Table no. 2 – The Malmquist index of Greek tourism regions during 2017-2021

YEAR	EFFTC	TECCH	PECH	SECH	TFPCH
2017-2018	0,98	1,08	1,01	0,97	1,06
2018-2019	0,96	1,01	0,98	0,98	0,97
2019-2020	0,89	1,03	1,12	0,79	0,92
2020-2021	0,96	1,40	1,32	0,73	1,34
Mean	0,95	1,13	1,11	0,87	1,07

Source: authors' own work

The average value of the Malmquist index for the period of 2017-2021 was 1.07, which pointed to a consistent overall performance as well as a yearly increase in TFPCH of the Greek tourist areas of 1.07% on average. The TFPCH index for the period 2017–2021 is shown to be more than one in Table no. 2, with the exception of the years 2018–2019 and 2019–2020, during which it was less than one. As a result of the significant expansion that will be seen in the years 2020 and 2021, the operational effectiveness of tourist areas will be very vulnerable to the affects of the economic climate, international circumstances, and regulatory conditions, amongst other factors. The PECH values of tourist areas stayed around 1 and averaged 1,11, with just a tiny amount of variability and no discernible disparities among the unit input and output from year to year. Regarding the SECH, the values that have been recorded during these years are all very below 1, with an average of 0.87. Following a decline that happened in 2018-2019 and 2019-2020, there was a sluggish rebound that took place in 2020-2021. The bad performance in SECH and steady performance in PECH immediately led to the poor performance in EFFCH, which of tourist regions resulted in an annual increase of -7%. In terms of the alterations brought about by TECHCH, the efficiency values are larger than 1, with an average score of 1,13; this makes it the sole indication that is showing a significant improvement. It is abundantly clear that the advancements in technology produced by tourist businesses in Greek areas have neutralized the unfavorable rise in scale economics and are the primary driving force behind the expansion of operational capabilities within the tourism sector. During the period of 2017-2021, Attica and the South Aegean had the greatest overall operating efficiency TFPCH. It is important to note that a significant portion of areas have Malmquist indices that are lower than 1. This indicates that these tourism destinations have been seeing a decline in output over the course of time. Concerning the inefficiency of a great number of areas, several theories may be conceived for the inefficient utilization of the inputs with the intention of maximizing the production potential for the greatest amount of output that is achievable.

According to the study's results, regions perceived as inefficient should consider investing in organizational aspects related to tourist management. These aspects encompass initiatives in marketing, enhancements in quality, and achieving a better balance between inputs and outputs, among other measures. Notably, certain regions like Eastern Macedonia and Trace, Thessaly, Western Macedonia, and Central Greece experience notable fluctuations in their technological efficiency levels over several years. This variability may be attributed to the inability of tourism region managers to effectively adjust inputs or accurately anticipate (or generate) the demand for tourism in their respective areas over time. Alternatively, a combination of these factors could contribute to the observed fluctuations. The variations in efficiency among regions highlight the need for a nuanced approach to regional tourism management. By understanding and addressing factors such as management capabilities, demand forecasting, and technology adoption, regions can work towards improving their efficiency and competitiveness in the tourism industry.

5. CONCLUSION

Regional tourist strategy in Greece plays an important part in laying the foundation for a progressive spatial expansion of the sector as well as the diversification of the country's model. This is an important function since regional planning for tourism in Greece is necessary. This study will investigate the tourism competitiveness of Greek areas from 2017 through 2021, as well as the evolution of that competitiveness over the course of those five years. Tourism regions are comparable to tourist profit units since they are responsible for the management of appropriate inputs in order to maximize outputs (i.e., the number of national and international tourists who arrive and stay in a destination). Particularly, we have examined one of the five factors that define the comparative advantage enjoyed by tourism sites, namely, the effective management of the resources available at these locations.

According to the findings of this research, the performance of a number of different areas in Greece has a lot of room for improvement. In addition, a collection of productive areas is able to keep its position unchanged over the course of several years. This conclusion is reinforced by the findings of the Malmquist index, which demonstrated that very few areas have seen an increase in their levels of production. To put it another way, the effectiveness of the Greek regions has not significantly changed during the years that were taken into consideration. Attica, Crete, the North Aegean, and the South Aegean are the areas with the highest levels of efficiency. On the other hand, the regions of Eastern Macedonia and Thrace, Western Macedonia, Thessaly, and Central Greece have the lowest levels of efficiency. There are a variety of potential reasons for such inefficiencies, including inadequate marketing of the tourist products in a particular region, overinvestment in the (highly cyclical) tourist sector, substantial variations in tourist attractiveness variables due to variation in in the past determined cultural facilities or in physical geography (for example, seaside areas), and so on and so forth.

The findings of this study provide enlightening perspectives that might be helpful to managers working in the hospitality and service sectors. The overall conclusion that can be drawn from the inefficiencies of the majority of Greek areas is that local destination management organizations need to make a significant effort in order to enhance the tourism performance of Greek locations by equilibrating the balance of inputs and outputs. This is the general conclusion that can be drawn from the inefficiencies of the majority of Greek regions. It is highly advised that the tourist policies and initiatives be decentralized because of the disparities in the performance of the regions of Greece. Additionally, it is strongly suggested that each area establish autonomously its tourism policy and development, always basing it on its own requirements and features. The regional administrations of Greece should build monitoring mechanisms (such as observatories) in order to assess the inputs/outputs ratio in significant tourist sectors such as the hotel and restaurant sectors, as well as to forecast the amount of demand that will be placed on their respective areas for tourism. Regional efforts for the lifetime training of tourist businesses in managing resources, as well as for transferring expertise from areas that are more efficient, will also be extremely valuable. These initiatives will be very useful.

In light of the fact that the vast majority of Greek areas are inefficient, the overarching conclusion that can be drawn is that regional destination management agencies need to put in a lot of effort in order to enhance the tourism success of Greek destinations by concentrating more on the equilibrium of inputs and outputs. Additionally, it is important for the regions of Greece to pay attention to the promotion of local tourist brands, to assist the development of "regional tourist districts," and to spend financial resources in tourism infrastructure.

Research Limitations and extensions

The study is confined to the years 2017-2021, and as such, it may not capture the most recent developments in the tourism industry. The dynamic nature of the field suggests that conditions beyond this period could influence the current landscape. To address these limitations, future research endeavors should consider incorporating more recent data, expanding the scope to diverse tourist zones, and exploring additional variables for a more nuanced understanding of the subject. To enhance the generalizability of findings, future research could explore a broader range of tourist zones, considering variations in size, popularity, and geographical characteristics.

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Evaluating Cognitive Factors of Attitude Formation: The Impact of the Consumer's Level of Education on the Formation of Attitudes Towards Health Behaviour

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Abstract: The article reviews the impact of cognitive factors on the formation of consumer attitudes towards health behaviour. Following a short overview of the cognitive component (level) of attitude formation and its factors, as well as a theoretical model of the formation of attitudes towards health behaviour, the results of the empirical study are presented to measure the impact of the consumer's level of education on the formation of consumer attitudes towards health behaviour. The evaluation of the results provides some insights, conclusions and directions for future research.

Keywords: attitude formation; cognitive attitude formation; consumer attitudes; formation of attitudes towards health behaviour; health behaviour.

JEL classification: M31; I12.

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1. INTRODUCTION

Attitudes and attitude formation have always been an area of interest for scholars in various fields. As mentioned in the previous publications (Walther *et al.*, 2011; Pratkanis *et al.*, 2014; Crano and Gardikiotis, 2015; Eagly and Chaiken, 2019; Bakanauskas *et al.*, 2022; etc.), attitude formation is a multilevel process that integrates affective, cognitive and behavioural components, and consumer behaviour is the result of this process. When it comes to the formation of attitudes towards health, health behaviours should always be considered. Health behaviour is presented in the scientific literature from different perspectives: risk and fear of disease, lifestyle links with habits and harmful behaviours, past experiences and health behaviour. The analysis of the links between attitudes and health behaviours (de Vries *et al.*, 2018; Hilz *et al.*, 2019; etc.) shows that consumer health behaviours are affected by a wide range of factors (legal, fiscal, demographic, political, etc.). There is a consensus that it is difficult for individuals to affect and change these legal, demographic and economic factors. Such changes and decisions require the intervention of national governments or global institutions (e.g. taxes on tobacco and alcohol, reimbursement for vaccines, health policies, reimbursement under certain preventive health programmes, etc.). Consumer attitudes, as a socio-cognitive factor, can be fully or at least partially controlled by an individual. Attitudes, unlike short-term opinions, are tacit and focused on long-term individual perspectives. Since attitudes can be controlled by an individual, research is needed on how to use attitude formation and its factors to understand the causal motives of consumer behaviours. The analysis of scientific literature (Braveman and Gottlieb, 2014; Kelli *et al.*, 2019; Rosengren *et al.*, 2019; Green *et al.*, 2022; etc.) suggests that social inequalities in health behaviour exist, with social status (income, education) being a key factor affecting attitudes towards health behaviour. The same study concludes that the socio-economic status reflects differences in income, educational attainment, health knowledge and attitudes, and lifestyle choices. Less educated consumers are thought to be in poorer health because they use their money on priorities other than those related to promoting or maintaining their health (e.g. bad habits). It is also discussed that the perception of income distribution and priorities may be influenced by limited education and medical literacy of these consumers. The importance of cognitive factors in shaping attitudes towards health behaviour is also suggested by the European Health Literacy Survey (Sørensen *et al.*, 2015; etc.), confirming that one in two respondents lacks health literacy. This highlights the need to improve health literacy among the European population. At the same time, the study overlooks the causal aspects of these results, indicating the need for such studies in Lithuania. The Lifestyle Survey of the Lithuanian Population (Javtokas and Žagminas, 2018; etc.) assesses the overall level of health literacy (index) of the Lithuanian population in three areas (healthcare, disease prevention and health promotion). The results of the survey suggest that the health literacy of the Lithuanian population is insufficient. To improve it, more attention should be paid to health education and disease prevention for the older, less educated rural population. For example, the study highlights the influence of cognitive factors (education, training) on health behaviours. However, most studies lack a cause-and-effect assessment. For instance, how accurate would it be to assume that, at the national level, Lithuanian citizens (hereinafter referred to as consumers) with a higher level of education are more likely to have positive attitudes towards health? Similarly, the more educated consumers are, the more likely they are to have positive health behaviours. From a

cause-and-effect perspective, the consumer's education and health knowledge could be an important factor influencing the consumer's attitude towards health, which significantly affects the consumer's perception of health-promoting behaviours (e.g. physical fitness, nutrition, weight control, psycho-emotional fitness, etc.), health- strengthening behaviours (e.g. exercise, diet, dietary changes, etc.) and health-related behaviours (e.g. smoking, alcohol consumption, etc.), health-protective behaviours (e.g. preventive measures, diagnostic tests, dietary supplements, etc.) and avoidance of harmful behaviours (e.g. restriction of unhealthy products, avoidance of alcohol, tobacco, avoidance of harmful environments, etc.), while health behaviour is the result of formed attitudes towards health.

Therefore, the research question is as follows: *How does the consumer's level of education affect their attitude towards health behaviour?*

The research target is the impact of the consumer's level of education, as one of the cognitive factors of attitude formation, on their attitudes towards health behaviour.

The object of this publication is to assess the impact of the consumer's level of education on the formation of consumer attitudes towards health behaviour, based on the theoretical model of attitude formation towards health behaviour and the results of the empirical study.

A quantitative research design was chosen to examine the means of different variables, make predictions, test causal relationships between factors of attitude formation and health behaviours and generalise results to a wider population. The quantitative research design allows for a relatively broad sample of respondents. It focuses on the breadth of the sample rather than the depth, which was necessary for this study to reflect the experiences and attitudes of the entire population of Lithuania about health, based on individual empirical experiences and individual observations (Creswell and Poth, 2017; Creswell and Creswell, 2018; etc.). Quantitative research does not require the modelling of situations, the use of paradigms or the involvement of the interviewer, but rather the neutrality of the interviewer, who is not collecting facts but the individual experiences of respondents. Therefore, the quantitative research was chosen for assessing the impact of attitude formation factors on health behaviours, i.e. establishing the relationship between two independent variables – attitudes and behaviours – in a given population. A questionnaire survey of the Lithuanian population aged 18-65 was conducted to reflect the health attitudes of the entire Lithuanian population. The sample size was 1,000 respondents. The interview was based on the CAWI (computer-assisted web interviewing) method. The target respondents were selected using the Norstatpanel. The survey ran from 1 September to 31 October 2021. The results were analysed by the SPSS software. The relationship between different attitudes and behaviour variables was analysed using non-parametric statistical methods cross-tabulation and the Kruscal-Wallis test.

2. CONSUMER'S LEVEL OF EDUCATION AS ONE OF THE COGNITIVE COMPONENTS OF ATTITUDE FORMATION

As stated in the previous publication by the authors of this article, as well as in the analysis of scientific literature (Arendt, 2005; Walther *et al.*, 2011; Pratkanis *et al.*, 2014; Voinea, 2016; Eagly and Chaiken, 2019; etc.), an attitude is a personal and subjective evaluation of a certain attitude object, causing either a positive or negative reaction, while attitude formation involves the integration of affective, cognitive and behavioural components and their factors. For example, the affective component of attitude formation can be defined as individual emotional characteristics such as feeling and emotions (e.g. fear

of disease, fear of disability). The behavioural (cognitive) component involves observing, evaluating and even copying or not copying the behaviour of others. In the cognitive component, the evaluation of objects is not based on emotions (as in the case of affective attitude formation) but on facts.

As mentioned in the other publications by the authors of this article, as well as in the analysis of scientific literature (Conner and Norman, 2021; etc.), the cognitive component of attitude formation is based on personal preferences, experiences and knowledge – factors directly related to the consumer's level of consumer. The process of attitude formation is affected by the following cognitive factors:

- information stored in a person's memory: personal experiences, knowledge and preferences that are directly related to the level of education;
- external information a person gets from external stimuli, such as media, advertising, social groups (family, friends) and their impact.

Factual information is information stored in the consumer's memory (personal knowledge, experiences and preferences) or new external information from external environment stimuli (advertising and media, friends, family, other social groups) – see Figure no. 1.

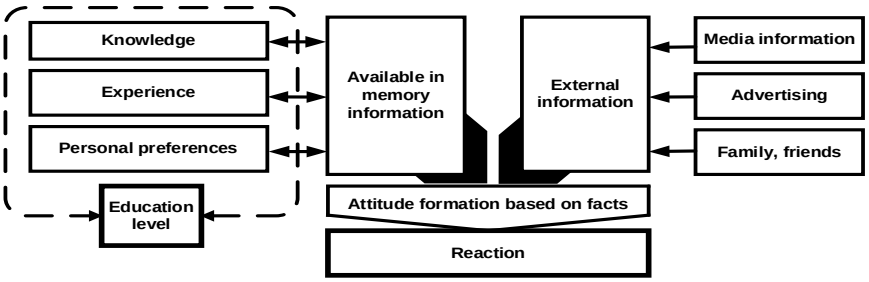

Figure no. 1 – Cognitive component of attitude formation
Source: composed by the authors

Overall, the consumer makes evaluations about an attitude object on the basis of the factual information the consumer gets from external stimuli (media, friends, family, advertising) and the information the consumer stores in their memory (personal knowledge, experiences and preferences). So, information stored in the consumer's memory (knowledge) is inextricably linked to the consumer's education and level of education. All this affects the formation of the consumer's attitude based on facts and leads to a certain (positive or negative) reaction to an attitude object and expression of this attitude with action (behaviour).

In medicine and health psychology, the term 'health behaviour' is used to refer to the protection of consumer health. It encompasses the consumer's activities, initiatives, habits and actions to strengthen and protect their health (Sanders and Suls, 2013; Conner and Norman, 2021; etc.), as well to facilitate the diagnosis and prevention of health diseases in early stages. As stated in the previous publication by the authors of this article, health behaviours can be grouped into three dimensions: **health strengthening behaviours, health protecting (preventive) behaviours and avoidance of health-harmful behaviours. They are all presented in the *attitude formation towards health behaviour model*** (Figure no. 2).

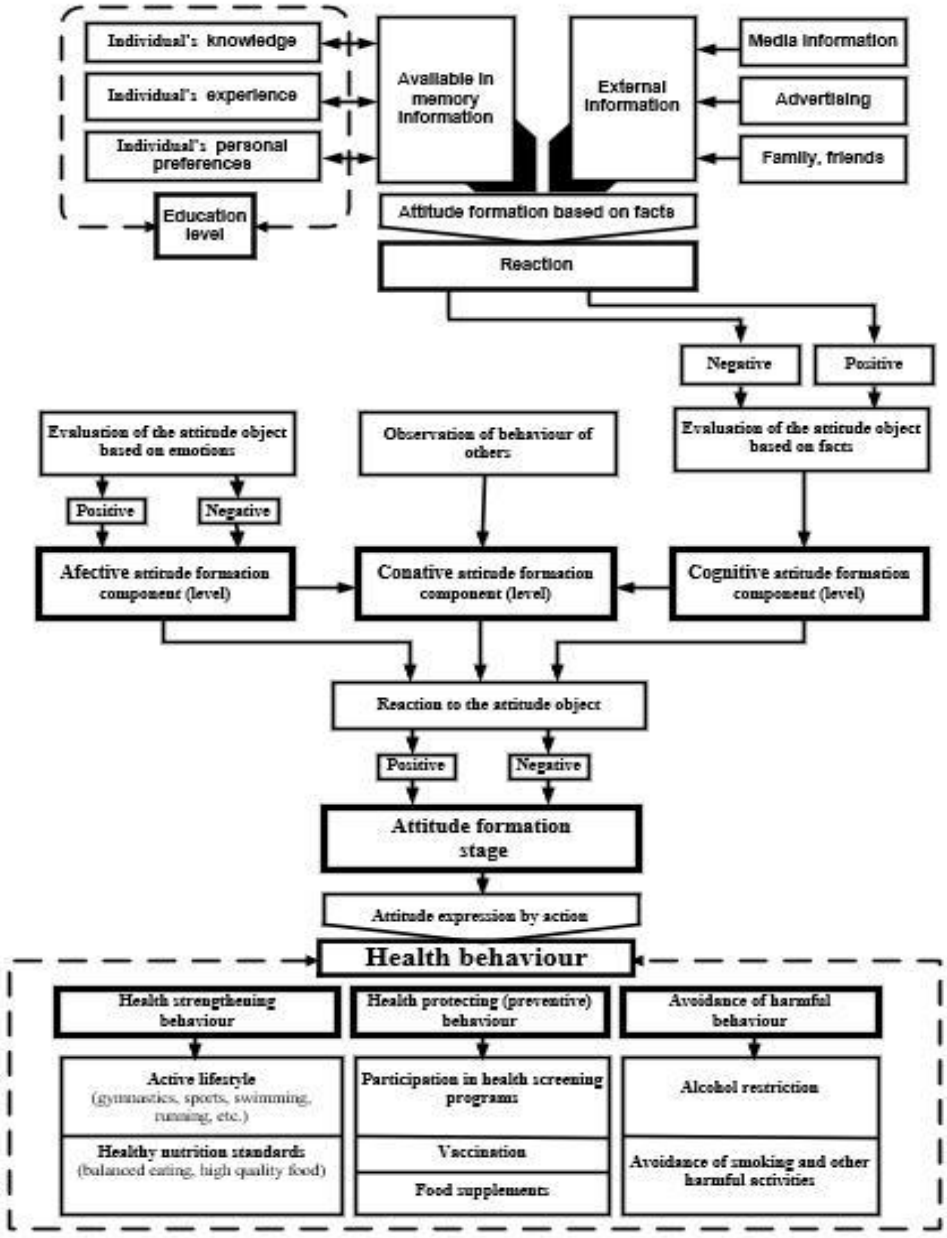

Figure no. 2 – Attitude formation towards health behaviour model
Source: composed by the authors

As illustrated above, the *attitude formation towards health behaviour model* shows the causes and consequences related to the formation of consumer attitudes and health

behaviours. For example, external stimuli and external information (e.g. received from the media, advertising, family and friends), one of the cognitive components of attitude formation, can affect the formation of certain consumer attitudes, and the expression of those attitudes with reactions and actions can affect certain consumer behaviours. While internal information (such as personal characteristics, experiences, preferences and knowledge), hence the consumer's level of education, can be defined as a causal cognitive factor that forms attitudes (attitudes towards health behaviour). These insights have served as a basis for the research hypotheses and some of the conclusions of the empirical study.

3. IMPACT OF THE CONSUMER'S LEVEL OF EDUCATION ON THE FORMATION OF ATTITUDES TOWARDS HEALTH BEHAVIOUR. RESEARCH HYPOTHESES

Scientists (Goldman and Smith, 2002; Arendt, 2005; Cutler and Lleras-Muney, 2006; Hilz *et al.*, 2019; etc.) agree that socio-economic groups vary considerably in terms of health status and behaviour and that it is not only health status that is different but also health-related behaviour between different consumers (individuals, consumers or consumer groups). They discuss the potential causes of this and what trends may emerge. The assumption is that perhaps more educated, higher-income consumers take a more active role in disease prevention and control, leading to differences in health status and health behaviours (Goldman and Smith, 2002; etc.). It is argued that lower-income consumers are in poorer health not only because they lack finances, but also because they spend their money on other priorities than healthcare or diagnostics (Marmot, 2002; Hilz *et al.*, 2019; etc.). This could probably be explained by a lack of education and knowledge. Consumers' knowledge and level of education may also affect their health behaviours and even increase their access to resources to improve health.

The links between socioeconomic aspects and health behaviours show that health behaviours may vary depending on the economic level of each country and should therefore be assessed at the national level of each country. The effects of social inequality manifest in health behaviours, in particular smoking, alcohol consumption, diet and physical activity, suggesting that the social inequality factor (level of education, income, etc.) may affect consumer attitudes towards health and health behaviours. Thus, it can be assumed that the socio-demographic profile of consumers, which may include not only the above-mentioned socioeconomic status, but also socio-demographic characteristics such as the level of education, knowledge and awareness, has a significant impact on the formation of attitudes towards health. Some aspects of the consumer's personal demographic profile (e.g. level of education) are classified as cognitive factors that shape consumer attitudes. In the *attitude formation towards health behaviour model* (Figure no. 2) this is referred to as stored information. This raises the question about the causal-and-effect relationship between this factor of attitude formation (level of education) and health behaviours. For example, how valid would it be to assume on a national scale that Lithuanian consumers with higher education have a strongly expressed cognitive component of attitude formation, leading to more positive attitudes towards health and better awareness of health protecting behaviours, health enhancing behaviours and avoidance of harmful behaviour? From the cause-and-effect perspective, the consumer's level of education and health knowledge (cognitive factors of attitude formation) could be the cause of the consumer's health behaviours, and

certain health behaviours could be the consequence of formed attitudes. In summary, the cognitive factor of consumer attitude formation (see Figure no. 2, level of education) could be a causal factor that forms the consumer's attitude towards health behaviour. These insights have served as a basis for the research hypotheses and the empirical study of the impact of the cognitive component (the level of education) on the formation of consumer attitudes towards health behaviour.

4. RESEARCH HYPOTHESES

Taking into account the insights from the scientific literature review and the *attitude formation towards health behaviour model* (Figure 2), the following research hypotheses have been formulated:

- **Null hypothesis:** Lithuanian consumers' attitudes towards health do not differ depending on the level of education.
- **Alternative hypothesis1 (A1):** Lithuanian consumers with a university degree are more likely to have positive attitudes towards health.
- **Alternative hypothesis1 (A2):** Lithuanian consumers with non-university education are less likely to have positive attitudes towards health.

5. RESEARCH METHODOLOGY

A quantitative study was conducted to explore the relationship between different variables and to compare different variables and data - e.g. factors of attitude formation and health behaviours) (Creswell and Poth, 2017; Creswell and Creswell, 2018; Bougie and Sekaran, 2019; etc.). The empirical study was performed among Lithuanian residents aged 18-65 to reflect the attitudes of the Lithuanian population towards health behaviour. The sample size of the survey was determined using an online sample size calculator. With 1,000 respondents, the survey's results could be analysed with 99% confidence and a ±4% margin of error.

The interview was based on the CAWI (computer-assisted web interview) method, and the target respondents were selected using the Norstatpanel. The survey ran from 1 September to 31 October 2021.

The results were analysed by the SPSS software. The data from the empirical study were analysed using statistical non-parametric methods of cross-tabulation and the Kruskal-Wallis test.

The SPSS software used the cross-tabulation (cross tables) method to compare the distribution of responses among respondent groups and determine whether group differences are statistically significant (Scott *et al.*, 2013; etc.).

The non-parametric Kruskal-Wallis test was used to look for any link between demographic variables (Islam, 2018; etc.). Differences are considered statistically significant when a p-value is 0.05 or lower. The Kruskal-Wallis research data analysis methods provide insight into the relationship between statements (i.e. attitudes towards health behaviour) and demographic blocks (e.g. consumer age, gender, education, etc.). They show the differences that emerge in certain demographic segments. As mentioned earlier, the demographic block of the consumer has been crucial not only in assessing attitudes, but also in their formation (e.g. through the cognitive component).

The hypotheses have been built on the insights from scientific literature and then tested using the results of the empirical study. For this purpose, the significance testing method (significance testing) was used to confirm the hypotheses with statistically significant research results or reject them with statistically insignificant research results (Poletiek, 2013; etc.).

6. RESEARCH RESULTS

Impact of the level of education on the formation of consumer attitudes towards health behaviour

When consumer groups with varying educational backgrounds are compared, it becomes clear that Lithuanian consumers with different levels of education have distinct attitudes towards health behaviour: Lithuanian consumers with higher education (non-university education (a college/bachelor's or master's degree) and university education (a bachelor's, master's or doctoral degree) tend to have more positive attitudes towards health behaviour compared to consumers with lower education (vocational training, school education and incomplete school education) (see Table no. 1).

Table no. 1 – Comparison of attitudes towards health behaviour among groups of Lithuanian consumers with different level of education

less comon			
more common	**Education**		
% from yes/ more yes	**professional school, shool, unfinished shool**	**non university (college, master degree, bachelor degree)**	**university (master degree , bachelor degree, phd)**
Attitudes			
1. In order to prevent diseases, it is necessary to move and exercise	79.0%	89.2%	88.9%
2. A balanced, wholesome diet is extremely important for human health	80.1%	89.7%	88.7%
3. In order to avoid diseases, you need to learn relax and not to stress	82.6%	88.7%	85.3%
4. Preventive researches can help to diagnose the disease in early stage	82.9%	86.7%	88.5%
5. In order to prevent diseases, it is important to take food supplements	30.2%	31.8%	31.3%
6. In order to avoid diseases, it is necessary to avoid harmful habits	75.8%	77.9%	82.4%

To sum up, better educated Lithuanian consumers are more likely to have positive health attitudes. No significant differences are observed only with the attitude 'it is important to use food supplements to avoid diseases.

To determine statistical significance, the Kruskal-Wallis test was employed to compare the distribution of responses between groups of respondents at all levels of education, and some significant differences ($p < 0.05$) were found (see Table no. 2).

Table no. 2 – Significant differences in some attitudes by level of education

	K3r1: In order to avoid diseases, it is necessary to move and exercise	K3r2: Balanced complete nutrition is extremely important for human health	K3r3: In order to avoid diseases, you need to learn relax and not to stress	K3r4: Preventive examinations help to timely diagnose and start treatment of the disease in an early phase	K3r5: In order to avoid diseases, it is important to take food supplements	K3r6: In order to avoid diseases, it is necessary to avoid bad habits
Chi-Square=x2	34,392	22,042	17,515	8,994	6,335	15,205
df	7	7	7	7	7	7
Asymp. Sig.	,000	,002	,014	,253	,501	,033

Note: a. Kruskal-Wallis Test; b. Grouping variable: D10: level of education

The evaluation of the attitudes of Lithuanian consumers towards health behaviour has revealed statistically significant differences ($p < 0.05$; attitudes K3r1, K3r2, K3r3, K3r6) among different levels of education.

The attitude K3r1 'Physical activity and exercise help to prevent disease' ($\chi2=34.392$, df=7; p= 0.000, Table no. 3) is most common among consumers with a doctoral degree or a non-university (college) master's degree, and least common among Lithuanian consumers with vocational training (see Table no. 3).

Table no. 3 – Attitudes of Lithuanian consumers towards health behavior (K3r1) by level of education

	D10: Eeducation level	**N**	**Rank**	**χ2**	**df**	**Asymp. Sig.**
K3r1: In order to avoid diseases, it is necessary to move and exercise	Not finished scool or lower	13	444,96	34,392	7,000	0,000
	Scool	116	432,35			
	Professional	152	423,25			
	Non university bachelor (college)	159	500,78			
	Non university master (college)	36	560,36			
	University bachelor	263	549,53			
	University master	250	518,22			
	Phd	11	577,23			
	TOTAL	**1000**				

As Table no. 3 shows, the attitude K3r1 'Physical activity and exercise help to prevent disease' depends on the consumer's level of education (Asymp. Sig. is p =0.000, p<0.05). It has been found that better educated consumers are more likely to have positive health attitudes than those with vocational training and lower education.

The attitude K3r2 'A balanced and complete nutrition is extremely important for human health' ($\chi2=22.042$, df=7; p= 0.002, Table no. 4) is most typical for Lithuanian consumers with a non-university (college) master's degree and least typical for Lithuanian consumers with vocational training (see Table no. 4).

Table no. 4 – Attitudes of Lithuanian consumers towards health behaviour (attitude K3r2) by level of education

	D10: Eeducation level	N	Rank	χ2	df	Asymp. Sig.
K3r2: Balanced complete nutrition is extremely important for human health	Not finished scool or lower	13	454,69	22,042	7,000	0,002
	Scool	116	475,78			
	Professional	152	421,14			
	Non university bachelor (college)	159	512,50			
	Non university master (college)	36	556,92			
	University bachelor	263	534,19			
	University master	250	509,93			
	Phd	11	533,86			
	TOTAL	**1000**				

As illustrated in Table no. 4, the level of education has a significant influence on the attitude 'A balanced complete nutrition is extremely important for human health' (K3r2, Asymp. Sig. is p=0.002, p<0.05). Again, a similar trend as with the first attitude (K3r1) emerges, showing that consumers with higher education have more positive health attitudes than Lithuanian consumers with vocational training and lower education.

The attitude K3r3 'You need to learn to relax and manage stress to prevent disease' (χ2=17.515, df=7; p= 0.014, Table no. 5) is most common among Lithuanian consumers with a non-university (college) master's degree and least common among Lithuanian consumers with school education (see Table no. 5).

Table no. 5 – Attitudes of Lithuanian consumers towards health behaviour (attitude K3r3) by level of education

	D10: Eeducation level	N	Rank	χ2	df	Asymp. Sig.
K3r3: In order to avoid diseases, you need to learn relax and not to stress	Not finished scool or lower	13	443,42	17,515	7,000	0,014
	Scool	116	425,10			
	Professional	152	476,19			
	Non university bachelor (college)	159	518,63			
	Non university master (college)	36	581,86			
	University bachelor	263	523,37			
	University master	250	504,74			
	Phd	11	527,50			
	TOTAL	**1000**				

As shown in Table no. 5, the level of education has a significant impact on the formation of positive attitudes towards health behaviour (attitude K3r3 'Physical activity and exercise help to prevent disease'). The same pattern of results can be seen again when evaluating Lithuanian customers' health attitudes as with the previous attitudes (K3r1 and K3r2).

The attitude K3r6 'You need to avoid bad habits to prevent disease' (χ2=15.205, df=7; p= 0.033, Table no. 6) is most common among Lithuanian consumers with a non-university (college) master's degree and least common among Lithuanian consumers with incomplete school or lower education (Table no. 6).

Table no. 6 – Attitudes of Lithuanian consumers towards health behaviour (attitude K3r6) by level of education

	D10: Eeducation level	N	Rank	χ2	df	Asymp. Sig.
K3r6: In order to avoid diseases, it is necessary to avoid bad habits	Not finished scool or lower	13	334,04	17,515	7,000	0,014
	Scool	116	460,31			
	Professional	152	480,37			
	Non university bachelor (college)	159	493,34			
	Non university master (college)	36	600,63			
	University bachelor	263	518,79			
	University master	250	511,34			
	Phd	11	491,36			
	TOTAL	**1000**				

Table no. 6 shows that the level of education has a significant effect on the formation of positive attitudes towards health behaviour (attitude K3r6 'You need to avoid bad habits to prevent disease'). Yet, compared to other Lithuanian consumers with higher education, Lithuanians with a doctoral degree tend to have a less positive health attitude. That being said, they represent a small proportion of respondents and therefore their data will not be further analysed.

In light of the statistically significant data from the results of the empirical study, the following conclusions can be made:

- The level of education has a significant effect on the formation of attitudes towards health behaviour. Better educated Lithuanian consumers are more likely to have positive attitudes compared to people with a lower level of education. Lithuanian consumers with higher education have more positive attitudes toward health behaviour than consumers with vocational training and lower education.
- In terms of the level of education, the most positive attitudes towards health behaviour are typical for Lithuanian consumers with a non-university master's degree, while the least positive attitudes are common among Lithuanian consumers with vocational training, school or incomplete school education.

Summarising the results of the empirical study, Lithuanian consumers with higher education are more likely to have positive attitudes towards health behaviour because they are more likely to seek information, show interest in health and healthy lifestyles, and search for information. The empirical study reveals that people with higher education are more likely to search for information. This finding supports the cognitive component of consumer attitudes toward health behaviour and its importance in the formation of positive consumer attitudes towards health behaviour, as presented in *attitude formation towards health behaviour model* (Figure no. 2).

The null hypothesis 'Lithuanian consumers' attitudes towards health do not differ depending on the level of education' has been rejected after testing and evaluating the hypotheses on the basis of statistically significant or insignificant results. Also, the analysis of the results reveals that Lithuanian consumers with higher education have more positive attitudes towards health behaviour than those with non-university education (people with a doctoral or non-university master's degree lead in all response groups). Alternative Hypothesis 1 (A1) 'Lithuanian consumers with a university degree are more likely to have positive attitudes towards health' and Alternative Hypothesis (A2) 'Lithuanian consumers with non-university education are less likely to have positive attitudes towards health' have both been confirmed.

Thus, to sum it up, the level of education makes a significant impact on the formation of consumer attitudes towards health behaviour, and the formed attitudes (positive or negative) are likely to result in the presence or absence of health behaviour – attitudes expressed in action. The impact of the cognitive factor under study – the level of education – on consumer attitudes towards health behaviour can be illustrated as follows (Figure no. 3).

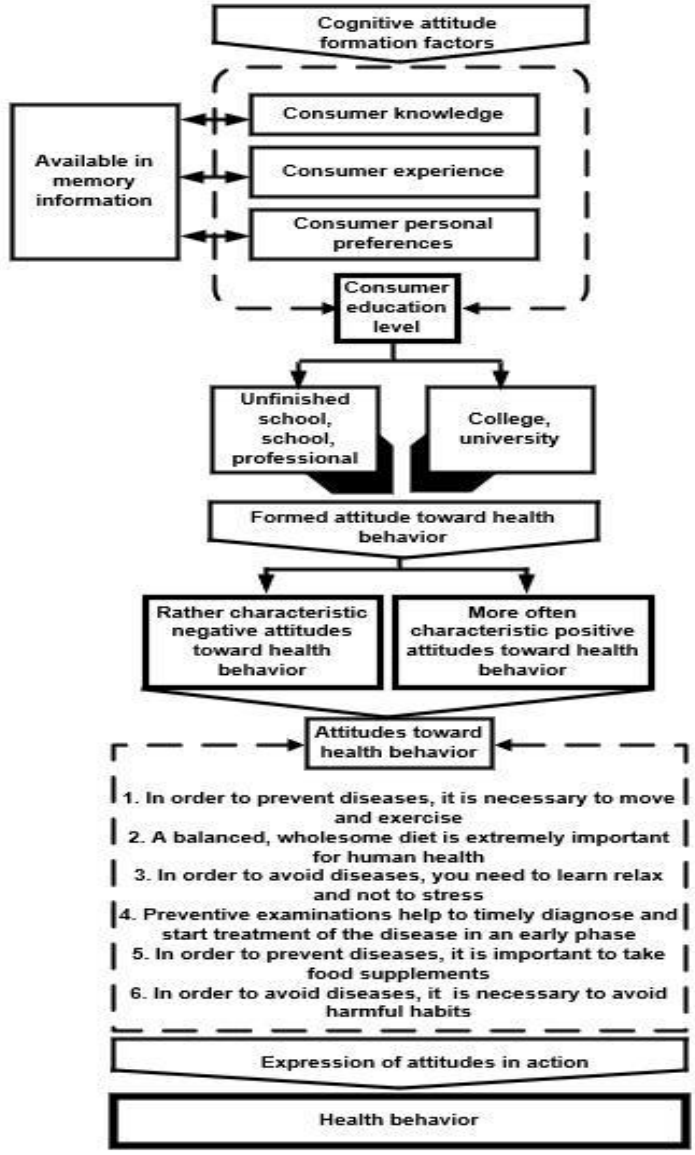

Figure no. 3 – Cognitive factors of attitude formation: the impact of the consumer's level of education on the formation of consumer attitudes towards health behaviour

Based on Figure no. 3, we confirm that the formation of consumer attitudes towards health behaviour is affected by certain cognitive factors, such as the level of education analysed in the empirical study and related to the information stored in the consumer's memory (knowledge, preferences, experience). The empirical study has revealed that the Lithuanian population with higher education (college, university) are more likely to have the following statistically significant positive attitudes towards health behaviour:

- physical activity and exercise help to prevent disease;
- a balanced, wholesome diet is extremely important for human health;
- you need to learn to relax and manage stress to prevent disease;
- you need to avoid bad habits to prevent disease.

These statistically significant positive attitudes towards health behaviour are attributed to certain directions of health behaviour:

- physical activity and exercise help to prevent disease –> **health strengthening behaviour**;
- a balanced, wholesome diet is extremely important for human health –> **health strengthening behaviour**;
- you need to learn to relax and manage stress to prevent disease –> **avoidance of harmful behaviour**;
- you need to avoid bad habits to prevent disease –> **avoidance of harmful behaviour**.

Based on the research results and Figure no. 3, it can be argued that attitudes towards health behaviour are the cause of health behaviours, and that behaviours as such are the consequence of the formed attitudes (=expression of attitudes in action). It can therefore be assumed that these formed attitudes already presuppose certain future trends with the directions of consumer health behaviour. For instance, the statistically significant attitudes 'Physical activity and exercise help to prevent disease' and 'A balanced, wholesome diet is extremely important for human health' imply the health strengthening direction of health behaviour, while the statistically significant attitudes 'You need to learn to relax and manage stress to prevent disease' and 'You need to avoid bad habits to prevent disease' indicate the health behaviour direction of avoiding harmful behaviour (Figure no. 4).

***Figure no. 4* – Statistically significant positive attitudes towards health behaviour. Consumers with higher education**

As illustrated in Figure no. 4, consumers with higher education level have more statistically significant positive attitudes towards health behaviours that imply two health behaviour directions: health strengthening behaviour and avoidance of harmful behaviour. Since behaviour is the result of an attitude formation process (the expression of attitudes in action), the next question is whether those formed positive attitudes towards health behaviour (Figure no. 4) are reflected in the actual behaviour of consumers? Are people with lower levels of education less likely to engage in health strengthening behaviours and less likely to avoid harmful behaviours than people with higher levels of education? Therefore, future research should review the results of the study evaluating the impact of the consumer's level of education on consumer health behaviours. These are the guidelines for the next research paper.

7. CONCLUSIONS

The literature of the foreign authors analysed in this paper has raised the issue of inequalities in terms of the level of education, health literacy and health behaviours of consumers. The study results of the Lithuanian population show that positive health attitudes are more prevalent among Lithuanian consumers with higher education. This confirms that the level of education has a significant impact on the formation of attitudes towards health behaviour. Positive attitudes are more common among more educated Lithuanian consumers and less common among less educated. From a cause-and-effect perspective, the knowledge that a consumer acquires through learning can be the cause of consumer health behaviours, while actual health behaviours are the expression of formed attitudes in action. Whether this trend is reflected in actual consumer health behaviours is a focus for future research.

The study results show that consumers with higher education have more statistically significant positive attitudes towards health behaviours (physical activity and exercise help to prevent disease; a balanced, wholesome diet is extremely important for human health; you need to learn to relax and manage stress to prevent disease; you need to avoid bad habits to prevent disease). This relates to two health behaviour directions: health strengthening behaviour and avoidance of harmful behaviour. Whether the consumer's level of education has an equally significant effect on these behaviours is a subject for future research.

The literature reviewed in this paper also raises the possibility that consumers with lower income are in poorer health, perhaps because they prioritise other things over health. Using the results of consumers' education and health behaviours, this could be one of the avenues for further research.

It is clear that health behaviours are not only affected by social inequalities, where the impact manifests in health behaviours, in particular smoking, drinking, diet and physical activity (Bridger *et al.*, 2023; etc.), but also by differences in the health literacy of each country's population, which is thought to be strongly affected by the consumer's education, income, religion and other demographics (Vaillancourt *et al.*, 2021; etc.). Thus, there is a need not only for consumer research in general, examining the cause-and-effect relationship between consumer attitudes and health behaviours, but also for such research at a national level in each country. The socio-demographic profile of the consumer in that country becomes crucial in this type of research, which may include not only the socio-economic status of the consumer mentioned above, but also socio-demographic characteristics such as the consumer's education, knowledge, occupation and even the demographic profile of the parents. These are also areas for future research.

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How can Retailers Help Consumers to Recycle? Exploratory Views on the Romanian Market

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Abstract: In recent years, sustainability has become a concept brought more and more frequently to the attention of consumers. European directives and legislation in force regulate the sustainable behavior of retailers, mentioning the changes they must include in the company's vision, respectively the facilities they must implement to encourage consumers to recycle. Starting from these considerations, the article focuses on the importance of the 3 R's – Reuse, Recycle, Reduce and how these concepts are implemented in consumer behavior. From a practical perspective, the research analyzes the sustainable behavior of Generation Z, starting from the premise that this cohort shows a greater interest in protecting the environment. The results of the research provide information regarding the interest in the recycling process undertaken by young people, as well as aspects related to the motivations underlying this action or the places where it takes place. Thus, we will be able to observe whether the workplace, college, or reference group exerts a greater influence on recycling behavior. At the same time, the article aims to identify the measures that retailers adopt to encourage consumers to recycle. The research results allow the identification of solutions that can be adopted by retailers to optimize the recycling process.

Keywords: sustainable behavior; generation Z; generational theory; recycling; waste-reducing.

JEL classification: Q01; Q53.

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1. INTRODUCTION

Sustainability has become an increasingly important concept in today's world as we grapple with the challenges of climate change and environmental degradation. It encompasses the principles of responsible resource management, social equity, and economic prosperity for present and future generations. When discussing sustainability, it is important not only to define this concept but also to consider the three pillars that make up the components of this paradigm. These three pillars of sustainability "3 R's - Recycle, Reduce, Reuse" have the potential to create a more sustainable future.

To carry out this study, we started from the definition provided by Wced (1987) according to this sustainability aims to satisfy the needs and desires of people, without compromising the future of the next generations. Thus, taking into account the definition we started, not only the needs and desires that we manifest in the present are important. Sustainability aims at a long-term projection that also takes into consideration the needs of future generations.

Recycling plays a crucial role in promoting sustainable waste management practices and mitigating the environmental impact of excessive waste generation. It involves the process of converting waste materials into reusable resources, thus reducing the strain on natural resources, conserving energy, and minimizing pollution. The mounting waste crisis poses significant challenges to the environment, economy, and public health, necessitating urgent measures to curb waste generation and promote sustainable practices. Reducing waste is a fundamental strategy for achieving a more sustainable future, conserving resources, mitigating pollution, and fostering a circular economy. Reusing, as an essential element of the circular economy, plays a vital role in promoting sustainability by extending the lifespan of products, reducing energy consumption, and minimizing waste generation.

Sustainability has emerged as a critical paradigm in our modern world, addressing the urgent need to balance environmental preservation, social responsibility, and economic prosperity. When we talk about sustainability it is mandatory to analyze the multifaceted benefits of sustainability across various domains, shedding light on its positive impacts on the environment, society, and the economy. Drawing upon authoritative research, we delve into the advantages that sustainability brings, highlighting its potential to pave the way toward a resilient future. From this perspective, we analyze the benefits of sustainability based on three directions: environmental impact, social implications, and economic benefits.

Environmental Impact of Sustainability: Sustainability plays a crucial role in addressing environmental challenges such as climate change, deforestation, and pollution. Research indicates that adopting sustainable practices can mitigate the adverse effects of these issues (Neacșu and Georgescu, 2023). According to Smith *et al.* (2020), sustainable land management practices, such as reforestation and afforestation, can significantly reduce carbon dioxide levels in the atmosphere. Additionally, implementing renewable energy sources, such as solar and wind power, helps reduce greenhouse gas emissions and dependence on fossil fuels (Brown and Sovacool, 2021). For instance, renewable energy sources, including solar and wind power, not only reduce greenhouse gas emissions but also contribute to long-term energy security (Brown and Sovacool, 2021). Furthermore, sustainable land and water management practices, such as conservation agriculture and water recycling, help protect ecosystems, preserve biodiversity, and safeguard natural resources (Carpenter *et al.*, 2020).

Social Implications of Sustainability: Sustainability also encompasses social dimensions, emphasizing the importance of social equity, community well-being, and inclusivity. Scholars argue that sustainable development should address social inequalities and ensure equal access to resources and opportunities (Bolay, 2022). By promoting fair labor practices, providing education and healthcare services, and fostering gender equality, sustainability can contribute to building more resilient and cohesive societies (Myers *et al.*, 2000). Research highlights that sustainable initiatives contribute to poverty alleviation, improved access to education and healthcare, and the empowerment of marginalized communities (Bolay, 2022). Sustainable urban planning, for example, can create livable and resilient cities, offering better housing, transportation, and social infrastructure (Carmona, 2021). Additionally, sustainable businesses that prioritize fair labor practices and promote diversity and inclusion help create equitable and just societies (Figge *et al.*, 2022).

Economic Benefits of Sustainability: Contrary to the perception that sustainability hinders economic growth, numerous studies suggest that sustainable practices can lead to economic benefits in the long run. According to Galli *et al.* (2020), adopting sustainable business models can improve resource efficiency, reduce waste, and enhance competitiveness. In addition, sustainable investments in green technologies and infrastructure can stimulate job creation and foster economic development (Liu *et al.*, 2022). Such investments not only create employment opportunities but also drive innovation and technological advancements. Research suggests that adopting sustainable business models can drive innovation, improve efficiency, and enhance competitiveness (Eccles and Saltzman, 2011). Sustainable investments in renewable energy, green technologies, and sustainable infrastructure can stimulate economic development, generate employment opportunities, and foster long-term economic resilience (Liu *et al.*, 2022). Additionally, sustainable practices, such as resource optimization and waste reduction, can lead to cost savings for businesses (Elkington, 2020).

Promoting sustainable lifestyles is a key component of achieving a greener future. Educating individuals about sustainable consumption patterns and encouraging them to adopt eco-friendly habits can have a significant impact. Research shows that raising awareness and providing information about the environmental consequences of consumer behavior can lead to changes in consumption patterns (Thøgersen and Olander, 2003). Moreover, governments, businesses, and civil society organizations can collaborate to develop policies and initiatives that promote sustainable practices, such as recycling programs and renewable energy subsidies.

Sustainability provides a pathway to long-term resilience and opens doors to future opportunities (Del Baldo and Baldarelli, 2017). By integrating sustainability principles into decision-making processes, organizations and governments can build adaptive capacity and prepare for future uncertainties, including climate change impacts and resource scarcity (Dangelico and Pujari, 2010). Furthermore, embracing sustainable practices can drive innovation and the development of new industries and markets. For instance, the transition to a circular economy, which emphasizes resource efficiency and closed-loop systems, presents significant economic and environmental opportunities (Kirchherr *et al.*, 2023). In the face of global environmental challenges, the concept of sustainability has gained significant traction in recent years. As individuals, communities, and nations strive to protect and preserve the planet, adopting sustainable practices has become essential. The “3 R's” of sustainability – Recycle, Reduce, Reuse – offer a practical framework for individuals and societies to promote environmental conservation.

2. LITERATURE REVIEW

2.1 Recycling – the importance in consumer behaviour

Recycling plays a crucial role in minimizing waste and conserving natural resources. By diverting materials from landfills and incinerators, recycling reduces the extraction of raw materials, energy consumption, and greenhouse gas emissions. Recycling processes involve converting waste materials into new products, reducing the need for virgin resources, and mitigating environmental degradation (Johnson *et al.*, 2019). For example, recycling one ton of aluminum saves approximately 14,000 kilowatt-hours of energy, equivalent to 10 metric tons of greenhouse gas emissions (EPA, 2020).

Recycling is a systematic approach to waste management that involves collecting, sorting, processing, and transforming discarded materials into new products or raw materials for manufacturing. It goes beyond traditional waste disposal methods, such as landfilling or incineration, by focusing on the recovery and reuse of valuable resources.

The recycling process typically involves several stages as collecting, sorting, processing, and manufacturing. Collection means that waste materials, such as paper, plastics, glass, and metals, are collected from households, businesses, and public spaces through curbside collection programs, drop-off centers, or recycling bins. Sorting assumes that collected materials are sorted based on their material types, such as plastic, metal, or paper, to ensure proper recycling. Forwards, the sorted materials undergo processing, which may include cleaning, shredding, melting, or breaking them down into smaller components. In the end, by manufacturing, the processed materials are then transformed into new products or used as raw materials for manufacturing industries (Geyer *et al.*, 2017).

Recycling is important because helps with resource conservation by reducing the need for extracting and processing raw materials. By recycling materials like paper, plastic, and metals, we can minimize deforestation, conserve energy, and preserve biodiversity. Also, it helps with energy and emission reduction because the recycling process consumes less energy compared to the extraction and production of new materials. It also reduces greenhouse gas emissions associated with resource extraction, manufacturing, and waste disposal, contributing to mitigating climate change. Recycling diverts waste from landfills, reducing the environmental and health risks associated with waste accumulation. It also promotes a circular economy, where materials are reused and repurposed instead of being discarded. In the end, recycling generates also economic benefits. Recycling creates economic opportunities by supporting industries that rely on recycled materials. It generates jobs in the collection, sorting, processing, and manufacturing sectors, contributing to local economies.

Nowadays, is important not only to know the recycling benefits, but also to know how to promote this concept and to convince others to put it into practice. The most important step is public education. Raising awareness about the importance of recycling through educational campaigns, community outreach programs, and school initiatives can instill recycling habits and knowledge from an early age. Also, we can't adopt sustainable principles if we don't have the infrastructure. We need to establish accessible recycling facilities, including recycling bins in public spaces, residential areas, schools, and workplaces, to encourage convenient and widespread recycling. All these measures need to have policy support. Governments can enact legislation and provide incentives to promote recycling. This includes implementing recycling

targets, offering tax incentives to recycling businesses, and enforcing regulations on waste management.

The significance of recycling is not limited to the act itself. The location where recycling takes place also holds great importance. So, it is important the proximity to waste Generation. The location of recycling facilities is critical because it affects the efficiency of recycling processes. According to Jones and Garbutt (2018), placing recycling centers near areas with high waste generation reduces transportation costs and minimizes carbon emissions associated with long-distance hauling. By reducing the distance between waste generation and recycling facilities, we can achieve greater resource efficiency and reduce the environmental impact of recycling operations.

Another crucial factor in successful recycling programs is the accessibility and convenience of recycling facilities. Research by Smith *et al.* (2019) reveals that individuals are more likely to participate in recycling initiatives if recycling centers are conveniently located near their homes or workplaces. The availability of easily accessible recycling locations encourages greater participation and decreases the likelihood of recyclable materials being discarded in regular waste streams. The location of recycling centers can also play a pivotal role in fostering community engagement and education. According to Houghton and Gifford (2020), strategically locating recycling facilities in visible areas encourages public awareness and interest in recycling practices. Such facilities can serve as educational hubs, providing information on recycling guidelines, materials accepted, and the environmental benefits of recycling. By raising awareness and educating the community, recycling locations become catalysts for broader environmental stewardship.

Recycling facilities located in the right places can have significant economic benefits. World Bank (2021) points out that proximity to recycling markets and industries enables efficient transportation and reduces costs associated with long-distance shipping of recyclable materials. Moreover, the establishment of recycling facilities can create local job opportunities, contributing to economic growth and community development. The location of recycling facilities should also consider principles of environmental justice. Studies by Bullard *et al.* (2019) indicate that marginalized communities often face higher exposure to environmental hazards, including waste facilities. By carefully selecting the location of recycling centers, policymakers can avoid further burdening already disadvantaged communities, ensuring fair access to recycling services and promoting equitable distribution of environmental benefits.

2.2 Reducing waste – a sustainable behaviour

The second "R" of sustainability, "Reduce," emphasizes the importance of minimizing consumption and waste generation. By practicing conscious consumption habits, individuals can reduce their ecological footprint and contribute to a more sustainable future. This involves thoughtful decision-making, such as purchasing durable products, avoiding single-use items, and adopting a minimalist lifestyle. The principle of the Three Rs – reduce, reuse, recycle – serves as the cornerstone of waste reduction efforts. According to the Environmental Protection Agency (EPA, 2019), reducing waste at its source should be the primary focus. By consuming less, individuals and businesses can significantly reduce their environmental impact. APA (2017) suggests that waste reduction strategies should be integrated into behavioral change campaigns to foster sustainable habits among the population.

According to Lundgren (2018), reducing waste generation at its source is more effective in addressing environmental challenges compared to solely relying on waste management practices. Implementing strategies like designing products with longer lifespans, promoting repair and refurbishment, and encouraging responsible consumption can significantly contribute to waste reduction.

When we analyze the "reduce" as a component of the Three Rs is important to mention the Extended Producer Responsibility (EPR). This is a policy approach that holds manufacturers accountable for the entire lifecycle of their products, including the management of post-consumer waste. Under EPR schemes, producers are incentivized to design products that are easier to recycle or repair, thus minimizing waste generation (APA, 2017). APA (2019) highlights the importance of government intervention in implementing and enforcing EPR policies to drive systemic change. Diverting organic waste from landfills through composting is another effective waste reduction strategy. Composting not only reduces greenhouse gas emissions but also produces nutrient-rich soil amendments (APA, 2017). APA (2019) emphasizes the role of educational programs in promoting composting practices among households and communities, empowering them to participate in waste reduction efforts.

In the last few years, we heard more frequently about the "Zero Waste Initiatives". The concept of "zero waste" aims to eliminate waste generation by redesigning products, systems, and processes to follow circular principles. Zero waste initiatives, such as bulk shopping, reusable packaging, and repair and sharing economies, are gaining momentum worldwide (APA, 2017). APA (2019) emphasizes the need for policy support and collaboration among stakeholders to create an enabling environment for zero-waste practices. Plastic pollution has emerged as a critical global issue. Reducing plastic waste involves various strategies, including promoting the use of alternatives, improving recycling infrastructure, and implementing plastic bag bans or fees (APA, 2017). APA (2019) recommends public awareness campaigns to educate consumers about the adverse impacts of plastic waste and to encourage behavior change towards more sustainable options.

Reducing consumption lies at the core of sustainable behavior. As individuals, our choices regarding what and how much we consume directly impact the environment. By embracing conscious consumerism, we can contribute to a more sustainable future. This involves making informed decisions to reduce our ecological footprint and prioritize sustainable alternatives. Research conducted by Jackson (2016) highlights the critical role of reducing consumption in achieving environmental sustainability. The study suggests that transitioning from a culture of materialism and overconsumption to one that values sufficiency and quality of life can significantly reduce resource depletion and waste generation.

Waste prevention is a crucial aspect of sustainable behavior, closely linked to the reduction principle. By preventing waste generation at its source, we can effectively address environmental challenges and conserve resources. This approach emphasizes the importance of reducing packaging, opting for durable products, and avoiding single-use items. According to Schanes *et al.* (2018), waste prevention strategies play a central role in sustainable waste management. The study demonstrates that focusing on waste prevention, such as reducing food waste and promoting circular economy practices, is more effective in reducing environmental impact compared to solely relying on waste treatment and disposal methods.

Embracing responsible consumption is a vital component of sustainable behavior. It involves making informed choices about the products and services we use, considering their environmental impact throughout their lifecycle. By selecting sustainable options, such as

energy-efficient appliances or eco-friendly products, we contribute to reducing our ecological footprint. Research by Vermeir and Verbeke (2006) emphasizes the significance of responsible consumption in sustainable behavior. The study suggests that individuals who are aware of the environmental impact of their choices are more likely to engage in pro-environmental behaviors, including reducing consumption and selecting sustainable alternatives.

Reducing consumption and promoting sustainable behavior are not solely individual efforts but require collective action within communities. Collaborative initiatives such as sharing economies, community gardens, and local exchange systems can foster sustainable practices and reduce overall consumption. By sharing resources and promoting localized production, communities can achieve greater self-sufficiency and reduce environmental impact. Bocken *et al.* (2014) highlight the importance of collaborative initiatives in promoting sustainable behavior. The study emphasizes the role of circular economy business models, where the focus shifts from product ownership to sharing, leasing, and regenerative practices. Such models enable communities to reduce consumption, minimize waste, and create more sustainable socio-economic systems.

2.3 Reusing – role in promoting sustainability

The third "R" of sustainability, "Reuse" advocates for extending the lifespan of products and materials. Reusing items instead of disposing of them after a single use not only conserves resources but also reduces the environmental impact of production and waste management processes. By embracing the concept of circular economy, where materials flow within closed loops, we can minimize waste and maximize resource efficiency.

Research by Chartrand *et al.* (2019) highlights the importance of reusing items in achieving sustainable consumption patterns. The study found that extending the lifespan of clothing through reuse and second-hand markets significantly reduces carbon emissions compared to the production of new garments. Similarly, initiatives such as sharing economy platforms, where people lend or rent items instead of owning them individually, promote resource sharing and reduce overall consumption. One of the primary ways reusing promotes sustainability is by extending the lifespan of products, thus reducing the need for new production and associated resource extraction. By repairing, refurbishing, or repurposing items, individuals and businesses can prevent the premature disposal of goods, thereby conserving raw materials and energy. According to Ahmed *et al.* (2020), extending the lifespan of products by just 10% could result in a 20% reduction in carbon dioxide emissions and a 30% decrease in resource use.

Reusing also contributes to sustainability by conserving energy throughout the product lifecycle. The production of new goods requires substantial amounts of energy, including extraction, manufacturing, and transportation. By reusing items, energy-intensive processes associated with production and distribution can be minimized. A study by Despotović *et al.* (2019) found that reusing electronic devices instead of manufacturing new ones reduced energy use by 70% for smartphones and 85% for laptops. One of the most visible benefits of reusing is the significant reduction in waste generation. The linear "take-make-dispose" model, which dominates many industries, contributes to the mounting waste problem. However, reusing diverts items from the waste stream, preventing them from ending up in landfills or incinerators. A study by Zhang *et al.* (2021) estimated that if 50% of discarded textiles were reused, it could save 3.3 million tons of waste from landfills annually.

Promoting reusing practices requires a shift in consumer behavior and increased awareness of the environmental impact of our choices. Educational campaigns, product labeling, and information dissemination are crucial to fostering a culture of reusing. According to De Massis *et al.* (2020), consumers who are aware of the environmental benefits of reusing are more likely to engage in such behaviors, emphasizing the importance of education and communication in driving sustainable choices.

Analyzing the "reuse" concept it is important to take into account the reuse packaging. Packaging plays a significant role in our daily lives, protecting and preserving products during transportation and storage. However, the excessive use of packaging materials contributes to waste generation and environmental degradation. To address this issue, the concept of reusing packaging has emerged as a sustainable solution that promotes resource conservation and waste reduction throughout the supply chain. By adopting reusable packaging systems, such as crates, pallets, and containers, businesses can eliminate the need for single-use packaging materials. A study by Poovarodom *et al.* (2017) found that implementing reusable packaging in a retail distribution system reduced packaging waste by 85% compared to traditional disposable packaging methods. This waste reduction not only conserves resources but also decreases the burden on landfills and waste management systems.

Reusing packaging materials helps conserve valuable resources, including raw materials, energy, and water. The production of packaging materials, such as plastic, paper, and metal, requires significant amounts of energy and resources. By reusing packaging, these resources can be saved by extending the lifespan of materials. A study by Lindhqvist *et al.* (2018) demonstrated that reusing cardboard packaging over multiple cycles resulted in a 50% reduction in energy consumption compared to the production of new packaging. Implementing packaging reuse systems can yield economic benefits for businesses. Reusable packaging reduces costs associated with purchasing new packaging materials, disposal fees, and waste management. A report by the World Economic Forum (2020) highlighted that implementing a circular packaging model, including reusing packaging, could save businesses up to $10 billion annually in packaging costs.

Reusing packaging also aligns with consumer demands for sustainable practices. A survey conducted by Det Udomsap and Hallinger (2020) revealed that a majority of consumers perceive reusable packaging as more environmentally friendly than single-use alternatives. Consumers are increasingly willing to support brands that embrace sustainable packaging practices, including reuse initiatives. By providing reusable packaging options, businesses can meet consumer expectations, enhance brand reputation, and foster long-term customer loyalty.

2.4 Generation Z

Generation Z, also known as Gen Z, is the demographic cohort following Millennials and represents the cohort born between the mid-1990s and early 2010s. As the first generation to grow up entirely in the digital era, Generation Z exhibits distinctive characteristics shaped by their experiences with technology and the evolving social landscape (Dabija *et al.*, 2019).

Generation Z has grown up immersed in a technologically advanced world. From an early age, they have embraced digital devices and platforms, seamlessly integrating them into their daily lives. According to a study by GfK MRI (2018), 95% of Gen Z individuals aged 13 to 17 own a smartphone, making them the most digitally connected generation to date. This familiarity

with technology has resulted in a high level of technological proficiency and adaptability among Gen Z individuals. Coined as "digital natives," Generation Z individuals possess an inherent understanding of digital tools and platforms. They have grown up navigating social media, online platforms, and search engines, leading to an unparalleled ability to find information and engage with technology. Prensky (2001) explains that digital natives are comfortable multitasking and prefer interactive, visual, and multimedia-rich learning environments. This characteristic has profound implications for education and the workplace, where Gen Z's digital fluency can be harnessed for collaborative and innovative efforts.

Generation Z displays a strong commitment to diversity and inclusivity. Growing up in an era of increased social awareness, Gen Z individuals have embraced progressive attitudes toward race, gender, sexuality, and other forms of identity. A survey conducted by the Pew Research Center (2019) found that Gen Z is the most racially and ethnically diverse generation in the United States, with 48% being non-white. This diversity has fostered a generation that values inclusivity, equality, and social justice, advocating for change and challenging traditional norms. Generation Z exhibits a notable entrepreneurial spirit. The proliferation of digital platforms and the gig economy have empowered Gen Z individuals to monetize their skills and pursue entrepreneurial endeavors at an early age. With access to online marketplaces, crowdfunding platforms, and social media, Gen Z has embraced self-employment and side hustles. A study by Upwork & Freelancers Union (2019) revealed that 53% of Gen Z individuals freelance, highlighting their resourcefulness, self-motivation, and desire for autonomy.

Generation Z is characterized by a heightened awareness of environmental issues, particularly climate change. Growing up in a time of increased environmental activism and the global climate movement, Gen Z individuals are more likely to understand the urgency of the climate crisis. A study conducted by Cone Communications (2017) found that 89% of Gen Z respondents believe that companies should take action to help solve environmental and social issues. This climate consciousness is driving Gen Z's commitment to sustainable behaviors. Generation Z exhibits a preference for eco-friendly and sustainable products. Research conducted by Nielsen (2020) revealed that Gen Z consumers are more willing to pay extra for sustainable and environmentally friendly goods compared to previous generations. This inclination toward eco-conscious consumerism has spurred the growth of sustainable brands and influenced companies to adopt environmentally friendly practices. Gen Z's emphasis on sustainability is reshaping market dynamics and encouraging businesses to adopt more sustainable practices throughout their supply chains.

Generation Z is embracing minimalism and waste reduction as part of their sustainable lifestyle. They are keen on reducing waste and adopting practices such as recycling, composting, and reusing. So, Gen Z individuals are more likely to engage in sustainable behaviors such as reducing single-use plastic consumption and embracing a circular economy (Dabija *et al.*, 2019). This commitment to waste reduction is driven by a desire to minimize its environmental impact and create a more sustainable future. Generation Z is leveraging social media and digital platforms to drive environmental activism. They are vocal advocates for sustainability and are using their collective voices to raise awareness, influence policy changes, and promote sustainable practices. A study by Jagers (2017) found that Gen Z is more likely to participate in collective action for the environment, such as signing petitions or participating in protests. The digital connectivity of Gen Z enables them to mobilize quickly and amplify their environmental messages to a broader audience, driving positive change.

Generation Z is demonstrating a preference for careers that align with their values and contribute to sustainable development. A survey by Deloitte (2020) revealed that 77% of Gen Z respondents considered a company's sustainability practices when choosing where to work. Gen Z individuals are seeking careers in renewable energy, sustainable agriculture, environmental advocacy, and green technology. Their ambition to make a positive impact on the environment extends beyond personal actions, with a focus on driving systemic change through their professional pursuits.

3. METHODOLOGY

For this study, we undertook two types of research. In the first stage, a desk-research was carried out which aimed to gather information about the retailers under consideration. For this scientific approach, we focused on some companies in the fast-moving consumer goods (FMCG) field. The decision is motivated by the fact that the FMCG industry has long been a cornerstone of global economies, encompassing a wide range of frequently purchased products. From everyday household items to personal care products and food and beverages, FMCG goods play an essential role in our daily lives.

Fast-moving consumer goods are products that have a relatively short shelf life and are consumed or replaced frequently. They are typically low-cost items that are in high demand and are purchased without much deliberation. Examples of FMCG products include toiletries, packaged foods, beverages, cleaning products, and over-the-counter medications. Consumer demand plays a vital role in shaping the FMCG industry. Rapid urbanization and the expansion of the middle-class population have led to increased consumer spending power, driving the demand for FMCG products. Consumers' growing awareness of health and wellness has also influenced their purchasing decisions, leading to a surge in demand for organic, natural, and healthy FMCG products (Nielsen, 2021)

Among the existing retailers on the market, to carry out this research, we analyzed the sustainable behavior of the companies Kaufland, Profi Romania, and Lidl. According to available statistical data, in 2022, the retailer Lidl was the market leader, followed by Kaufland - part of the Schwartz group. Thus, we turned our attention to the Profi Romania group (a company located in fourth place in the ranking) (Nicolae, 2023).

For the retailers considered we analyzed the packaging storage spaces they have at the entrance to the stores or in the parking lot. It should be noted that this measure was taken as a result of ordinance no. 1074/2021 which assumes that every retailer that has an area of more than 200 sqm must have special machines (GRS) or other forms of selective collection to help customers in the packaging recycling process.

In the second stage, we carried out a quantitative research among people from Generation Z. The research instrument was represented by a questionnaire consisting of 14 questions regarding the motivation for recycling plastic packaging and aluminum cans, the place where they recycle, the attitude towards recycling, and future intentions. The items are part of validated scales, having support in specialized literature, some of these items are mentioned in Table no. 1.

Table no. 1 – Items used for the questionnaire

Source	Items
Smeesters *et al.* (2003)	I recycle with care for the environment. I recycle because it is a social duty. I recycle because that's what the legislative regulations require. I recycle because it is an easy/easy process. I recycle because it's healthy for me. I recycle for economic reasons (I receive vouchers, rewards, etc.).
Vining and Ebreo (1989)	I recycle because in this way I contribute to the conservation of resources. I recycle because that way I reduce the amount of waste produced. I recycle because the people around me do.
Hage *et al.* (2009)	I recycle because it's a moral duty.
Arli *et al.* (2020)	Recycling substantially reduces the use of landfills. Recycling protects natural resources. Recycling will make a difference to the quality of the environment. I will try to recycle my waste at home every day for the next month.

The final part of the questionnaire included the segmentation variables: background, gender, level of education, etc. The questionnaire was applied in the spring of 2023 (February - April 2023), and the sample consisted of 500 persons. The respondents were represented by young people who are part of Generation Z, aged between 18 and 24 years. For the sample, we aimed to maintain a gender ratio, with the distribution being 57% female and 43% male. Regarding the area of origin, the majority of respondents (83%) come from the urban area.

From a statistical perspective, for this research, having in view the resulting database, we ran descriptive statistics, which show us the generational profile, and consumption preferences. Following the analyses carried out, it could be observed that 89.6% of respondents recycle plastic packaging, their percentage being higher than those who opt for recycling aluminum cans (62.4%). Equally, most respondents mention that they recycle plastic packaging or aluminum cans with a frequency of two to five times a week, the preferred location for this process being their own home.

4. FINDINGS

4.1 The findings of the documentary research

As part of the documentary research carried out, we analyzed the spaces intended for selective collection, taking into account the previously mentioned retailers.

According to Figure no. 1, the selective collection action includes plastic and glass packaging, as well as aluminum cans. Thus, when customers go shopping, they have the opportunity to bring the packaging and get rid of it in an organized way, using the containers located in the store's parking lot.

In Figure no. 2, the poster promoting the campaign carried out by Kaufland Romania is visible. Similar to the program developed by Lidl and in the case of the Kaufland retailer, plastic packaging, and glass or aluminum cans are targeted. The major difference compared to the competing company is that, if at least 3 packages (of the same or different categories) are recycled, the customer can receive a voucher based on which they benefit from different discounts on distinct product ranges. Discounts are mentioned both on the website and in the app.

Figure no. 1 – Lidl Romania – Packaging collective selection
Source: Lidl Romania (2021)

Figure no. 2 – Kaufland Romania – packaging collective selection
Source: Kaufland (2022)

Unlike Kaufland and Lidl, Profi Romania (Figure no. 3) was the first retailer to bring GRS machines to support customers. As part of a pilot program, some stores in Timisoara, Cluj-Napoca, and Bucharest were equipped with this equipment, so that customers could recycle plastic packaging and aluminum cans before the legislative regulations appeared. Because they believe that rewards are important in the process of educating consumers, Profi representatives offered vouchers to consumers based on the number of recycled packaging, and these could be used on subsequent store visits.

So, whether it is the retailers' initiative or the legislative regulations that compel them to equip their stores with this equipment, at present, every retailer in the FMCG sector has a space dedicated to selective collection. Individuals must become aware of the importance of recycling and contribute to a cleaner environment by storing packaging in specially designed spaces.

Regarding the promotional actions of the considered retailers, their advertising spots are based on some key concepts such as “recycling", “sustainability", packaging", and “environment". We believe that the use of these phrases helps to fix the message in the consumers' minds, in the end, they remain with the idea that retailers are actively involved in protecting the environment and implementing sustainable principles, by carrying out the recycling process.

Figure no. 3 – Profi Romania – Packaging collective selection
Source: made by the authors

At the same time, analyzing the campaigns carried out, it is important to refer to the company of which the organizations are a part. For example, Lidl and Kaufland are companies that are part of the Schwartz group. The motto under which they have defined their sustainability report is “Be a part of our sustainable future", conveying to their customers that, in reality, they are part of the change. At the group level, in Germany, they launched the REset Plastic initiative, which is a recycling program that encourages consumers to continue this process. Unlike Romania, which is an emerging market even from this point of view, in Germany, the packaging recycling process represents an aspect deeply rooted in the citizens' consciousness, being a habit they practice continuously. Through the REset Plastic program, Schwartz representatives aim to create their own-brand packaging as recyclable as possible by 2025, reducing the amount of plastic used by approximately 20%. Also, in the next two years, they aim to use an average of 25% recycled material in their private label packaging made of plastic (Schwartz Group, 2021).

Sustainable behavior is increasingly being implemented by large groups operating in the retail sector. The Ahold Delhaize Group, under the slogan “Grounded in Goodness", aims at three directions: “Healthier People and Healthier Planet", “Partners” and “Environmental, Social and Governance performance". Practically, through the axes on which it acts, it aims to protect the environment, combat climate change, and food shortages, and establish relations with local producers, who have the opportunity to supply healthy products, thus contributing to the development of the local economy (Ahold, 2023a).

Equally, they pay more attention to aspects related to waste management. Starting from the premise that a very large amount (millions of tons) of plastic is found thrown into nature, polluting the seas and oceans, the group is actively involved in the process of eliminating plastic waste. Thus, they try to reduce the plastic packaging they use, thus, the materials used are 100% reusable, recyclable, or compostable (Ahold, 2023b).

Thus, recycling behavior, which we consider an element of novelty, is already implemented in developed countries, being adopted by consumers. Although it is at the beginning of the road in terms of the new process, Romania benefits from the existing legislative framework, and the retailers in the market provide the necessary infrastructure to encourage consumers to recycle.

4.2 The findings of quantitative research

Before conducting the quantitative research, we analyzed the behavior of Generation Z globally through a documentary research. The collected data are presented in Table no. 2.

Table no. 2 – Generation Z behaviour around the World

	Generation Z	Source
Australia	60% of respondents from Gen Z are willing to pay more for brands that try to have a positive impact on society and brands that treat employees and suppliers fairly.	Statista Research Department (2023b)
France	Nearly two-thirds of respondents from Generation Z were willing to pay at least five percent extra for a carbon-neutral delivery when shopping online.	Beyrouthy (2022)
United Kingdom	Over 80% of Generation Z consumers stated they would be willing to pay at least ten percent more for products if the items in question were considered sustainable.	Tighe (2022)
United States and Canada	Almost 60% of Gen Z consumers stated that they prefer purchasing environmentally sustainable products.	Tighe (2020)
United States	37% of surveyed Gen Z consumers are willing to pay a premium for environmentally sustainable products.	Tighe (2020)
Canada	31% of Gen Z consumers are willing to pay a premium for environmentally sustainable products.	Tighe (2020)
China	87 % of the respondents stated they would pay more for a brand that supported the issues they care about.	Ganbold (2022)
Japan	44 % of Gen Z consumers said they would pay more if a brand supported the issues they cared about	Ganbold (2022)

Also, we analyzed waste recycling around the world. The results are presented in Table no. 3.

Table no. 3 – Waste recycling around the World

Country	Waste recycling around the World	Source
Spain	Generated over 3.8 million metric tons of paper and cardboard packaging waste (the largest packaging waste stream in the Mediterranean country, followed by plastic and glass).	Alves (2023)
Spain	The amount of plastic packaging waste generated surpassed 1.7 million tons that year.	Alves (2023)
Hungary	47 kilograms of plastic packaging waste produced per capita.	Statista Research Department (2023a)
United Kingdom	The recycling rate from waste from households was 44.4% in 2020 - a decrease from 46 percent in 2019.	Statista Research Department (2023a)
Wales	The highest recycling rate for household waste in the UK (56.5%).	Alves (2023)
Scotland	The lowest recycling rate (41%).	Alves (2023)
Ireland	The biggest producer of plastic packaging waste per capita in the European Union in 2020 (61.52 kilograms per person).	Alves (2023)

According to our research, carried out on the sample considered, 89.6% of respondents mention that they recycle plastic packaging (Figure no. 4), and 62.4% recycle aluminum cans (Figure no. 5).

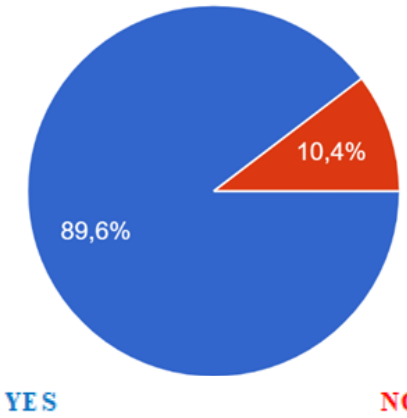

Figure no. 4 – Plastic packaging recycling
Source: authors' calculations

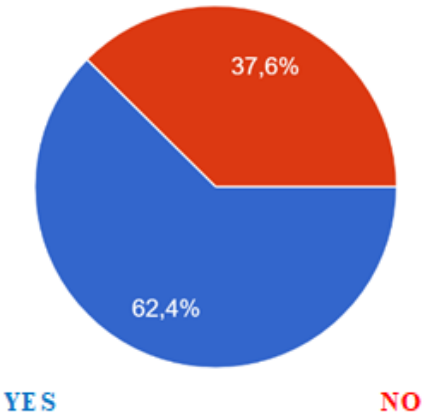

Figure no. 5 – Aluminum cans recycling
Source: authors' calculations

As we can see, fewer respondents state that they recycle aluminum cans, a possible reason being the fact that quite a few products we consume/use have plastic packaging.

Another important aspect that was captured by the research carried out concerns the frequency of recycling plastic packaging or aluminum cans.

Figure no. 6 shows that, for the sample considered, in the last three months, most consumers have recycled plastic packaging or aluminum cans two to five times. Considering the rather long interval we considered – three months, the recycling frequency is quite low. Thus, we can conclude that the habit of recycling packaging is not yet rooted in the usual behavior of consumers.

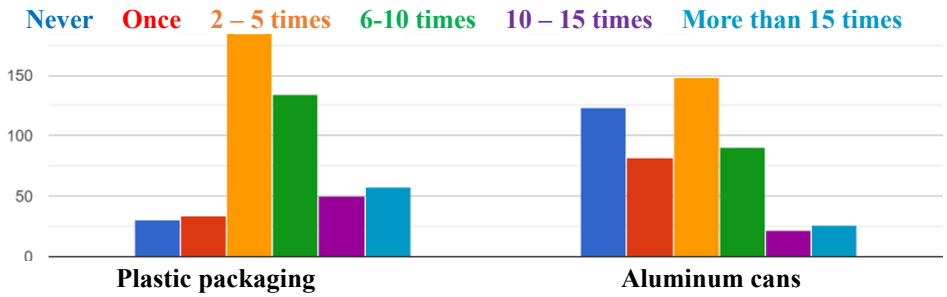

Figure no. 6 – Recycling frequency
Source: authors' calculations

One of the most important aspects we looked at in conducting this research was related to where consumers recycle. In the case of plastic packaging, most of the respondents mentioned that they carry out this action at home, later storing them in specially arranged

spaces (Figure no. 7). The second option mentioned was at the big stores. Starting from these considerations, we can conclude that the retailer's installation of devices that allow selective collection is a beneficial and important aspect for consumers.

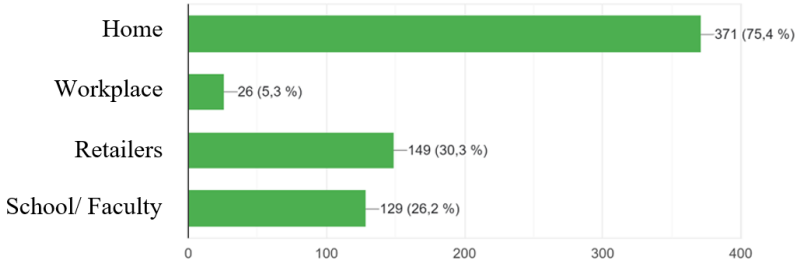

Figure no. 7 – Recycling plastic packaging location
Source: authors' calculations

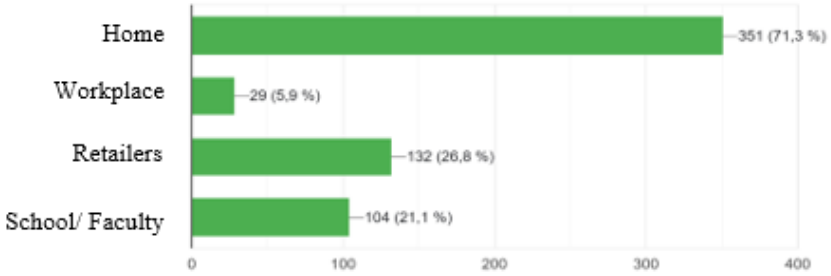

Figure no. 8 – Recycling aluminum cans location
Source: authors' calculations

With small differences related to the number of respondents, the previously established hierarchy is also preserved in the case of recycling aluminum cans (Figure no. 8).

5. DISCUSSION

Sustainability is a powerful tool to address the pressing environmental, social, and economic challenges of our time. By adopting sustainable practices, we can reduce our ecological footprint, promote social equity, and unlock economic opportunities. The integration of sustainability into all aspects of our lives, from individual choices to government policies, is essential for creating a greener and more sustainable future. Recycling is a fundamental component of sustainable waste management, enabling the conservation of resources, energy reduction, waste reduction, and economic benefits. By actively participating in recycling practices and supporting initiatives that promote recycling, individuals, communities, and governments can contribute to a more sustainable future. The integration of education, infrastructure development, and policy support will pave the way for a circular economy where resources are utilized efficiently, waste is minimized, and the environment is protected for future generations. Also, recycling creates jobs and promotes economic growth.

In the pursuit of environmental sustainability, the principle of reduction plays a central role. By minimizing consumption, preventing waste, embracing responsible consumption, and fostering collaborative initiatives, individuals and communities can contribute to a more sustainable future. The importance of reduction as a part of sustainable behavior is supported by research highlighting its positive impact on resource conservation, waste reduction, and the overall well-being of our planet. By adopting reduced practices, we can make a meaningful difference and create a more sustainable world for future generations. Reusing plays a pivotal role in promoting sustainability by extending the lifespan of products, conserving energy, reducing waste, creating jobs, and encouraging a shift towards more sustainable consumption patterns. The benefits of reusing extend to both the environment and the economy, making it a crucial element in the transition towards a circular economy. By recognizing the value of reusing and adopting practices that support it, individuals, businesses, and policymakers can collectively contribute to a more sustainable future.

In the recycling process, we have to consider that there are at least two parties involved: on the one hand the retailers and on the other hand the customers. Of course, for retailers to help consumers recycle, public education is necessary. Practically, the recycling infrastructure exists in the market, and retailers have adapted to the existing legislative framework. Thus, the question arises of how we can convince customers to recycle, using devices available on the market. Through public education campaigns, retailers can bring the existence of recycling infrastructure to the attention of customers. Also, the guarantee-recycling systems (GRS) can be brought closer to the consumer, through their positioning.

Equally, we must not omit the fact that Romania is an emerging market. In our case, there is the legislative framework that informs us what measures retailers must take, and how consumers must be involved in this process, but usually due to ignorance, the legislation is more difficult to implement. In this case, to support customers, retailers have implemented GRS machines, which allow offering direct rewards in the process of stimulating recycling.

Another direction that can be followed for retailers to encourage customers to recycle would be through campaigns with public authorities and town halls, with school units, as well as with companies with a large number of employees. In addition to running educational programs in schools, to introduce the concept of recycling in the minds of potential customers from a young age, they could also run these campaigns for organizations that have a large number of employees. Last but not least, through collaboration with public authorities, depending on the recycled packaging, customers could receive vouchers that can be used at the retailers considered.

In the theoretical part of this paper, we mentioned some statistics related to the recycling process carried out in other states and the level at which it is located. Speaking of more developed markets, public education is more advanced, so the involvement in the recycling process is also more extensive. Thus, we must also take into account the experience that developed countries have in the sphere of sustainability. For example, Wales has the highest recycling rate (56.5%), but they are more than 15 years old in the recycling process, which means that citizens already treat this aspect as a habit.

6. CONCLUSION

While recycling as a practice is undoubtedly crucial for environmental sustainability, the location where recycling takes place holds equal significance. Proximity to waste generation,

accessibility and convenience, community engagement and education, economic considerations, and environmental justice are all factors that underscore the importance of the place where we recycle. By recognizing and addressing these factors, we can optimize recycling systems and foster a more sustainable future. As we can see from the research carried out, most consumers prefer to recycle packaging from the comfort of their own homes or at large stores. For this reason, we believe that retailers, even in the absence of legislation to this effect, should pay more attention to collective selection spaces and encourage consumers in the recycling process.

Efforts to reduce waste play a pivotal role in creating a sustainable future. By embracing strategies such as the Three Rs, extended producer responsibility, composting, zero waste initiatives, and plastic waste reduction, we can minimize the environmental and social consequences of waste generation. Governments, businesses, communities, and individuals must collaborate to drive systemic change and foster a waste-conscious society. Through education, policy support, and collective action, we can create a world where waste is minimized, resources are conserved, and a sustainable future is secured.

Generation Z represents a unique cohort shaped by the digital age and its accompanying dynamics. Their characteristics, such as technological savviness, digital nativism, diversity and inclusion advocacy, entrepreneurial spirit, and mental health awareness, set them apart from previous generations. Understanding these distinctive traits is essential for educators, employers, marketers, and policymakers, as they shape strategies and approaches to effectively engage and cater to the needs of Generation Z. By embracing their strengths and leveraging their digital fluency, society can unlock the immense potential of this generation. Moreover, retailers should try to benefit from the expertise and willingness of young people to be involved, as they respond in a positive way to the social responsibility actions initiated by companies.

7. RESEARCH LIMITS AND FUTURE RESEARCH DIRECTIONS

When discussing the limitations of the research, the first important aspect to mention is that we only considered three retailers: Profi Romania, Lidl, and Kaufland. Of course, sustainable behavior can be different depending on the retailer's size, financial resources, and market experience. Thus, for an overview of the retail market in Romania, there is the possibility of expanding this analysis by taking into account a larger number of companies (Auchan, Carrefour, Penny, etc.).

Another possible limitation of the research may be given by the selected sample. For this study, we only considered members of Generation Z, based on the premise that they are more involved in social responsibility campaigns and environmental protection actions, and have a sustainable behaviour. In the future, we consider expanding the research by analyzing the behavior of Generation Y and Generation X.

Also, another limitation of this research may be the sampling method we selected. In this case, we opted for convenience sampling, without considering aspects related to consumer preferences. Changing the sampling method and adopting a probabilistic method is likely to generate distinct results.

Another future research direction is the analysis of sustainable behavior towards other materials such as glass and paper. In this research, we only analyzed the sustainable impact of recycling plastic packaging and aluminum cans.

In the future, we aim to continue this research by considering retailers in other domains. For example, we thought of companies active in the Do-IT-Yourself (DIY) or fast-fashion sector. Thus, we aim to see how these retailers motivate consumers to recycle, respectively to follow what measures these organizations adopt.

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Exchange Rate Changes and Trade Flows in East Asia

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Abstract: This study investigates the impact of exchange rate changes on trade flows among East Asian countries spanning 1990–2021, using pooled mean group estimator, within the framework of panel data analysis. Findings indicate that world income, trade openness, and the real effective exchange rate strongly affect trade balance, and that the real depreciation of exchange rate exerts strong positive benefits on trade flows in the long run. The study also infers that trade openness and real effective exchange rate had strong influence on exports and imports for Hong Kong, Japan, and South Korea in the short run. However, the depreciation of their currencies discouraged imports in the long run. More so, world income strongly affects the exports and imports of Hong Kong and Japan, while trade openness is advantageous for all the countries. The study recommends the continuation of the prevailing trade-growth pattern, and the existing bilateral pegged exchange rate policy with their trading partners.

Keywords: asymmetry; East Asia; exchange rate; trade flows.

JEL classification: F14; F31; O24; P33; P45.

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1. INTRODUCTION

Since the breakdown of the Bretton Woods Agreement, characterized by the Nixon crisis of the 1970s, there appeared to be a dramatic shift from the fixed to the floating exchange rate regimes globally. Monetary authorities all over the world simultaneously adopted either the flexible or managed float regimes at one point in time or the other. A common feature with the flexible regime is its high susceptibility to incessant fluctuations with its attendant implications on a range of macroeconomic fundamentals, such as trade flows. Trade flows, has to do with the sum total of the transactions and movement of goods and services between one country and another (Doojav, 2018; Gbaka *et al.*, 2023).

One prominent feature with both developed and developing economies was the systematic devaluation or depreciation of their currencies relative to US dollar as a trade-enhancing measure. Against the backdrop of persistent negative balance of payments crises experienced, most developing economies (East Asia inclusive), embarked on the depreciation or devaluation of their local currencies in order to boost their export and curtail imports. However, devaluation can only yield positive tangible impact on trade balance and output if and only if the sum of elasticities of exports and imports for a country exceed unity, which is in consonance with the postulations of the Marshall-Lerner condition. The J-curve hypothesis on the other hand emphasizes an initial fall in the value of domestic output and trade balance, following the depreciation/devaluation of a nation's currency, up to a minimum point, after which trade output rises with trade balance, thus conforming to an identical J-shaped curve. However, the validity or otherwise of these models has constituted an unresolved debate in the literature. For instance, Doojav (2018), Karamelikli and Ongan (2022), Guo (2020), Adhikari (2018), Iqbal *et al.* (2015), and Choi (2012) for Marshall Lerner condition, and Ijirshar *et al*. (2023), Jain and Das (2022), Bahmani-Oskooee *et al.* (2020), Duru *et al*. (2022) for the case of J-curve hypothesis.

Some related studies such as Shahbaz *et al.* (2012) and Baharumshah (2001) found no support for the J-curve, with Shahbaz *et al.* concentrating on the real exchange rate and trade balance relationship in Pakistan, and Baharumshah examining the trade dynamics of Malaysia and Thailand with the US and Japan. These studies were limited in terms of the response of exports to changes in exchange rate and the substitution effect of imports leading to the long-run positive benefits of exchange rate changes. Besides, the Marshall-Lerner condition and country-specific effects were limited given the methodologies employed. In alignment with the methodology employed by Baharumshah (2001), and closely related to the current study, Onafowora (2003) concentrated on South-Eastern Asia, distinct from the current study's focus on Eastern Asia. Although Onafowora (2003) traced the effects of shocks on trade balance for each country in South-Eastern Asia, variations in trade composition, trading patterns, and the responsiveness of exports and imports to exchange rate changes may differ among Eastern Asian countries even within the same region. In a similar approach of using generalized impulse response functions, Hacker and Hatemi-J (2004) validated the J-curve for three transitional central European countries, while Barkat *et al.* (2022) confirmed its existence for Gulf Cooperation Council countries using a comparable approach. Other studies examined the asymmetries between exchange rate changes and trade balance (Tochitskaya, 2007; Chang *et al.*, 2018), while others have confirmed the evidence of J-curve (Trinh, 2014).

Exploring specific cases from Eastern Asia, Bahmani-Oskooee and Baek (2016) revealed asymmetric effects in Korea's bilateral trade with the US, while Barkat *et al.* (2022)

extended the analysis to seven Asian countries. These studies, covering Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, and Thailand, identified asymmetric effects in the selected Asian economies. Recognizing the uniqueness of each country in its trade responses to exchange rate changes, as well as the trade pattern and composition of these Asian countries, it has become imperative to unravel these conjectures and add to the existing debate on the subject matter in the light of the East Asian region.

Recent developments reveal that Asian countries feature prominently in the global business arena, and are fast becoming a global business hub. Most economies in East Asia particularly are either developed, developing or transition countries. Not only that they have increasingly opened up their economies to international trade participation and are major trade partners to the EU, Euro-Asian region, USA and Africa (Wilson *et al.*, 2003), they are also key players in the virtual market, portfolio investment and foreign direct investment. Changes in exchange rates due to its depreciation is expected to produce both symmetric and asymmetric impact on trade flows and output. Earlier studies in the 1970s concluded that its impact on trade is always expected to be negative. However, the works of de Azevedo *et al.* (2023), and Bahmani-Oskooee and Payesteh (1993) later confirmed the possibility of a positive impact.

The East Asian region comprises such countries as China, Hong Kong, Japan, Macau, Mongolia, North Korea, South Korea and Taiwan. With a landmark of 11,840, 000 square kilometers and an estimated population of about 1.69 billion people (United Nations, 2023 Estimates), the region is home to developed, transition and low income economies. These countries witnessed tremendous productivity growth in recent times, amidst exchange rate depreciation/devaluation of their local currencies. Innovations in the form of banking revolution, Research & Development (R&D), technological advancement, internet revolution and e-commerce have witnessed tremendous transformations in the region, especially in the last three decades. Taiwan and Hong Kong, currently classified as high income economies for instance, are labelled among the "Four Asian Tigers", with massive magical transformation from typical underdeveloped to the verge of becoming developed economies (Hamadeh *et al.*, 2022). China is an upper middle income country, while Japan, another high income economy is currently being reckoned among the developed economies of the world. Mongolia, a resource-rich economy is ranked as the lower middle income economy since 2015 (Hamadeh *et al.*, 2022), just as South Korea and Macau are equally high income economies, with only North Korea ranking as a low income economy. It is equally on record that Asian advanced economies and China have recently emerged as the *innovation hubs* of the world, with about 57% of all global patents and 58% of the entire patents for digital technologies in 2020. Conversely, other Asian emerging market and developing low income economies are severely lagging in terms of innovation, accounting for a negligible share of 1% and 0.3% respectively for the same year (IMF, 2022).

Apart from Mongolia, the rest of the countries witnessed significant positive trade balance between 2011 and 2021, with slight fluctuations. Statistics from the World Bank (2022) Database reveal that the average net trade in goods over the period rose to US $5.56 billion for Hong Kong, US $2.70 billion for China, US $2.57 billion for Macau, US $0.24 billion for North Korea and US $5.25 billion for South Korea. On the other hand, Mongolia, and Japan suffered a decline in merchandize trade to the tune of US $-3.84 billion, and US $-4.19 billion respectively within the same decade. However, it is not very clear whether the giant economic feat simultaneously attained by these economies is connected with the persistent depreciation of their local currencies. This informs the motivation behind this study.

Moreover, the conflicting submission about the impact of exchange rate fluctuations on trade flows remains a hot debate in the literature (Perée and Steinherr, 1989; Chowdhury, 1993; Stokman, 1995; Kearns and Patel, 2016; Yakub *et al.*, 2019; Ijirshar *et al.*, 2023).

Arising from the above premise therefore, the following pertinent questions have been posed; 1. What has been the driving force of favourable trade flows achieved among the East Asian economies in recent times? 2. Has devaluation/depreciation as a market penetration strategy actually been instrumental in accelerating and sustaining the favourable trade position recorded by these economies? 3. Does the trade pattern of the East Asian economies satisfy the Marshall-Lerner condition and hence, exhibited the J-curve hypothesis? The actual impact of exchange rate fluctuation on trade flows, particularly in the East Asian region also appears to be lacking in the literature due to the mixed findings by previous studies. This study therefore fills this gap by determining whether or not devaluation as a market penetration strategy has actually been instrumental to accelerating and sustaining the pace of favourable trade position achieved in recent times by the East Asian economies, with particular focus on examining the asymmetric influence on the disaggregated values of trade flows (trade balance, imports, and exports), while accounting for specific country effects and heterogeneity among the countries using panel nonlinear autoregressive distributed lag (NARDL) approach. To do this, the study is structured into six sections. Section 2 deals with theoretical framework as well as with the review of empirical literature. The methodology of this study is captured in Section 3. While Section 4 deals with data presentation and analysis, Section 5 concludes and recommends policy implications for the regional economy.

2. LITERATURE REVIEW

2.1 Theoretical framework

This study employs a blend of theories to elucidate the intricate relationship between fluctuations in exchange rates and trade flows. The Purchasing Power Parity (PPP) theory, originating from the Salamanca School in 16th-century Spain and later refined by Cassel in 1918, posits that the nominal exchange rate between two currencies should mirror the ratio of aggregate price levels in their respective nations. This concept implies that a unit of currency from one country should have equivalent purchasing power in a foreign country. This theory links a country's current account transactions to foreign exchange market dynamics, drawing parallels to the "law of one price" model, which asserts that identical goods should share the same price in distinct markets. Despite criticisms for its static assumptions and disregard for non-trade-related exchange rate influences, PPP remains a valuable tool to understand currency value instability and its relation to inflation differentials.

The International Fisher Effect (introduced by Fisher in 1929) offers an alternative perspective, attributing exchange rate volatility to expected inflation rates and the gap between real and nominal interest rates, while highlighting the significance of interest rate parity. This theory underscores the role of interest rates and inflation expectations in driving exchange rate movements. While PPP focuses on price level differentials, the International Fisher Effect draws attention to interest rates and their impact on exchange rate behavior. Both theories provide valuable insights into understanding exchange rate dynamics, each offering a unique lens through which to analyze the complex interplay of factors shaping trade flows and currency values in the global economy.

The theory of comparative cost advantage (advanced by Ricardo in 1817), stresses the very precipitating factors upon which international trade flows is anchored. It attributes trade flows between East Asian countries and other nations for instance, to be primarily induced by factors such as variation in natural resource endowments and differences in the relative cost of production of commodities in those nations, which may partially be attributed to exchange rate variations. This would naturally foster division of labor, specialization and maximize world output and welfare. If the comparative cost advantage theory were to be strictly maintained by nations as a guiding principle of international trade, all nations would have possibly attained favorable exchange rates, since each nation's exports would reflect the world's real aggregate demand for her products, while her imports would be her demand for world output, which would in turn naturally cause the nation's exports to exceed her imports, thus, maintaining a favorable balance of payments and her long run real exchange rate stability. This would definitely minimize excessive volatility in the exchange rate of the domestic currencies of Asian economies for instance against other foreign currencies.

The J curve hypothesis (introduced by Davies in 1962) reveals an initial sharp fall in a country's trade balance due to exchange rate depreciation, accompanied by a substantial improvement in the long run. It is often used to observe the impact of a weaker currency on the trade balance of a country. It shows that depreciation/ devaluation immediately ameliorates a nation's trade balance by causing exports to be dearer and imports to be cheaper, hence trade deficit (or a negligible trade surplus). Afterwards, export volume increases gradually proportional to its prices. Consequently, the demand for domestic goods rises since they are comparatively cheaper than imports. However, trade balance recovers due to a rise in net positive returns to equity investment and diversification, which widens the productive base and hence, boots national productivity in the long run. It is not yet clear if the sustained economic progress apparently witnessed among the East Asian economies is in conformity with the postulations of the J curve hypothesis, given the simultaneous depreciation in their national currencies, especially in the last three decades. This study is therefore an attempt to verify the validity or otherwise of this model, in the context of the East Asian countries. The Marshall-Lerner condition (propounded by Marshall and Lerner in 1870), states that depreciation/devaluation of a country's currency can only be beneficial to such a country only if the sum of elasticity of its absolute imports and exports is greater than unity (Bahmani-Oskooee *et al.*, 2013). Though sharply criticized by scholars such as Choi (2012), due to misleading assumptions and the use of "absolute" as opposed to the "relative prices" of imports and exports, the model still remains a useful tool for analyzing exchange rate dynamics as well as policy prescription in a typical economy.

2.2 Review of related empirical literature

The empirical review section is considered under the following strands; the nature of the impact or relationship between exchange rate fluctuations and trade flows in perspective, the transmission channels involved, the degree of asymmetry and the persistence or strength of the volatility. Recently, literature has increasingly shifted focus to capture a unique aspect of international economics which has to do with the response of trade flows to persistent fluctuations in exchange rate. The universal submission by earlier empirical studies in the 1960s up to the 1980s generally indicated that exchange rate fluctuations negatively impacted on trade flows (Bahmani-Oskooee *et al.*, 2020). Such studies claimed that since exchange rate

fluctuation is associated with uncertainty and, hence fuels business risk, its trade impact is always certainly expected to be adverse. Recent theoretical and empirical developments have however proven the possibility of the positive impact of exchange rate fluctuations on trade flows, due to changes in expectation and business forecast that often accompany exchange rate uncertainty. The pioneer works of Perée and Steinherr (1989) provided such empirical support. Thus, depending on the degree of uncertainty and traders' reaction to risk, there is the possibility of changes in exchange rates rather boosting trade. Generally, exchange rate fluctuation is said to constitute risk to business transaction. A trader's response to exchange rate fluctuation is a function of his attitude towards the risk of uncertainty (De Grauwe, 1988). A risk averse trader may tend to avoid risk as exchange rate fluctuation intensifies. Studies have equally alluded to the fact that instability in exchange rate may pose significant risk to business transaction and forecast, thus increasing the chance of uncertainty and negative impact on trade flows. This is applicable to both bilateral and multilateral trade engagements (Perée and Steinherr, 1989; Chowdhury, 1993; Stokman, 1995; Kim and Lee, 1996; Dell'Ariccia, 1998; Yakub *et al.*, 2019; Gbaka *et al.*, 2023). Moreover, some empirical studies treat the trade flow impact of exchange rate volatility from the perspective of either a single country versus the rest of the world; in terms of aggregated bilateral trade flow relations or nominal trade flows involving any two countries.

The impact of exchange rate on the trade balance has been extensively treated in the literature (Baharumshah, 2001; Onafowora, 2003; Hacker and Hatemi-J, 2004; Tochitskaya, 2007; Trinh, 2014; Bahmani-Oskooee and Baek, 2016; Bahmani-Oskooee and Kanitpong, 2017; Chang *et al.*, 2018; Barkat *et al.*, 2022). The general submission is that fluctuation in exchange rate, occasioned by depreciation or appreciation significantly influence trade balance, with variations in the direction and magnitude of impact. For instance, while there was no clear evidence of the J-curve effect established (Baharumshah, 2001; Shahbaz *et al.*, 2012). However, in another strand of empirical literature, the J-curve hypothesis and Marshall-Lerner condition were confirmed (Onafowora, 2003; Hacker and Hatemi-J, 2004; Trinh, 2014; Barkat *et al.*, 2022). Tochitskaya (2007) established a positive influence of exchange rate depreciation on trade balance both in the short and long run, whereas Chang *et al.* (2018) and Bahmani-Oskooee and Kanitpong (2017) obtained asymmetric effects, with only exchange rate appreciation imposing significant effect.

The argument that volatility engenders symmetric behavior in most financial variables, such as exchange rate is also established in the literature. But the effects of exchange rate volatility on trade flows are not just symmetric. Central Banks have developed a means of curtailing the impact of volatility of trade flows via strict monitoring and swift response system; For instance, if the central bank perceives trade flows to fall by 2% due to a rise in exchange rate fluctuation, it may respond accordingly by increasing trade flows by 2% within the period, thus producing asymmetric effects (Kearns and Patel, 2016). Also, not only do domestic prices respond to exchange rate volatility in an asymmetric manner, but import and export prices (Bussiere, 2013) and then the trade balance equally follows suit. Conversely, Bahmani-Oskooee and Payesteh (1993) and Bailey *et al.* (1986) could not obtain a negative relationship between exchange rate fluctuations and trade flows. Frankel and Wei (1993) found contradicting results. Earlier, Thorbecke (2011) had established a close functional link between exchange rate fluctuations and the degree or pattern of trade flows particularly among the East Asian economies.

On the channels of transmission of exchange rate fluctuation to trade flows, Kearns and Patel (2016) identified the working capital channel and financial channel. Exchange rate fluctuations are influenced by factors like government expenditure, money supply, terms of trade, and output shocks (Alagidede and Ibrahim, 2016), as well as government policy and regime type (Mpofu, 2016). In terms of the regime type, such studies are unanimous in their submission that exchange rates are generally more prone to fluctuations during flexible than fixed regimes, though the former is perceived to be relatively more beneficial to the economy.

Earlier studies primarily relied on the Marshall-Lerner condition to gauge the trade impact of exchange rate fluctuations (Arora *et al.*, 2003). The validity or otherwise of this model has been verified by several empirical studies, though there are differences in submissions. A group of scholars have confirmed that the model holds. For instance, see Doojav (2018) for the case of Mongolia using VECM model, Karamelikli and Ongan (2022) for South Korea versus Japan, using ARDL, Panda and Reddy (2016) for India-China trade relations between 1987-2014 using ARDL and Nakatani (2018), using Papua New Guinea as a case study. Other similar findings include Guo (2020) for China involving the period of 2008-2018, using ARDL, though it only validates the traditional as opposed to the so-called generalized model, Iqbal *et al.* (2015) involving multilateral transaction between Pakistan and its ten major trading partners between 1980-2013 but only for 6 trading partners out of the ten sampled countries (US, UK, South Arabia, China, Canada and France). Also, Ali *et al.* (2022) found evidence in support for the Marshall-Lerner condition for 7 disaggregated countries (Japan, China, Kuwait, Germany, US, Saudi Arabia and Italy) and Duru *et al.* (2022) for Nigeria in the long run. Conversely, Adhikari (2018) invalidates the model for the case of US-China trade ties, using VECM model, Guo (2020), Iqbal *et al.* (2015) for Pakistan and its 4 trading partners (Japan, Germany, UAE and Kuwait), Panda and Reddy (2016), Vieira and MacDonald (2016) for 106 selected countries for 2000-2011 and Panda and Reddy (2016), using the ARDL methodology in the long run. Choi (2012) had earlier provided a theoretical and deductive proof that it is practically impossible for devaluation to improve a country's trade balance, even if the Marshall-Lerner condition holds. Instead, it would either reduce or worsen it.

The Marshall-Lerner condition is however considered to be grossly inadequate in adjudging the overall impact of exchange rate fluctuation on the trade balance. This is because, the actual transmission impact usually takes time due to the contract acquisition and execution process, the lag required to adopt and expand the exportable sector and the market adjustment mechanisms (such as the response of the stock market to spot returns on financial assets/portfolio). To arrive at a more balanced analysis therefore, the J curve hypothesis has to be estimated, as it provides a more realistic framework for depicting the long run adjustment of trade balance to changes in exchange rates. This study is therefore an attempt to fill this vital gap in the context of the East Asian economies by testing for the validity of the two models in the region.

The validity of the J curve hypothesis remains a contested issue, supported by studies like Jain and Das (2022), Hsing (2005), and others, while some affirm it only in the short run (Wang *et al.*, 2012; Bahmani-Oskooee *et al.*, 2017). Certain cases show validation in both short and long runs (Panda and Reddy, 2016; Ongan *et al.*, 2018), but others find no evidence for it (Singh, 2004; Duru *et al.*, 2022). These variations might arise from methodological choices, sample frames, or economic differences. This study contributes to the debate by re-evaluating the Marshall-Lerner condition and J curve hypothesis within East Asian economies, acknowledging that outcomes hold regardless of economic nature or development level.

3. RESEARCH METHODOLOGY

3.1 Data description

The study utilized annual panel data spanning from 1990 to 2021, obtained from World Development Indicators. The dataset encompassed several variables, including the real effective exchange rate (measured as an index), trade openness (expressed as a percentage of GDP), and world real GDP (measured in billions of current US dollars), which were employed as explanatory factors. Additionally, trade balance (BoP, current US$) in billions, exports of goods and services (BoP, current US$) in billions, and imports of goods and services (BoP, current US$) in billions were utilized as proxies for trade flows. To determine the elasticities, all variables, except for trade openness, were logarithmically transformed.

3.2 Model specification

To analyze the impact of the exchange rate on trade flows, this study follows the model previously employed by Serenis and Tsounis (2014) and Ijirshar *et al.* (2023) who assert that trade flows are determined by exchange rate and world real GDP, while incorporating trade openness as one of the explanatory variables of trade flows. Therefore, in order to accurately represent the functional relationships and capture the impact of the real effective exchange rate on trade balance (TBAL), as well as exports (EXPT) and imports (IMPT) as proxies for trade flows, both symmetric (equations 1 to 3) and asymmetric (equations 4 to 6) forms are considered (expressed in natural logarithm) as:

$$\ln TBAL_{it} = f\left(\ln REER_{it},\ OPEN_{it},\ \ln \mathrm{WRGDP}_{it}\right) \tag{1}$$

$$\ln EXPT_{it} = f\left(\ln REER_{it},\ OPEN_{it},\ \ln \mathrm{WRGDP}_{it}\right) \tag{2}$$

$$\ln IMPT_{it} = f\left(\ln REER_{it},\ OPEN_{it},\ \ln \mathrm{WRGDP}_{it}\right) \tag{3}$$

$$\ln TBAL_{it} = f\left(\ln REER\_POS_{it},\ \ln REER\_NEG_{it},\ OPEN_{it},\ \ln \mathrm{WRGDP}_{it}\right) \tag{4}$$

$$\ln EXPT_{it} = f\left(\ln REER\_POS_{it},\ \ln REER\_NEG_{it},\ OPEN_{it},\ \ln \mathrm{WRGDP}_{it}\right) \tag{5}$$

$$\ln IMPT_{it} = f\left(\ln REER\_POS_{it},\ \ln REER\_NEG_{it},\ OPEN_{it},\ \ln \mathrm{WRGDP}_{it}\right) \tag{6}$$

where $\ln$ is the natural logarithm, $TBAL$ is trade balance, $REER$ is the real effective exchange rate, $REER\_POS$ is positive changes in the real effective exchange rate, $REER\_NEG$ is negative changes in the real effective exchange rate, $OPEN$ is trade openness, and WRGDP is world real gross domestic product. Anticipating the effects of explanatory variables, a positive influence on trade balance and exports is expected from the real effective exchange rate if the combined elasticity of exports and imports to exchange rate changes surpasses 1, indicating elasticity. Conversely, if this elasticity is below 1, the net

impact on trade balance may be negative. Additionally, increased world real GDP and trade openness are foreseen to positively affect trade flows. The stochastic form of the symmetric models and the asymmetric models for equation (1) and equation (6) gives:

$$\ln TBAL_{it} = \alpha_0 + \alpha_1 \ln REER_{it} + \alpha_2 \ln OPEN_{it} + \alpha_3 \ln WRGDP_{it} + \varepsilon_{it} \quad (7)$$

$$\ln EXPT_{it} = \beta_0 + \beta_1 \ln REER_{it} + \beta_2 \ln OPEN_{it} + \beta_3 \ln WRGDP_{it} + \varepsilon_{it} \quad (8)$$

$$\ln IMPT_{it} = \omega_0 + \omega_1 \ln REER_{it} + \omega_2 \ln OPEN_{it} + \omega_3 \ln WRGDP_{it} + \varepsilon_{it} \quad (9)$$

$$\ln EXPT_{it} = \alpha_0 + \alpha_1 \ln REER\_POS_{it} + \alpha_2 \ln REER\_NEG_{it} + \alpha_3 \ln OPEN_{it} + \alpha_4 \ln WRGDP_{it} + \varepsilon_{it} \quad (10)$$

$$\ln EXPT_{it} = \beta_0 + \beta_1 \ln REER\_POS_{it} + \beta_2 \ln REER\_NEG_{it} + \beta_3 \ln OPEN_{it} + \beta_4 \ln WRGDP_{it} + \varepsilon_{it} \quad (11)$$

$$\ln IMPT_{it} = \omega_0 + \omega_1 \ln REER\_POS_{it} + \omega_2 \ln REER\_NEG_{it} + \omega_3 \ln OPEN_{it} + \omega_4 \ln WRGDP_{it} + \varepsilon_{it} \quad (12)$$

where α_0 is the intercept, while $\alpha_1 - \alpha_3$, $\beta_1 - \beta_3$ and $\omega_1 - \omega_3$ are parameters for symmetric equations (6 to 9) while $\alpha_1 - \alpha_4$, $\beta_1 - \beta_4$ and $\omega_1 - \omega_4$ are parameters for asymmetric equations (10 to 12). $\alpha_0, \beta_0,$ and ω_0 are the intercepts, $\varepsilon_{it} = \mu_i + \eta_{it}$, β_0 =intercept, $\beta_1 - \beta_{10}$ =parameter to be estimated, μ_i =individual specific effect or fixed effects and η_{it} = idiosyncratic error, $i = 1,...,4,\ t = 1,...,32$. The above models have been employed to analyze the dynamic relationship between exchange rate changes and trade flows in four East Asian countries including China, Hong Kong, Japan and South Korea. It therefore follows that in the symmetric models (equation 7-9), the following *a priori* expectations are anticipated: In equation (7), REER< 0; OPEN>0 and WRGDP>0. In equation (8), REER<0, OPEN>0 and WRGDP>0. In equation (9), REER>0; OPEN>0; WRGDP>0.

The real effective exchange rate is expected to exert negative influence on exports and trade balance but positive influence on imports of goods and services. This is because an increase in the Real Effective Exchange Rate (REER) suggests an appreciation of the country's currency in real terms. Thus, when the REER increases, it indicates that the country's currency has strengthened in relation to the basket of foreign currencies, considering both exchange rate movements and changes in relative price levels. The implication is that the nominal exchange rate appreciates making imports cheaper for domestic consumers but reducing the competitiveness of the country's exports in global markets. This means that the country's goods and services become more expensive for foreign buyers when measured in a common currency. Consequently, it discourages exports of goods and services but encourages imports of goods and services.

The trade openness is expected to exert positive influence exports and trade balance and negative influence on imports of goods and services. This is because increased trade openness often means that a country is opening up its markets and reducing trade barriers. This provides domestic exporters with expanded access to international markets, allowing them to reach a broader customer base. Consequently, exporters are likely to find more opportunities to sell

their goods and services in foreign markets. This can lead to an increase in export volumes as businesses take advantage of the newly accessible markets. While increased exports are a positive outcome, the overall impact on the trade balance depends on various factors, including the responsiveness of imports to changes in trade openness and the economic conditions of trading partners. But an increase in trade openness implies greater engagement in international trade, which can affect both exports and imports. The direction of the impact on the trade balance depends on how these two components respond.

The expected impact of world real Gross Domestic Product (GDP) on exports of goods and services and the trade balance is positive. This is because an increase in world real GDP leads to higher demand for goods and services across countries, positively influencing country's exports. This implies the expected impact of world real GDP on exports and the trade balance is generally positive, indicating increased global economic activity and demand for goods and services. On the other hand, the real Gross Domestic Product (GDP) is expected to exert positive influence on imports of goods and services. This is because a higher real GDP often implies increased consumer purchasing power and demand for a broader range of goods and services. Thus, as domestic consumption rises, there may be an increased need to meet this demand through imports, especially for products not readily available or competitively produced domestically.

3.3 Variable description

This study employed this study are presented in Table no. 1 as follows.

Table no. 1 – Description of Variables in the Study

S/N	Variable	Description	Measurement of Variable
1	TBAL	Trade balance	Expressed as the difference between a country's imports and exports in current US$ in billions
2	REER	Real Effective Exchange Rate	Measured as an index, which is expressed as the product of the exchange rate and the ratio of the foreign to domestic prices, multiplied by 100.
3	OPEN	Trade Openness	Determined as the ratio of the sum of export and import to GDP, and expressed as a percentage.
4	WRGDP	World Real Gross Domestic Product	Measured in billions of current US dollars
5	EXPT	Exports	Measured in Billions (BoP, current US$)
6	IMPT	Imports	Measured in Billions (BoP, current US$)

Source: authors' construction

3.4 Techniques of data analysis

The study begins by examining descriptive statistics and conducting various unit root tests, including Harris-Tsavalis, Breitung, Levin-Lin & Chu panel unit root tests, Im-Pesaran-Shin, ADF Fisher panel unit root tests, and Pesaran CD Test. The results confirm no common unit root process through the Hadri Lagrange Multiplier Stationarity test. The pooled mean group estimator and mean group estimator within non-stationary heterogeneous panel models are utilized, guided by the Hausman test. Granger noncausality is assessed using the Half-Panel Jackknife (HPJ) Wald-type test, and cross-sectional independence is evaluated using Pesaran's test.

4. RESULTS AND DISCUSSION

The findings and analysis are outlined in the following manner.

4.1 Overview of Statistics

Table no. 2 presents the results obtained from the descriptive statistics.

Table no. 2 – Descriptive statistics

	Overall		China		Hong Kong		Japan		Korea	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
TBAL	73.62	86.09	125.99	122.75	14.72	8.56	124.11	52.88	29.67	37.26
REER	110.37	21.46	100.34	15.81	117.78	18.05	98.08	18.52	125.27	20.53
OPEN	114.62	126.40	41.47	11.37	320.22	75.62	25.77	7.22	71.02	16.86
EXPT	651.45	656.88	1183.15	1086.18	373.11	206.41	658.37	204.47	391.17	248.51
IMPT	603.49	588.60	1041.68	978.95	367.42	202.85	644.87	228.48	359.98	221.24
WRGDP	58525.14	15936.10	58525.14	16127.73	58525.14	16127.73	58525.14	16127.73	58525.14	16127.73

Source: STATA 15 output

Results of the descriptive statistics in Table no. 2 reveal that world real gross domestic product (WRGDP) has the overall highest mean of US$58, 525.14 billion, with foreign direct investment (FDI) yielding the least average value of US$50.4836. The series has a highest spread for gross fixed capital formation (GFCF) and the lowest spread for real effective exchange rate (REER). Further results indicate that the average trade balance recorded in the East Asian region stands at US$73.62251. Mean real effective exchange rate (REER), openness index, gross fixed capital formation (GFCF) and foreign direct investment (FDI) for the region within the study period stands at US$110.3664, US$114.6218, US$959.8791 and US$50.4836 respectively. Also, mean real gross domestic product (RGDP) recorded is US$2917.962. Empirical evidence further indicates that the region witnessed more average export than import within the study period.

In terms of individual country performance, all the sampled countries recorded average favorable trade balance with China having the highest value of US$125.9908, followed by Japan with US$124.1123, while Hong Kong recorded the lowest average favorable trade balance of US$14.71617. Similarly, the highest export value was recorded by China (with the average of US$1183.152) as against Hong Kong which witnessed the lowest export performance of US$373.1075. However, China witnessed the highest average imports of US$1041.675 with the least average value of US$367.4199 from Hong Kong.

Hong Kong exhibited a high trade openness index of 320.22% of GDP, while China had a relatively lower index of 41.47%. A higher index indicates stronger trade influence on the economy. East Asian economies generally demonstrated openness to international trade during the study period. Japan's real effective exchange rate (REER) stood below 100 basis points, signaling a robust yen value. Positive Gross Fixed Capital Formation (GFCF) was evident in the region, with China leading at a mean value of US$2189.93. Population values mirrored the same pattern, aligning with other variables, and China had the highest population.

4.2 Results of panel unit root tests

The outcomes displayed in Table no. 3 provide evidence of the variables' stationarity as determined by the panel unit root tests. These results were utilized to ascertain the integration order of the variables. According to Table no. 3, the real effective exchange rate (LREER), openness (OPEN), and imports (LIMPT) were found to have first-order integration (I(1)) across all conducted tests. Conversely, other variables such as trade balance (LTBAL), exports (LEXPT), and world real gross domestic product (LWRGDP) achieved a mixed order of integration (both I(0) and I(1) processes). This implies that, except for world real gross domestic product and export of goods and services (LEXPT) as indicated by the Levin-Lin-Chu unit-root test, all other variables possessed unit roots at levels. However, after taking the first difference, all variables with unit roots achieved integration. To ensure dependable and robust results, non-stationary heterogeneous panel models were employed for estimating the panel. Optimal models were determined based on the Schwarz information criteria (SIC) results.

Table no. 3 – Panel Unit Root Test Results

S/N	Test Method	LTBAL	LREER	OPEN	LEXPT	LIMPT	LWRGDP
1	**Unit root with common process (Ho: Panels contain unit roots)**						
	Harris-Tsavalis (rho)	0.7270***a	0.2295***b	0.1362***b	0.0888***b	0.0874***b	-0.1496***b
	Breitung (t-stat) (Lambda λ)	-7.5128***b	-4.3724***b	-6.5822***b	-7.1990***b	-7.0133***b	-5.7727***b
	Levin, Lin& Chu (t*)	-4.5305***b	-4.7557***b	-3.9030***b	-1.6858**a	-6.1244***b	-1.7457**a
2	**Unit root with individual process (Ho: All panels contain unit root)**						
	Im-Pesaran-Shin (z-t-tilde-bar)	-6.1331***b	-4.7164***b	-5.3689***b	-5.7241***b	-5.7145***b	-6.4954***b
	ADF Fisher (Chi square P)	55.2140***b	-47.6019***b	-43.5089***b	58.1205***b	67.2360***b	62.7714***b
3	**Unit root with cross sectional dependence (Ho: Panels contain unit root or they are homogenous)**						
	Pesaran CD Test [z(t-bar)]	-3.081***b	-4.052***b	-2.752***b	-1.886***b	-2.978***b	
4	**No unit root with common unit root process (Ho: All panels are stationary; Ha: Some panels are stationary)**						
	Hadri (2000) Lagrange	-21.3572***	-16.8746***	31.8933***	38.3923***	38.1130***	39.5084***
	Multiplier Stationarity test (z)	-1.7810b	-0.1675b	-0.5731b	0.4120b	-0.3534b	-1.2375b
	Remarks	Stationary Mixed	Stationary I(1)	Stationary I (1)	Stationary Mixed	Stationary I(1)	Stationary Mixed

Note: The asterisk (*** ** and *) denotes rejection of the null hypothesis at 1%, 5% and 10% level of significance, while a and b indicate stationarity at level and first difference respectively.

Source: STATA 15 output.

4.3 Results of Panel Cointegration Test

Given that there is no evidence of asymmetric effect in the models, the study estimated and presented only the cointegration results of the symmetric model as shown in Table no. 4.

Table no. 4 reveals the result of the cointegration test of the symmetric models. The information indicates that for the trade balance model (LTBAL Model), the results of the Kao test statistics are statistically significant at 1% significant level. However, the Pedroni and Westerlund statistics are not statistically significant at 1%, 5% or 10% levels. None of the tests showed significant results for exports model (LEXPT Model). However, the results of the imports model (LIMPT Model) show that three statistics proved significant (the ADF t value for both Kao and Pedroni test and the Modified Philip Perron t tests). On the basis of the results, the study concludes that there is evidence of long run cointegration among the variables in the models.

Table no. 4 – Cointegration Test Results (Symmetric Models)

	LTBAL MODEL	LEXPT MODEL	LIMPT MODEL
Kao Test Results			
Modified Dickey-Fuller t	-6.3727***	-0.6436	-0.8941
Dickey-Fuller t	-3.8520***	-1.1576	-1.3995
Augmented Dickey-Fuller t	-3.6274***	-1.5415	-1.7474*
Unadjusted modified Dickey-Fuller t	-6.7122***	-0.1282	0.3404
Unadjusted Dickey-Fuller t	-3.9012***	-0.8877	0.1168
Pedroni Test Results			
Modified Phillips-Perron t	0.1209	1.4778	1.7874**
Phillips-Perron t	-1.1177	0.7220	1.2315
Augmented Dickey-Fuller t	-0.9902	1.2219	1.6056*
Westerlund Test Results			
Gt	-3.138**	-2.598	-2.612
Ga	-6.769	-6.842	-6.197
Pt	-6.634***	-1.755	-2.990
Pa	-14.369**	-3.43	-6.906

Note: *** p<0.01, ** p<0.05, * p<0.1

Source: extracted results from STATA

4.4 Results of Granger causality test

Table no. 5 contains the results of the Granger non-causality tests for the heterogenous panels developed by Juodis *et al.* (2021).

Table no. 5 – Panel Non-Causality Test Results

Causality Flow	Z stat	Prob. value	Decision
H_0: LTBAL does not Granger-cause LREER	1.21	0.225	Accept H_0
H_0: LREER does not Granger cause LTBAL	1.89	0.058*	Accept H_0
H_0: LREER does not Granger cause LIMPT	-2.09	0.036**	Reject H_o
H_0: LIMPT does not Granger cause LREER	-1.57	0.117	Accept H_o
H_0: LREER does not Granger cause LEXPT	-2.68	0.008***	Reject H_0
H_0: LEXPT does not Granger cause LREER	-5.25	0.000***	Reject H_0

Note: *** p<0.01, ** p<0.05, * p<0.1

Source: extracted results from STATA

Table no. 5 demonstrates that a one-way causal relationship exists from the real effective exchange rate to imports. Exchange rate fluctuations concerning foreign trading partners' currency baskets can trigger changes in imports. A country's depreciating exchange rate can increase import costs relative to exports. Similarly, bidirectional causality is confirmed between the real effective exchange rate and exports, indicating that exchange rate fluctuations influence exports and vice versa. Currency devaluation can make exports more affordable, encouraging export sector investments. Conversely, improved export performance raises the local currency's value. Consequently, expansion in the region's export sectors contributes to exchange rate appreciation and alterations in the real effective exchange rate.

4.5 Effects of Exchange rate changes on trade balance among East Asian Countries

Table no. 6 displays the Hausman test outcomes investigating symmetric and asymmetric models on the exchange rate's impact on trade balance within East Asian nations. The test employs chi-square probabilities to identify the preferred estimator. The study favored PMG (pooled mean group (PMG) estimates due to its Hausman test probability value of 0.3313, compared to MG (mean group) and DFE (dynamic fixed effects) estimators. The PMG estimator maintains constant long-run coefficients across countries while allowing short-run coefficient variations. No asymmetry was detected in the exchange rate-trade balance relationship, supported by Wald test values (3.035 and 2.23) and associated probabilities (0.0673 and 0.1352). PMG findings revealed a significant positive impact of world real GDP on East Asian trade balance in the long run (5% significance level). A unit rise in WRGDP corresponds to a 2.047 trade balance increase, aligning with economic theory. A rise in global GDP would imply a boost in the aggregate demand for the export of the East Asian region, and hence promote positive trade balance, thus corroborating the findings of Hacker and Hatemi-J (2004). The massive boost in output of East Asian economies in the wake of the financial crisis witnessed in 1998/99 and 2008 could have accounted for this development. Trade openness displayed a positive, significant influence on trade balance in both short and long runs, with a near asymmetric long-run relationship at a 10% level of significance. The study highlighted a 21.2% yearly adjustment speed in initial distortions. It is noteworthy that most economies in the region increasingly opened up their economies to foreign trade in response to the requirement of membership of the Association of South East Asia (ASEAN) bloc. Given therefore that all the understudied economies are part of the ten-member regional trade arrangement (ASEAN-10), the positive result obtained clearly justifies this trend. The result also conforms with theoretical a priori expectation. Trade openness guarantees increased participation in foreign trade, which in turn fosters expansion in the tradable goods (export) sector and boosts total exports. This finding agrees with that of Bahmani-Oskooee and Kanitpong (2017), but disagrees with the findings of Chang *et al.* (2018). Exchange rate changes exhibited an insignificant negative effect on trade balance in the short run, but a positive impact in the long run, corroborating the findings of (Baharumshah, 2001) and Barkat *et al.* (2022) who confirmed the worsening impact of currency depreciation on trade balance in the short run but a positive impact in the long run in the GCC countries. An increase in the real effective exchange rate (coinciding with the concurrent depreciation) in the local currencies of most ASEAN countries in recent times rather worsened terms of trade for the home countries and exacerbated their trade balance in the short run, perhaps due to some perceived structural imbalances. In the long run however, the response of trade balance to exchange rate adjustments exceeds negative changes, thus confirming the validity of the J-curve hypothesis. Similarly, trade openness's positive and statistically significant influence on trade balance in the long run was emphasized. This implies that trade openness, world real GDP, and exchange rate collectively drive favorable trade outcomes in the long run in the region. These results provide insight into the intricate dynamics of exchange rate and trade balance relationships in the context of East Asian economies.

4.6 Effects of Exchange rate changes on exports among East Asian Countries

Table no. 7 presents the findings from the Hausman test analyzing the impact of exchange rate fluctuations on exports within East Asian nations. The PMG estimator is favored over MG. PMG estimates reveal that the coefficient of the real effective exchange rate (LREER) demonstrates a significant positive relationship at the 10% significance level. This suggests that changes in the real effective exchange rate favorably affect East Asian exports. This outcome implies the region's responsiveness to exchange rate shifts, making exports more affordable internationally. The real exchange rate notably promotes exports in East Asia, aligning with prior studies like Barkat *et al.* (2022), but contradicts Thorbecke (2011)'s finding, while Urgessa (2024) found no significant link between exchange rate changes and exports.

Moreover, the outcome indicates trade openness's (OPEN) substantial positive influence on East Asian exports in both short and long runs. This suggests that increased market access beyond domestic boundaries enhances demand for exports, subsequently boosting export supply. Additionally, heightened trade openness can grant firms access to cost-effective inputs, improving competitiveness in global markets. The results also underscore world real gross domestic product's strong positive influence on East Asian exports, indicating effective global demand for the region's exports. This study contributes to understanding the intricate relationship between exchange rate fluctuations and exports in East Asia, highlighting the significance of exchange rate dynamics and trade openness in driving export outcomes.

4.7 Effects of Exchange rate changes on imports among East Asian Countries

Table no. 8 presents the Hausman test result for impact of exchange rate changes on imports among East Asian countries. The estimations of both symmetric and asymmetric models of the relationship are shown. In comparing the estimates of the PGM and MG estimators, the study preferred the PMG estimates given the Hausman probability value of 0.6344. Taking into account the PMG and DFE estimations, the PMG estimates were again favored for both the symmetric and asymmetric models.

Table no. 6 – Impact of Exchange rate changes on trade balance among East Asian countries

Variables	MG Estimates (Symmetric)	PMG Estimates (Symmetric)	DFE Estimates (Symmetric)	MG Estimates (Asymmetric)	PMG Estimates (Asymmetric)	DFE Estimates (Asymmetric)
Ec	-0.547***	-0.212***	-0.434***	-0.494***	-0.342*	-0.432***
	(0.146)	(0.0797)	(0.0864)	(0.157)	(0.193)	(0.0875)
D.lLTBAL	0.000993	-0.00360**	0.00161	0.00102	0.00234**	0.00159
	(0.00165)	(0.00163)	(0.00113)	(0.00165)	(0.000916)	(0.00115)
D.LREER	-0.849	-1.653	-1.166*			
	(0.612)	(1.033)	(0.640)			
D.OPEN	-0.0177**	0.0124	-0.00150	-0.0324*	0.0403***	-0.00166
	(0.00766)	(0.00943)	(0.00464)	(0.0185)	(0.0138)	(0.00474)
D.LWRGDP	3.644**	5.316*	0.884	6.400	7.244**	1.088
	(1.817)	(3.189)	(3.036)	(5.157)	(2.960)	(3.071)
D.LREER_pos				1.184	2.192	0.709
				(2.817)	(1.847)	(1.311)
D.LREER_neg				-0.829	-1.288*	-0.320
				(0.688)	(0.730)	(0.877)
LREER	-1.543	2.041***	-0.120			
	(0.972)	(0.609)	(0.698)			
OPEN	-0.00834	0.0128***	-0.00429	0.0178	0.0238**	-0.00424
	(0.0230)	(0.00247)	(0.00358)	(0.0132)	(0.0110)	(0.00349)
LWRGDP	2.047**	3.612***	1.989***	2.274**	1.765***	1.992***
	(0.850)	(0.565)	(0.500)	(0.885)	(0.586)	(0.520)
LREER_pos				-4.732	-11.84**	-2.871
				(5.564)	(4.692)	(4.128)
LREER_neg				-3.438	-1.152	-2.818
				(2.721)	(2.745)	(3.023)
Constant	-7.961	-1.501***	-7.147**	-8.825*	-5.748*	-7.379***
	(6.373)	(0.496)	(2.968)	(4.505)	(3.309)	(2.784)
Hausman	PMG VS MG (chi2(3) =3.42)	PMG VS DFE (chi2(3) =2.05)		PMG VS MG (chi2(4) =21.25)	PMG VS DFE (chi2(4) =1.01)	
Prob>chi2	Prob>chi2 = 0.3313	Prob>chi2 = 0.5611		Prob>chi2 = 0.0003	Prob>chi2 = 0.9087	
Long-run Asymmetry (Wald Test)					chi2(1) =3.035	
Prob>chi2					Prob > chi2 =0.0673*	
Short-run Asymmetry (Wald Test)					chi2(1) =2.23	
Prob>chi2					Prob > chi2 =0.1352	

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.
Source: extracted results from STATA output

Table no. 7 – Impact of Exchange rate changes on exports among East Asian countries

Variables	MG Estimates (Symmetric)	PMG Estimates (Symmetric)	DFE Estimates (Symmetric)	MG Estimates (Asymmetric)	PMG Estimates (Asymmetric)	DFE Estimates (Asymmetric)
Ec	-0.225**	-0.182	-0.0276	-0.278**	-0.0602*	-0.0320
	(0.108)	(0.115)	(0.0261)	(0.137)	(0.0317)	(0.0224)
D.lLEXPT	-0.000112	-6.14e-05	-2.92e-05	-0.000132*	-8.27e-05	-6.07e-05
	(7.98e-05)	(0.000117)	(0.000109)	(7.79e-05)	(8.97e-05)	(0.000106)
D.LREER	0.571***	0.489***	0.207*			
	(0.0883)	(0.103)	(0.111)			
D.OPEN	0.0171***	0.0177***	0.00337***	0.0146***	0.0179***	0.00294***
	(0.00654)	(0.00671)	(0.000835)	(0.00495)	(0.00602)	(0.000826)
D.LWRGDP	0.783	0.943	3.111***	0.727	1.135	3.195***
	(0.697)	(0.726)	(0.550)	(0.706)	(0.695)	(0.538)
D.LREER_pos				0.264	0.341	0.631***
				(0.288)	(0.275)	(0.234)
D.LREER_neg				0.0715	0.0558	-0.144
				(0.135)	(0.0828)	(0.155)
LREER	-3.109	-0.0710	-2.601			
	(2.383)	(0.0764)	(4.091)			
OPEN	-0.0247	0.00227***	0.00704	0.0264	0.00512**	0.00762
	(0.0368)	(0.000326)	(0.0121)	(0.0205)	(0.00226)	(0.0104)
LWRGDP	4.197**	1.607***	0.671	2.263***	1.319***	0.105
	(1.911)	(0.0829)	(2.355)	(0.807)	(0.245)	(2.254)
LREER_pos				1.740**	5.075***	-20.01
				(0.849)	(1.872)	(18.30)
LREER_neg				-0.625	6.236***	15.03
				(4.070)	(1.800)	(12.37)
Constant	-3.712***	-2.157	0.256	-3.906**	-0.501*	0.143
	(1.067)	(1.431)	(0.876)	(1.606)	(0.285)	(0.694)
Hausman	PMG vs MG (chi2(3) =1.67)	PMG vs DFE (chi2(3) =0.01)		PMG vs MG (chi2(4) =46.71)	PMG vs DFE (chi2(4) =0.13)	
Prob>chi2	Prob>chi2 = 0.6434	Prob>chi2 = 0.9995		Prob>chi2=0.0000	Prob>chi2 =0.9980	
Long-run Asymmetry (Wald Test)					chi2(1) =0.19	
Prob>chi2					Prob > chi2 =0.6626	
Short-run Asymmetry (Wald Test)					chi2(1) =0.91	
Prob>chi2					Prob > chi2 =0.3401	

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.
Source: extracted results from STATA output

Table no. 8 – Impact of Exchange rate changes on imports among Eastern Asian countries

Variables	MG Estimates (Symmetric)	PMG Estimates (Symmetric)	DFE Estimates (Symmetric)	MG Estimates (Asymmetric)	PMG Estimates (Asymmetric)	DFE Estimates (Asymmetric)
Ec	-0.234***	-0.0672	-0.0762**	-0.0796***	-0.0858*	-0.0627**
	(0.0698)	(0.0463)	(0.0321)	(0.0208)	(0.0445)	(0.0257)
D.lLIMPT	2.17e-05	6.88e-05	6.69e-05	-0.000219***	-0.000152	-6.94e-05
	(5.32e-05)	(7.01e-05)	(0.000131)	(8.11e-05)	(0.000112)	(0.000119)
D.LREER	0.688***	0.620**	0.426***			
	(0.180)	(0.245)	(0.146)			
D.OPEN	0.0186**	0.0196***	0.00391***	0.0180**	0.0213***	0.00331***
	(0.00736)	(0.00616)	(0.00110)	(0.00818)	(0.00670)	(0.00106)
D.LWRGDP	0.297	0.657	3.085***	0.570	0.398	3.173***
	(0.853)	(0.811)	(0.729)	(0.907)	(0.921)	(0.690)
D.LREER_pos				0.561	0.181	0.738**
				(0.577)	(0.267)	(0.301)
D.LREER_neg				0.184	0.218	-0.101
				(0.219)	(0.225)	(0.199)
LREER	-0.507	-0.241	-0.184			
	(0.810)	(0.498)	(1.091)			
OPEN	-0.0334	-0.00425	0.00261	0.00134	0.00746**	0.00236
	(0.0434)	(0.0116)	(0.00500)	(0.0376)	(0.00357)	(0.00569)
LWRGDP	4.236***	2.071***	2.234***	2.431***	1.701***	1.652*
	(1.509)	(0.435)	(0.701)	(0.918)	(0.215)	(0.968)
LREER_pos				-8.460	6.130***	-14.87
				(14.98)	(1.499)	(9.700)
LREER_neg				3.441	6.283***	15.18**
				(4.761)	(1.610)	(7.730)
Constant	-5.577***	-1.005	-1.394	-1.619**	-1.090*	-0.746
	(1.055)	(0.707)	(1.090)	(0.697)	(0.585)	(0.869)
Hausman	PMG vs MG (chi2(3) =1.71)	PMG vs DFE (chi2(3) =0.01)		PMG vs MG (chi2(4) =5.26)	PMG vs DFE (chi2(4) =0.89)	
Prob>chi2	Prob>chi2 = 0.6344	Prob>chi2 = 0.9999		Prob>chi2 = 0.2617	Prob>chi2 = 0.9256	
Long-run Asymmetry (Wald Test)					chi2(1) =0.01	
Prob>chi2					Prob > chi2 =0.9384	
Short-run Asymmetry (Wald Test)					chi2(1) =0.01	
Prob>chi2					Prob > chi2 =0.9190	
Observations	120	120	.	120	120	.

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.
Source: extracted results from STATA output

Table no. 9 – Summary of PMG Estimates for the Three Models (Short-run and Long-run Estimates)

Variables	PMG Estimates for TBAL Model					PMG Estimates for EXPT Model					PMG Estimates for IMPT Model				
	ec	China	Hong Kong	Japan	South Korea	Ec	China	Hong Kong	Japan	South Korea	ec	China	Hong Kong	Japan	South Korea
Ec		-0.352**	-0.229***	-0.0341	-0.863***		0.00429	-0.518***	-0.106**	-0.110***		-0.0125	0.0311	-0.118**	-0.169**
		(0.166)	(0.0724)	(0.0455)	(0.188)		(0.0230)	(0.123)	(0.0504)	(0.0255)		(0.0387)	(0.0706)	(0.0597)	(0.0809)
D.lLTBAL		0.000678	-0.00329	0.000859	0.00512										
		(0.00124)	(0.00432)	(0.00133)	(0.00793)										
D.lLEXPT							0.000258*	-2.98e-05	-0.000227*	-0.000246					
							(0.000138)	(0.000141)	(0.000122)	(0.000154)					
D.lLIMPT												0.000136	0.000160	0.000119	-0.000140
												(0.000208)	(0.000190)	(0.000145)	(0.000226)
D.LREER		-0.368	-0.940**	0.0107	-1.957		0.3010	0.3230***	0.6380***	0.6950***		0.2690	0.2360*	0.6840***	1.2890***
		(1.728)	(0.420)	(0.759)	(1.525)		(0.365)	(0.0792)	(0.118)	(0.0864)		(0.583)	(0.124)	(0.170)	(0.139)
D.OPEN		0.00116	-0.000504	-0.0398	-0.0279		0.0327***	0.00114***	0.0230***	0.0141***		0.0268**	0.00298***	0.0307***	0.0180***
		(0.0331)	(0.00130)	(0.0252)	(0.0225)		(0.00694)	(0.000408)	(0.00437)	(0.00137)		(0.0108)	(0.000360)	(0.00609)	(0.00230)
D.LWRGDP		1.1830	2.2530*	7.4590**	7.6580		-0.3080	1.2110***	2.8840***	-0.0130		-0.0791	1.6470***	2.3100**	-1.251
		(6.436)	(1.219)	(3.695)	(10.67)		(1.321)	(0.262)	(0.682)	(0.615)		(2.100)	(0.349)	(0.949)	(0.955)
LREER	2.041***					-0.0710					-0.241				
	(0.609)					(0.0764)					(0.498)				
OPEN	0.0128***					0.00227***					-0.00425				
	(0.00247)					(0.000326)					(0.0116)				
LWRGDP	3.612***					1.607***					2.071***				
	(0.565)					(0.0829)					(0.435)				
Constant		-8.775*	-5.070***	-1.035	-21.89***		0.148	-6.341***	-1.213**	-1.222***		-0.0779	0.435	-1.833**	-2.546*
		(4.567)	(1.367)	(1.142)	(6.089)		(0.263)	(1.642)	(0.537)	(0.322)		(0.604)	(1.094)	(0.828)	(1.520)
Observations	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.
Source: extracted results from STATA output

The study revealed that there is a no asymmetry both in the long-run and the short run relationships of exchange rate and import in the East Asian countries as evidenced by the Wald test values of 0.9384 and 0.919 respectively. In the short run, the result of the PMG estimator indicates that the real effective exchange rate has a positive and significant impact on imports in East Asian countries at 5% level of significance but negative and insignificant influence in the long-run. This conforms with Bahmani-Oskooee *et al.* (2020), Gbaka *et al.* (2023) and Yakub *et al.* (2019) but contrasts with the submission of Kearns and Patel (2016) and Adhikari (2018). This implies that real currency depreciation discourages the demand for import but only in the long-run. This further explains that real currency depreciation makes the imports very expensive to the East Asian countries. However, the elasticity of import demand in the face of this situation deters imports only in the long-term. It is worth noting that as a country's currency depreciates, imported items become more expensive, hence reducing their demand. This conforms with Bahmani-Oskooee *et al.* (2020), Gbaka *et al.* (2023) and Yakub *et al.* (2019) but contrasts with the submission of Kearns and Patel (2016) and Adhikari (2018) who also confirmed exchange rate fluctuations' significant impact on imports and exports. Additionally, in the short run, trade openness significantly boosts East Asian imports. In the long run, world real gross domestic product positively and significantly influences imports in the region at a 5% significance level, re-echoing Qamruzzaman (2023) and Usman and Bashir (2022)'s findings. The implication of the result is that increased world's real gross domestic product has resulted in increase in import demand, industrial capacity expansion, and potentially more advantageous trade policy.

Table no. 9 reveals that in the short run, the parameters (D.LREER) indicates that a 1% increase in real effective exchange rate (LREER) exert negative influence on trade balance by 0.94% for Hong Kong. This implies that it may raise the price of Hong Kong's exports to global customers. This conforms to the J-curve hypothesis of negative effect of exchange rate changes on trade balance in the short-run. The estimated short-run coefficients reveal that 1% increase in world real gross domestic product (D.LWRGDP) leads to 7.459% increase in trade balance for Japan. Also the coefficient reveals that a 1% increase in world real gross domestic product (D.LWRGDP) leads to 2.253% increase in trade balance for Hong Kong at 10% level of significance. This implies that as the world real GDP increases, global demand for goods and services may rise, which could lead to an increase in Japan's and Hong Kong's favorable trade.

Second, the estimated short-run model shows that a 1% increase in real effective exchange rate exerts 0.323%, 0.638%, and 0.695% increase in exports for Hong Kong, Japan, and South Korea at 1% level of significance. Similarly, positive changes in trade openness significantly influence the level of exports for all the countries (China, Hong Kong, Japan, and South Korea) as shown by their respective proportions (0.0327%, 0.00114%, 0.023%, and 0.0141%). This positive relationship between trade openness and exports indicates more opportunities for these countries to access larger markets and expand their customer base. With greater access to international markets, China, Hong Kong, Japan, and South Korea can increase their export volumes and boost their export performance. The positive influence of embracing trade openness on exports for China, Hong Kong, Japan, and South Korea indicates that these nations have reaped the benefits of expanding their economic engagement in global trade. This would help these countries to drive economic growth and create jobs. Similarly, a 1% increase in world real gross domestic product leads to 1.211% and 2.884% increase in exports for Hong Kong and Japan respectively.

Turning to the import model, a 1% increase in real effective exchange rate leads to 0.236%, 0.684%, and 1.289% increase in imports for Hong Kong, Japan, and South Korea. Furthermore, trade openness exerts significant positive influence on imports for all the countries (China, Hong Kong, Japan, and South Korea) in the short-run as shown by their respective proportions (0.0268%, 0.00298%, 0.0307%, and 0.018%). However, world real GDP exerts significant positive influence only for Hong Kong and Japan with 1.647% and 2.31% variations in imports respectively as a result of a percentage increase in world real GDP.

5. CONCLUSION

The study concludes that in East Asia, trade balance is significantly influenced by world income, trade openness, and real effective exchange rate. Long-term trade balance and exports benefit from real exchange rate depreciation. Trade openness and real effective exchange rate impact exports and imports across the region, especially in Hong Kong, Japan, and Korea in the short term. Yet, their currency depreciation deters long-term imports, offset by trade openness and world real GDP. World income shapes exports and imports for Hong Kong and Japan, while trade openness benefits all countries. The study confirms the validity of the Marshall-Lerner condition and J-curve hypothesis in East Asia.

5.1 Policy implications

The findings of the study have significant policy implications for the East Asian region. Policymakers should focus on maintaining favorable trade balances by closely monitoring and managing the real effective exchange rates. They should consider the potential benefits of controlled depreciation of currencies to boost exports and achieve favorable trade balances in the long run. Given that the currency depreciation/devaluation was found to be an effective trade-enhancing measure among the East Asian economies, maximization of potential gain from international trade could be optimized if this policy option is explored or sustained. Emphasizing trade openness remains crucial for most economies, especially Hong Kong, Japan, and Korea, in both short and long terms. To enhance exports and imports, policies should aim to stimulate world income growth, particularly for Hong Kong and Japan. Additionally, policy interventions aligning with the principles of Marshall-Lerner condition and J-curve hypothesis can enhance trade dynamics by promoting currency adjustments to improve trade balances.

5.2 Study Limitations

The study was limited by data availability that necessitated the choice of four countries which may limit the generalization of the findings to all developed and developing countries. The heterogeneity problem among the countries was also considered as another limitation. However, the challenge was addressed by studying the Asian countries, while utilizing an appropriate approach that could account for individual specific behavior of the countries being studied.

5.3 Recommendations

Based on the findings, this study recommends that countries in the region should be more open to global markets in order to take advantage of the rise in global income. Trade-growth pattern should equally be maintained in order to maximize the actual benefits from globalization. The policymakers should consider a controlled depreciation of their currencies to boost exports and achieve favorable trade balances in the long run. However, careful management is essential to prevent negative impacts on long-term imports. Given the significant role of trade openness in influencing trade balances and exports, governments should continue to prioritize policies that facilitate international trade through trade agreements, reduced tariffs, and streamlined customs procedures.

The study also recommends the adoption of policies aligned with the principles of the Marshall-Lerner condition and J-curve hypothesis. Timely and coordinated currency adjustments can enhance trade balances without severely affecting imports, while maintaining the current bilateral exchange rate policy of pegging domestic currencies to trading partners' currency values. Governments should implement targeted export promotion strategies, offer incentives to high-potential industries, invest in R&D, and enhance product quality and innovation. Ongoing monitoring of policy impacts on trade balances, exports, and imports is essential, with adjustments based on effectiveness assessments. Following these recommendations, East Asian economies can harness positive trade determinants for sustainable growth, improved trade performance, and enhanced regional cooperation.

5.4 Suggestions for Future Research

The study suggests more empirical studies on countries across regions and income groups in order to determine the true interactive effects of exchange rate changes on trade flows using panel data approach.

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