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ASSESSING THE IMPACT OF OIL PRICE VOLATILITY ON FOOD PRICES IN SAUDI ARABIA: INSIGHTS FROM NONLINEAR AUTOREGRESSIVE DISTRIBUTED LAGS (NARDL) ANALYSIS

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ABSTRACT

This research investigates the impact of oil price fluctuations on food prices in Saudi Arabia between 1979 and 2020 using Nonlinear Autoregressive Distributed Lags (NARDL) methodology. The study employs Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests to determine the integration order of the variables and Bounds testing to confirm the existence of long run cointegration relationships between each variable. The results indicate that oil shocks influence food prices through several mechanisms. Firstly, the cost of energy increases due to the rise in oil prices, affecting the agricultural commodity market, including farm equipment, food processing, packaging, and distribution costs. Secondly, the demand for agricultural commodities to produce biofuels affects food availability and thus food prices. Thirdly, as an oil-based economy, the oil price shock affects food prices through its impact on government spending, which affects aggregate demand and liquidity. Therefore, Saudi Arabia should adopt appropriate policies to mitigate the impact of oil price shocks on food prices, including investing in renewable energy sources, diversifying its economy, and improving food production and supply chain efficiency. Additionally, implementing appropriate fiscal policies to ensure sufficient budget allocation for food support programs is crucial. However, Investing in groundwater exploration can contribute significantly to the development of Saudi agriculture and to gradually achieving food self-sufficiency.

Keywords: *Food prices, Oil prices, Real GDP, Nonlinear ARDL, Saudi Arabia*

1. INTRODUCTION

After almost three decades of price stability and some periods of deflation, inflationary pressures reemerged in Saudi Arabia in the middle of 2000s following the increase in global oil prices, reduction of subsidies, and exchange rate weaknesses. Even though Saudi Arabia's local

oil prices and many other necessities are still subsidized, prices of imported goods especially foodstuffs are affected by the increase in global oil prices. According to the Saudi Arabian Monetary Agency (2008), the inflation reached its highest level in three decades, even though eased in 2008; inflation remained at a relatively high level during 2009-2021 period compared to the levels in the 1980s, 1990s and early 2000s. The rise was due partly to the increase in the price level of foodstuff, which constitutes the largest share of the cost-of-living index. For example, from 2005 to 2012, the price index for meat and poultry increased from 106 to 167, fresh fruits increased from 123 to 218 and 127 to 260 for fish and crustaceans (Saudi Arabian Monetary Agency, 2023). The implications of the increase to the welfare of the Saudis have stimulated extensive discussions and obliged the Saudi government to review its socio- economic policy (Yousif and Al-Kahtani, 2014).

About 80% of foodstuffs is imported, thus it is expected that changes in Saudi Arabia are driven by changes in global food prices which in turn is affected by changes in global oil prices (Saudi Arabian Monetary Agency; 2023; Saudi energy minister, 2023; Podlevska and Podlevskyi, 2023). Indeed, the correlation between food prices in Saudi Arabia and global food prices is about 70% (Khan, 2012). Global food prices and oil prices have been moving in tandem. Changes in oil price are transmitted to food prices via several channels. Modern agriculture uses oil products to fuel farm machineries and for transportation. An increase in oil price raises the cost of farm equipment's and the costs of food processing, packaging and distribution (Baumeister and Kilian, 2012). It is also input for agricultural chemicals such as pesticides and fertilizers. Additionally, demand for biofuels, often made from corn and other agricultural products increase as oil prices rise as it is the only non-fossil liquid fuels to replace petroleum products in combustion engines and motor vehicles. In the case of a food importing country, this leads to an increase in its import bills (Alghalith, 2010; Ibrahim, 2014, 2015). In addition, in oil- based economy, the aggregate demand built mainly by oil revenue forms a potentially important channel for oil price pass through into food prices.

In the case of Saudi Arabia, the increase in global oil prices is advantageous on the revenue side as it led to greater revenue, however the increase in oil price led to increase in the prices of foodstuffs, the increase in economic activities due to higher oil prices also put a pressure on the price level.

This paper examines the effect of oil price on the price of foodstuffs. The general consumer price index is not sufficient to reflect the behavior of the prices of specific commodities, such as foodstuffs, response to the changes in oil prices. Examining the relationship between oil prices on food prices help to examine the external pressures that oil price have on the food prices even though price of oil is heavily subsidized. The findings from this study contribute to the current debate about the pass through effect of oil prices into food prices. In particular, it shows how the reliance of Saudi government on oil revenue results in high response of this factor to the fluctuation of oil prices. In addition, as the analysis also test for asymmetric relationship between oil price and food prices, this study is beneficial to show the extent of the market power's effect on the food prices as the latter respond to negative oil price shocks.

2. BACKGROUND

Saudi Arabia is the second largest producer of crude oil behind Russia, and the second largest producer of petroleum liquids behind the USA. The average of total petroleum liquids in 2020 was 10.8 million b/d of which 9.2 million b/d was crude oil production and 1.6 million b/d was non-crude liquids production (British Petroleum, 2015; Energy information Administration,

2014). The production of oil has been increasing from 2340.5 million barrels in 1990 to 3573.4 million barrels in 2012, and accounting for more than 10% of world production of crude oil during the period. Beside the production of crude oil, Saudi Arabia has expanded its natural gas, refining products such as gasoline and Naphta, gasoline oil and fuel oil. Domestic consumption of crude oil is also trending upward. Saudi Arabia is the 11th largest consumer of total primary energy in 2019 (Energy Information Administration, 2021). The high level of domestic consumption despite the dramatic increase in global oil prices is due to the high oil revenue and large fuel subsidies. Saudi subsides have registered an increase from US$2 billion and US$3 billion in gasoline and diesel in 2004 to US$14 billion and US$15 billion in 2012 (Charles, Moerenhout, & Bridle, 2014; Chikhi et al., 2022). As a result of the large fuel subsidies, the domestic prices of fuel have for long time been of the lowest in the world. The Gasoline and Diesel prices were between US$ 0.24 to 0.16 per litter for Gasoline, and 0.07 to 0.1 for Diesel. While lowering fuel prices has long been an important measure to achieve economic and social goals, it has led to domestic over-consumption of hydrocarbons and the absence of incentives to achieve energy efficiency in the economy.

Saudi Arabia inflation rate was relatively low from 1964-1972, averaging about 2.5% per annum. However, during the period 1973-1976, inflation increased and peaked at 34.6% in 1975. The high level of inflation was accompanied by a drastic rise in oil revenue which stimulated growth in government spending. In addition, supply bottlenecks, increase in the wage levels and non-wage income are thought to be among the main causes of inflationary pressure during this period (SAMA, 1976). Nevertheless, Saudi Arabia initiatives to reduce the inflation such as elimination of taxes for certain products, subsidization of the imports of foodstuffs and reduction in the cost of electricity have helped to reduce inflation in addition to changes in global oil price. In January 1974, the government introduced subsidy programs for rice, flour, sugar, milk products, frozen meat, and vegetable oil (SAMA, 1976). The decrease in government spending and the Saudi Riyal appreciation against US dollar, control inflationary pressure. The downward trend of inflation continued over the period 1982-1987 due to improvements of infrastructure facilities and development of competitive market as well as reduction of oil price which contributed to the reduction of production costs and thus decline of imported inflation (Ujkani and Gara, 2023). In fact between 1983 and 1987, Saudi economy experienced deflation averaged at -2.35%. Inflation was around 4.9% in both 1991 and 1995; the average of inflation rates during 1988-1992 and 1993-1997 were 1.76% and 1.58%, respectively. This trajectory of inflation was attributed to moderate economic activity, availability of cheap imports, elastic labor market, full capital mobility, and low inflationary expectations because of the fixed exchange rate policy. In fact, for a long period if price of foodstuffs is not included in CPI, Saudi Arabia was experiencing deflation.

The second inflationary episode began to emerge, in effect, the CPI increased from 2.4% in 2006 to 4.2% in 2007 and it continued to rise reaching a peak of approximately 10% in 2008. Even though these rates are relatively low compared with many countries, relative to Saudi Arabia historical inflation.

Inflation moderated since then but remains relatively high compared to previous decades; averaged around 5% during the period 2009 to 2020. The later spike in inflation despite tighter monetary policy undertaken by Saudi Arabia Monetary Authority (SAMA), advocated a considerable debate about the main causes of inflation. The pegging of Saudi riyals to US dollar was claimed to generate imported inflation. The devaluation of the US dollar against most major currencies put upward pressure on Saudi import prices. Furthermore, the fixed exchange rate constrained SAMA (Saudi Arabia Monetary Authority) influence over money supply, i.e., it

limits its ability to adjust interest rate and control credit growth. This constraint was noticeable since bank loans to private sector expanded dramatically, reaching 35% in the middle of 2008 (SAMA, 2010). However, with many deposits are placed on an Islamic basis, even if Saudi Arabia Monetary Authority (SAMA) was freely able to adjust interest rates, this would have only a limited effect on inflationary pressure in Saudi economy.

Table 1. Saudi Arabia: Index for Food Prices (2005-2012)

Index	2005	2006	2007	2008	2009	2010	2011	2012
Food – stuffs	106.5	112.2	120.1	137.0	139.7	148.4	156.1	**163.0**
Meat and Poultry	105.9	112.6	119.5	131.3	136.5	150.9	162.4	**166.7**
Fish and crustaceans	126.5	142.2	159.3	186.9	192.9	208.1	230.0	**259.1**
Fresh vegetables	120.9	143.3	160.6	183.1	179.9	206.8	213.3	**227.2**
Legumes and tubers	125.4	148.8	193.2	211.9	220.3	246.5	254.7	**263.7**
Fresh fruits	123.3	133.9	150.0	179.6	182.6	187.5	199.7	**217.7**

Source: SAMA annual report, different issues

Since the foodstuffs group carries the largest weight of the cost-of-living index (between one quarter and one third) the rise in this category was one of the major driving forces of inflation. In 2007, there was a considerable rise in the agricultural commodities such as fresh vegetables and fish (12%), cereals (7%) and meat and poultry (6%). The transportation cost of food has also increased due to the increase in oil price in this period.

At the disaggregated level, the symmetric and asymmetric pass-through effect of oil price to food prices have been examined in the recent literature due to the recent volatile trends of world oil and food prices. As the agricultural sector is energy- intensive, it has been shown oil price is the main force behind food price hikes in recent years (Dancy, 2012). The price of oil affects inflation through the cost of mechanized farm equipment and the cost of food processing, food packaging and distribution (Baumeister and Kilian, 2012). However, empirical findings about the pass-through effect of oil price on food prices varied depending on the country, methodology and data period.

Alghalith (2010) investigated the effect of oil price uncertainty on food prices and concludes that in an oil-producing country like Trinidad and Tobago, a higher oil price positively and significantly affects food price. Moreover, higher oil price volatility results in higher food price. Similarly, Esmaeili and Shokoohi (2011) examined the effect of macroeconomic variables including oil price on world food prices. The results showed that oil price has a significant effect on the food price. Chen and al. (2010) analyzed the effect of oil price on world grain prices for corn, wheat and soybean. The results indicate the existence of the same relationship.

Ibrahim and Said (2012), Ibrahim (2015), Karimi and al. (2014) examined the asymmetric response of food prices to the fluctuations in oil price. According to Ibrahim (2015), the presence of market power and the role of public policy such as price ceiling and price subsidies for some kinds of foodstuffs have normally been held responsible for this asymmetry. Ibrahim and Said (2012) studied the effect of oil price fluctuations on the indexes of aggregate and disaggregate consumer prices in Malaysia. Their findings from the cointegration technique indicate that long run association among the variables exists only in the case where the food price index and the aggregate price index are used as the dependent variables. Based on these results, they concluded that the effect of oil price on inflation in the long run stems from its effect on the food prices. The test for asymmetric behavior of consumer price indexes showed that the food prices

tend to exhibit a downward rigidity in the short run. In contrast, the upward movement of oil price would immediately raise food prices. Using the NARDL, Ibrahim (2015) also showed the existence of a long run asymmetric response of food prices to changes in oil prices where an increase in oil prices has a higher effect on food prices than a decrease.

Karimi and al. (2014) analyzed the asymmetric effects of world oil prices on the inflation of US food price. Using MTAR technique, the results indicated the existence of an asymmetric cointegration between oil price and food prices. In addition, the result of an asymmetric error correction model indicate that food prices adjust faster to an increase in oil price compared to a decrease in oil price.

In contrast, Nazlioglu and Soytas (2010), Ibrahim and Chancharoenchai (2014), Baumeister and Kilian (2014). found no evidence of a relationship between oil price and food prices. Nazlioglu and Soytas examined the short and long run relations between world oil prices, exchange rate and the price of a number of agricultural commodities in Turkey: wheat, maize, cotton, soybeans and sunflower. The exchange rate was included to examine the indirect effect of oil price increase on the prices of agricultural commodities. According to them, beside its effect on the cost of production, the increase on oil prices in USD would depreciate the local currency value and thus increase the price of foods. They used a linear causality approach; namely, the Toda-Yamamoto causality method, and monthly data from January 1994 to March 2010. However, they concluded that the agricultural commodity markets in Turkey are neutral to fluctuations of oil price and exchange rate.

Ibrahim and Chancharoenchai (2014) used symmetric and asymmetric cointegration techniques and quarterly data over the period 1993 to 2010 to examine the long run relationship between oil price and different components of consumer price index in Thailand. The findings revealed that, the food and beverage price and raw food price indexes have no cointegration with oil prices. However, in the short run the results indicated significant effect of oil price shocks on the indexes of aggregate consumer prices and its components.

The findings of Baumeister and Kilian (2014) based on US data also indicate that there is no evidence that oil price shocks are associated with an increase in US food prices. According to them, even though increases in the real prices of some foodstuffs can be linked positively to increases in the real price of oil, that link is driven by common macroeconomic determinants of the prices of oil and agricultural commodities. In the long term, Ding et al. (2020) show an opposite association among oil prices and food prices centered on deep models and sub-models in riche countries. The description is not the same throughout the crisis period: in poor nations and all the nations merged, oil prices and food prices co-change in the long term.

By means of the time series Norway country, Lauvsnes and Ingulsvann (2023) confirm the presence of constant long term steadiness relationships amid the oil price and food imports. In effect, a 1% increase in the oil price was reliable with a growth in food imports of about 0.17% on regular, a amount convened the “oil price elasticity of food imports”.

Shokoohi and Saghaian (2022) discovers the association amid energy and food nourishment prices and natural oil price relations in the case of United State, South Korea, China and Japan (oil importing countries) and exporting countries (Canada, Saudi Arabia, United Arab Emirate and Iran) using a Panel-VAR model during 1974–2018 periods. The authors found that the impacts of oil price upsets on food nourishment prices are distinct in the two collections of countries. These consequences, in oil importing states, are initially decreasing and then changing over numerous phases, while these states are incremental and significant for oil distributing countries. Furthermore, the belongings of economic growth measured by the GDP and con-

versation charges on food prices are statistically important in the oil distributing nations, while they have no through consequence on the food prices in the clear oil importing republics. These findings propose that natural oil prices have an actual part in guiding food shortage directs and expanding food safety in oil-exporting territories.

Sun et al. (2023) show positive correlation linking the food prices and symbols about the quantiles. In the case of an oil plead shockwave, a sturdier association is observed among the exceptionally high and low quantiles specifically in food prices indexes.

However, Raza et al. (2022) prove that the link between the food prices and oil prices during January 1993 to September 2020 is bidirectional. Furthermore, the findings prove that the oil prices are the principal sponsors to instability conduction evaluated to food prices. The result of their research will support the agricultural area's officials explain consistent and look plan proposes that will aid regulate the effect of oil prices on food prices.

Amolegbe et al. (2021) discovery that introduced rice price rises are negative to equally nutritional variety and the food part of consumption spending, in contrast effects of national rice charge instability are uncertain. The results show disparity possessions by prosperity position that differ crossways indicators of food security: a rise in the price of imported rice rises food part more between unfortunate persons than rich persons, and diminutions eating variety more between rich persons than poor persons.

Overall, these contrasting findings have continued to motivate further research to question the effect of oil prices on food prices. Obviously, understanding the pass-through effect of oil prices on domestic food prices for a country is important for continuous welfare assessment. In the case of a small open economy like Saudi Arabia, the subject is of intense interest for at least two reasons. First, Saudi Arabia is a net food-importing country where the major types of foodstuffs are all imported. As a result, Saudi Arabia is particularly vulnerable to oil and global food crises. Secondly, since Saudi economy is an oil-based economy, the rise in oil price is assumed to stimulate strong inflationary pressure through the increase in oil revenue, money liquidity and excess demand. Combined, the factors put Saudi Arabia at a higher inflationary risk when exposed to oil price shocks. In light of these facts and the recent experience of food price surge, a study on food price dynamics and its response to oil price movements is urgently needed. The potential asymmetric adjustment of food prices to oil price fluctuations is often attributed to factors such as the presence of market power and the role of public policy schemes such as price floor and price ceiling (Siagian, 2023). Hence, in this study, we attempt to analyze the asymmetric effect of oil price on inflation in the case of Saudi Arabia.

3. EMPIRICAL METHOD

The pass-through effect of oil price as a supply shock on inflation is often examined using the Gordon's Triangle Phillips Curve (Gordon, 1982). The "triangle model of inflation" indicates inflation is a function of three determinants; built in inflation or lagged rate of inflation, demand-pull or excess demand measured by output gap or unemployment gap, and the cost-push or supply shocks. Based on the model, an extensive body of literature about the effect of oil price shocks on inflation has been established (see, Hooker 2002; Gregorio et al., 2007; Chen, 2009; Cavallo, 2008; Clark and Terry, 2009; Herrera and Pesavento, 2009; Blanhard and Gali, 2010).

The empirical model used in this study is based on Gordon (1982; 1990) triangle model of inflation. Since supply shocks can create positive correlation between inflation and unemployment, the failure of including supply shocks in conventional Phillips curve is likely to lead to unreli-

able conclusion regarding the secular change in price stickiness (Gordon, 1990; Debdatta et al., 2020). The triangle Phillips curve model is presented as the following equation:

$$\pi_t = \beta \sum_{i=1}^{n} \pi_{t-i} + \delta [Y_t - Y_{Nt}] + c Z_t + \varepsilon_t \quad (1)$$

where is the indicator of supply shocks, π_t is inflation, Y_t is GDP which indicates the actual output and Y_{Nt} is the potential output. Equation (1) is expanded as a framework to estimate the effect of oil price on food prices in both long and short run (see, for example, Gregorio et al., 2007; Cavallo, 2008; Chou and Tseng, 2011; Ibrahim and Said, 2012; Ibrahim, 2015). Oil price shock indicators in several studies have also included exchange rate. Exchange rate is expected to be a channel of oil price pass through into inflation. Since oil is mainly traded in US dollars, changes in oil prices have direct impact on local currency which in return affects the prices of its imports/exports of goods and thus its consumer price index (Scheibe amd Vines, 2005; Nazlioglu and Soytas, 2011; Ibrahim and Chancharoenchai, 2013).

However, the effect of oil price on exchange rate depends on whether a country is exporter or importer of oil. In the case of oil-exporting countries, an increase in oil price is expected to lead to an appreciation in the local currency. Consequently, the costs of imported goods would decline. In contrast, for oil-importing countries, an increase in oil price will lead to a depreciation in local currency hence raise the cost of imports (Ibrahim and Said, 2012). In order to account for such channel, studies such as Cunado and Gracia (2005), Ibrahim and Said (2012) and Ibrahim (2014) chose to convert the oil price in US dollar to the prices in domestic currency. However, as Ibrahim and Chancharoenchai (2013) argued, while oil price fluctuations could affect the value of domestic currency vis-à-vis dollar, changes in the domestic currency value can also be caused by a host of other factors such as productivity differentials, capital flows and financial uncertainties. Thus, to distinguish between the effect of oil price and the exchange rate on inflation they choose to include the exchange rate of domestic currency against US dollar separately in the inflation equation.

In the case of Saudi Arabia, the exchange rate is pegged to the US dollar. Thus, the appreciation and depreciation of Saudi Riyal would be affected by the impact of oil prices fluctuations. According to Lizardo and Andre (2010), there is a negative correlation between oil price and US exchange rate. If so, it can be expected that increase in oil prices will lead to US dollar depreciation and through the dollar peg, this would increase Saudi's cost of its imports. In order to maintain the exchange rate peg to the U.S. dollar, Saudi Arabia Monetary Authority (SAMA) followed the Federal Reserve by cutting its policy rate and devaluating the Saudi Riyal against other currencies, which led to double digit inflation rates in mid-2008 (Westelius, 2013).

Another important reason for the inclusion of exchange rate in inflation modeling is due to the share of import items in the consumer price index (Scheibe and Vines, 2005). Since imports of foodstuffs account for 80% of the total food supply in the country, the inclusion of exchange rate is important in modeling Saudi Arabia food inflation. We can express the equation of food prices as:

$$fp_t = \beta \sum_{i=1}^{n} fp_{t-i} + \delta\, ygap + \gamma\, op_t + \vartheta\, er_t + \varepsilon_t \quad (2)$$

Equation (2) indicate the short run and long run determinants of food prices, where op_t is oil price, er_t is exchange rate and fp_t is food prices, and *ygap* is output gap.

Different methods have been developed to estimate output gap i.e. the difference between the actual and potential level of output, such as Hodrick and Prescott filter, Paxter and King's filter, and Kalman filter. Hodrick and Prescott filter is the most common method to measure the output gap in the literature of inflation and oil price (Gregorio, 2007; Ibrahim and Chancharoenchai, 2013; Ibrahim and Said, 2012). This measure, therefore, will be applied in this study to measure the output gap using both Gross Domestic Product (GDP) and non-oil Gross Domestic Product (NOGDP). Oil GDP accounts for considerable part of GDP and that the oil revenue is directly generated by the government and does not have a direct impact on private sector or investment. In contrast, NOGDP. This is because, accrues to the private sector directly through payments of wages and other income sources (Alsahafi, 2009; Basher and Elsamadisy, 2011; Basher and Fachin, 2014; Erkişi and Boğa, 2023). Therefore, non-oil output is expected to have higher impact on food prices.

Similarly, different indicators have been used to measure the world oil price; Brent spot crude oil price in the US dollars (Ibrahim and Chancharoenchai, 2013), West Texas Intermediate (Ibrahim and Said, 2011), Brent, and Dubai Fateh's calculation of the weighted average spot price (Chou, 2011), the producer price index for crude oil (Cunado and Gracia, 2005). Following Ibrahim and Chanchroenchai (2013) and due to limited availability of annual data on oil prices for the period 1970-2013, we use the Brent spot crude oil price in the US dollar.

To proxy exchange rate, we follow Scheibe and Vines (2005) in using the nominal effective exchange rate (NEER). The advantage of using NEER as an indicator of exchange rate variable is that it comprises several exchange rates and thus reduces the risk of erroneous generalizations that may result from measuring the domestic currency in terms of a specific single currency. Since NEER is measured as foreign currency price per local currency an increase in NEER represents an appreciation of the local currency. Thus, the changes of NEER are expected to have negative effect on food prices.

Different econometric techniques such as Threshold Autoregressive (TAR), Momentum Threshold Autoregressive (MTAR), and non-linear autoregressive distributed lag (NARDL) have been used to test the existence of asymmetrical cointegration and causalities between oil price and food prices variables. TAR and MTAR techniques are limited to examining only the long run cointegration between the variables. In contrast, the NARDL model developed by Shin et al. (2014) has the capability of modeling both the long-run and short-run asymmetric relation between the variables simultaneously (Derouez et al., 2023). In the NARDL model, the short-run and long-run nonlinearities are introduced via positive and negative partial sum decompositions of the explanatory variables. By doing this, the model becomes linear in the parameters of these decompositions and becomes easy to estimate by the standard ordinarily least square method (OLS). The NARDL approach is a single-equation error correction model that allows for asymmetry with respect to positive and negative changes in the explanatory variable(s). It is an extension of the autoregressive distributed lag (ARDL) model, and it has many advantages over the ARDL model. First, it allows for the possibility of asymmetric effects of the independent variable on the dependent variable. This is important in many economic and financial applications, where the effects of positive and negative shocks can be very different. Second, the NARDL model can be applied to stationary and non-stationary time series variables. Finally, the NARDL model is relatively easy to estimate and interpret. However, the assumptions of the NARDL model are summarized as follows: Primary, the dependent variable and independent variables must be stationary. Then, there must be a cointegration relationship between the dependent variable and the independent variables. Thirdly, the model must be correctly specified, that is, all relevant variables must be included in the model and the functional form of the

model must be correct. Lastly, the error term must be normally distributed and homoscedastic. If these assumptions are met, the NARDL model can be used to estimate the dynamic relationship between the dependent variable and the independent variables, as well as the asymmetric effects of the independent variables on the dependent variable (Lutfi, et al.,2022). Due to these advantages, NARDL is the preferred method to investigate the relationship (Shin et al., 2014).

The model of oil price and food prices based on the NARDL model is written as:

$$\Delta fp_t = \alpha + \delta\, Lfp_{t-1} + \theta^{+} op^{+}_{t-1} + \theta^{-} op^{-}_{t-1} + \omega\, er_{t-1} + \sum_{i=1}^{p} \partial_i\, \Delta fp_{t-i} + \sum_{i=0}^{q} \gamma_i\, ygap_{t-i} + \sum_{i=0}^{r} (\vartheta_i^{+}\, \Delta OP^{+}_{t-i} + \vartheta_i^{-} \Delta OP^{-}_{t-i}) + \sum_{i=1}^{n} \sigma_i\, \Delta er_{t-i} + e_t \quad (3)$$

Where and are the partial sums of positive and negative changes in log oil price:

$$op_t^{+} = \sum_{i=1}^{t} op_t^{+} = \sum_{i=1}^{t} \max(\Delta op_i, 0)$$

$$op_t^{-} = \sum_{i=1}^{t} op_t^{-} = \sum_{i=1}^{t} \min(\Delta op_i, 0) \quad (4)$$

Equation (3) is derived to examine the cointegration between the food prices, exchange rate and the partial sum of negative and positive changes in oil prices; where the null hypothesis of cointegration is $\alpha_1 = \theta^{+} = \theta^{-} = \omega = 0$ (Delatte and López-Villavicencio, 2012).In addition, the long and short run coefficients will be estimated; whereas: α/δ, θ^{+}/δ, θ^{-}/δ, ω/δ, are the long run coefficients of explanatory variables. It is assumed that θ^{+}/δ and $\theta^{+}/\delta > 0$ while $\omega/\delta < 0$. The short run coefficients of explanatory variables are ∂_i, γ_i, ϑ_i^{+}, ϑ_i^{-}. It is assumed that; ∂_i, γ_i, ϑ_i^{+}, $\vartheta_i^{-} > 0$ while $\sigma_i < 0$. The study uses annual data over the period 1979-2021 to estimate the model.

However, the NARDL model constitutes a powerful tool for analyzing the impact of oil shocks on food prices. However, it has some potential limitations. The NARDL model requires accurate estimation of relatively long time series data. This may not be available for all countries or for all time periods. The NARDL model is a complex model that requires careful specification and estimation. This can be a challenge for researchers with limited experience in time series analysis. Interpreting results from NARDL models can be difficult, particularly in cases where there are multiple explanatory variables.

In addition to these general limitations, some specific limitations may apply to the use of the NARDL model in the Saudi context, including the variable quality of economic data in Saudi Arabia. This may affect the accuracy of the NARDL model results. The Saudi economy has undergone significant structural changes in recent years. These changes may not be fully captured by the NARDL model. The Saudi government implements various policies that affect food prices. These policies may change over time, which could affect the applicability of the NARDL model.

Despite these limitations, the NARDL model constitutes a valuable tool for analyzing the impact of oil shocks on food prices in Saudi Arabia. The study cited in the prompt provides important insights into the mechanisms by which oil shocks affect food prices in Saudi Arabia.

The study also highlights the importance of adopting appropriate policies to mitigate the impact of oil shocks on food prices.

4. ANALYSIS

This paper aims to analyze the interrelationship between global oil prices and food prices in Saudi Arabia during 1979-2020 periods. In our case, the NARDL approach developed by Pesaran et al. (2001) was utilized to conduct the cointegration test and to detect how global oil prices impact the food prices in short and long term. This method follows the bounds testing approach to cointegration that was introduced by Pesaran and Shin (1999) and subsequently improved upon by Pesaran et al. (2001). As suggested by Alimi (2014), the NARDL approach to cointegration is more dependable for small sample sizes, which is relevant to our study.

Table 2. Descriptive analysis

	Fp	*Op*	*Er*	*Ygap*	*noygap*
Average	3.996	2.028	6.984	6.248	1.341
Median	4.000	2.000	6.000	6.000	1.000
Maximum	5.000	3.000	11.000	10.000	2.000
Minimum	1.000	1.000	1.000	1.000	1.000
Skewness	-0.553	-0.055	-0.178	0.077	0.668
Kurtosis	2.533	1.251	1.939	3.578	1.446
Jarque-***Bera***	661.654	1406.838	574.224	164.368	1924.739
P-value	0.000	0.000	0.000	0.000	0.000
Observations	205	205	205	205	205

Source: Primary data analysis output

The given table reports descriptive statistics for five variables: Fp, OP, Er, Ygap, and noygap. The Fp variable has an average value and a median value, indicating a somewhat symmetrical distribution around the center. The minimum value and the maximum value, suggesting a relatively narrow range of values. The data appears to be slightly negatively skewed, with heavier tails than a normal distribution. The OP variable has an average value and a median value, indicating a relatively symmetrical distribution. The range of values is from 1 to 3, suggesting little variation in values. The OP variable is relatively symmetric with lighter tails than normal. The Er variable has an average value and a median value, indicating a slightly positively skewed distribution. The range of values is from 1 to 11, suggesting moderate variation in values. The Er variable is slightly positively skewed with heavier tails and a more peaked distribution than normal. The Ygap variable has an average value and a median value, indicating an approximately symmetrical distribution. The range of values is from 1 to 10, suggesting moderate variation in values. The Ygap variable appears to be approximately symmetric with heavier tails and a more peaked distribution than normal.

The noygap variable has an average value and a median value, indicating a right-skewed distribution. The range of values is from 1 to 2, suggesting little variation in values. The noygap variable is skewed to the right, with a longer tail to the right of the mean but is otherwise close to a normal distribution.

All five variables were found to be non-normally distributed according to the Jarque-Bera test, indicating the presence of outliers or other non-normal factors. The range of values varies across the variables, with some showing moderate variation and others showing very little. In

order to detect the order of integration of each variable, we have used the ADF (Augmented Dickey-Fuller) test and PP (Phillips-Perron) test. The results indicated in Table 3 show that all variables are first order integrated.

Table 3. Unit root test for dependent and independent variables in food price model

	ADF		PP	
Level	**Intercept**	**Trend& intercept**	**Intercept**	**Trend& intercept**
Fp	1.049	-0.986	1.150	-0.410
op^+	1.046	-1.796	1.077	-1.761
op^-	-1.238	-1.982	-1.521	-1.919
Er	-1.558	-1.714	-1.774	-2.120
Ygap	-2.532	-2.547	-2.524	-2.673
noygap	-3.108**	-3.022	-1.868	-2.077
First difference				
Fp	-3.125**	-3.728**	-3.137**	-3.668**
op^+	-4.296***	-4.769***	-4.566***	-4.701***
op^-	-6.675***	-6.801***	-6.760***	-8.225***
Er	-4.068***	-4.008**	-4.015***	-3.937**
Ygap	-5.481***	-5.428***	-5.498***	-5.454***
noygap	-3.887***	-3.868**	-3.887***	-3.868***

Source: Primary data analysis output

NARDL results are reported in Table 4. To test the null hypothesis of no cointegration in long term among the variables, the F-statistic was computed using the Bounds test for coefficient restrictions. The critical values generated by Narayan (2005) with restricted intercept and no trend are used. The result shows that the F bound statistic (6.177) The results of the Bounds test show that the F-statistic value exceeds the 10%, 5%, 2.5% and 1% upper bounds, indicating the existence of cointegration in the long run among variables.

Table 4. Bounds test for cointegration

Model	Upper bounds	F-statistic
FFp(OP, Er, Ygap, noygap)		6.177****
	Critical Value bounds	
Significance level	I(0)	I(1)
10%	1.52	2.00
5%	2.01	2.54
2.5%	2.62	3.42
1%	2.23	3.98

Source: Primary data analysis output

Diagnostic tests of the dynamic model of food prices are also reported in Table 3. Results of J-B, LM, and ARCH enhance that the estimated models are well specified and that error terms are independent, homoscedastic, normally distributed and linear. In addition, the plotted charts of the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) of recursive residuals at 5% shows that the data is structurally stable (Figures 2 and 3).

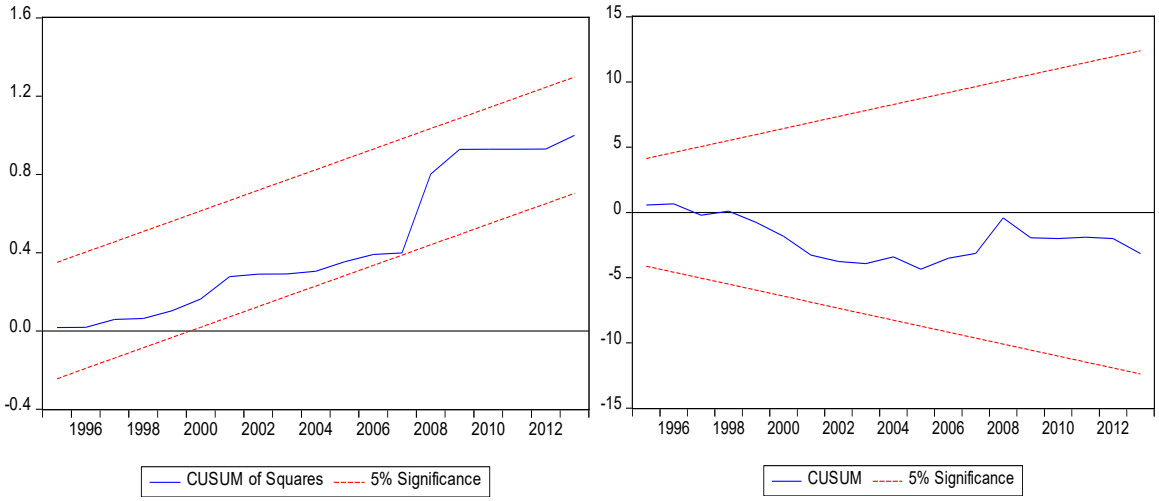
Table 5. The nonlinear ARDL Estimation results

Variable	***Model(1)***	***Model(2)***
C	2.292***	1.760***
	(0.288)	(0.258)
LFP_{t-1}	-0.310***	-0.269***
	(0.048)	(0.041)
LOP^{+}_{t-1}	0.098***	0.088***
	(0.012)	(0.010)
LOP^{-}_{t-1}	0.077***	0.068***
	(0.012)	(0.010)
Ler_{t-1}	-0.237***	-0.190***
	(0.034)	(0.028)
ΔLFP_{t-1}	-0.188	-0.191
	(0.119)	(0.112)
ΔLFP_{t-2}	-0.143	-----
	(0.291)	
ΔLOP^{+}_{t}	0.034	0.031
	(0.023)	(0.021)
ΔLOP^{+}_{t-1}	-0.082***	-0.102***
ΔLOP^{-}_{t}	(0.023)	(0.022)
	-0.017	-0.025
	(0.022)	(0.022)
ΔLOP^{-}_{t-1}	-0.014	0.058
	(0.023)	(0.048)
$* Lygap_{t}$	0.159**	0.064***
	(0.072)	(0.029)
ΔLer_{t}	0.044	0.058
	(0.055)	(0.048)
R^2	0.8957	0.894
F	13.602	18.716
DW	1.9684	1.970
F-Bound	19.279***	18.716***
J.B	2.2815	0.813
	(0.319)	(0.665)
LM(1)	0.148	0.245
	(0.704)	(0.784)
LM(2)	0.07366	1.085
	(0.929)	(0.306)
ARCH(1)	0.04948	1.085
	(0.825)	(0.306)
ARCH(2)	0.43926	1.600
	(0.649)	(0.219)
W_{LR}	0.069***	0.075***
W_{SR}	0.071***	0.069***

*Note: output gap (Ygap) is measured by NOGDP in the first model, and GDP in the second. ***, * indicate the significance at 1%, 5% and 10% respectively. The number between the brackets under the coefficients is the values of standard error. The results of LM, ARCH are shown up to lag between the brackets. The reported values in front LM, ARCH are for F statistics, and the numbers between the brackets are the associated p values. W_{LR} and W_{SR} is the Wald test of the null hypothesis of symmetry in the long and short run, respectively.*

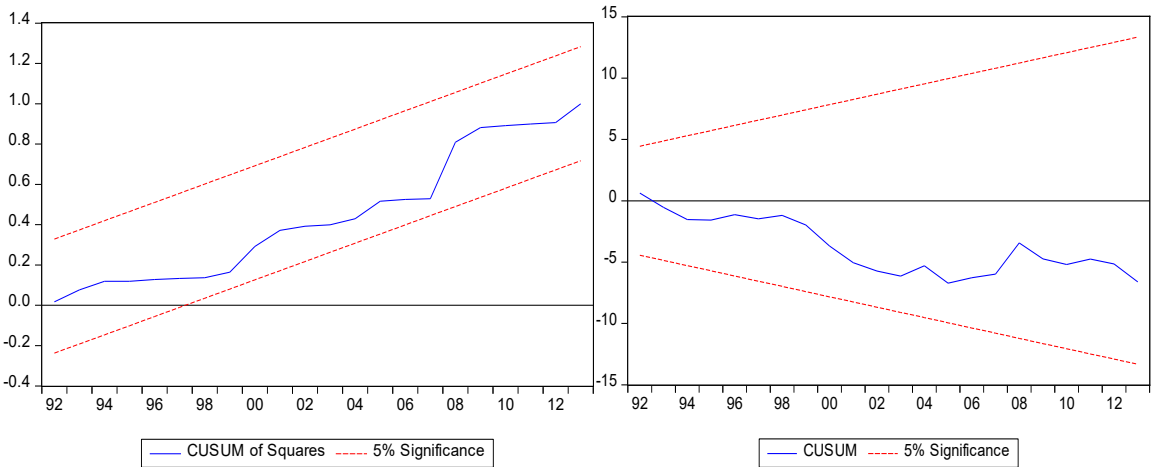
Source: Primary data analysis output

Figure 1. CUSUM and CUSUMQ of model (1)



Source: Primary data analysis output

Figure 2. CUSUM and CUSUMQ of model (2)



Source: Primary data analysis output

The long run equation of the food price in Saudi Arabia is generated and reported in Table 4. In the first model the NOGDP is used to generate the output gap, while the GDP gap was used in the second model. All the coefficients of potential explanatory variables in the long run have the expected sign. Both partial sums of positive and negative changes of oil price have a statistically significant effect on food prices. The long run effect of oil price on food prices is in consistent with findings of Alghalith (2010), Baffes (2007) Ibrahim and Said (2012) and Ibrahim (2014). However, the results of our analysis indicate that this effect is economically important and higher in the case of Saudi Arabia compared to those conducted on other countries. For example, the long run effect of oil price on food prices in Malaysia according to the study of Ibrahim and Said (2012) is 0.05%. In addition, the study of Ibrahim (2014) indicates the absence of oil price decline effect on food prices in Malaysia and the effect of oil price increases was only 0.06% for every 1% increase in global oil prices. Furthermore, the oil price pass through effect into world food prices is about 0.18% according to Baffes (2007). On the other hand, the studies of Alom et al. (2011) and Esmaeili and Shokoohi (2011) found no evidence of long run effect of oil prices on food prices. This important effect of oil prices on food prices in Saudi has very important

implication. It indicates that, being one of the top exporters of oil in the world, the pass-through effect of oil price into Saudi food price stems not only from increasing the cost of imports but also from the Saudi economy's heavy reliance on oil revenue. As we show previously the current expenditure is highly driven by the oil revenue which boosts consumer confidence and spending (Westelius, 2013). These results indicate the potential risks from oil price shocks on Saudi economy. Expenditure on foodstuffs accounts for substantial proportion of households' income and rising oil price have the ability to deteriorate their purchasing power.

The results show statistically significant asymmetry of oil price pass through into food prices, even though moderate in magnitude. It is shown that the increase in oil prices affect food prices more than oil prices' decreases. In other words, food prices display relatively rigid downward movements to the changes of oil prices. While a 1% increase of oil prices results in almost 0.32% increase on food prices, a 1% decline in oil prices results in 0.25% decline in food prices. This could indicate that there is some form of market power resistance which encourage food companies to be reluctant to transmit the decline of food prices to retail market (Chatham, 2013; Mohammed et al., 2014). However, it should be noted that the significant effect of negative oil price shocks on food prices indicate that the existence of market power is not strong enough to stop entirely the pass-through of negative changes in oil price to the food price in Saudi. Another potential reason for asymmetric oil price pass through is the asymmetric effect of oil revenue to current expenditure which is more related to the personal income.

Table 6. The long run equations of food prices in Saudi Arabia

Variable	Model (1)	Model (2)
C	7.391*** (0.613)	7.087*** (0.611)
OP_t^+	0.317*** (0.032)	0.326*** (0.032)
OP_t^-	0.248*** (0.047)	0.251*** (0.047)
EC_t	-0.764*** (0.135)	-0.705*** (0.168)

*Note: The numbers between the brackets are the values of standard error. The asterisks ***, ** and * denote the significance 1%, 5% and 10%, respectively.*

Source: Primary data analysis output

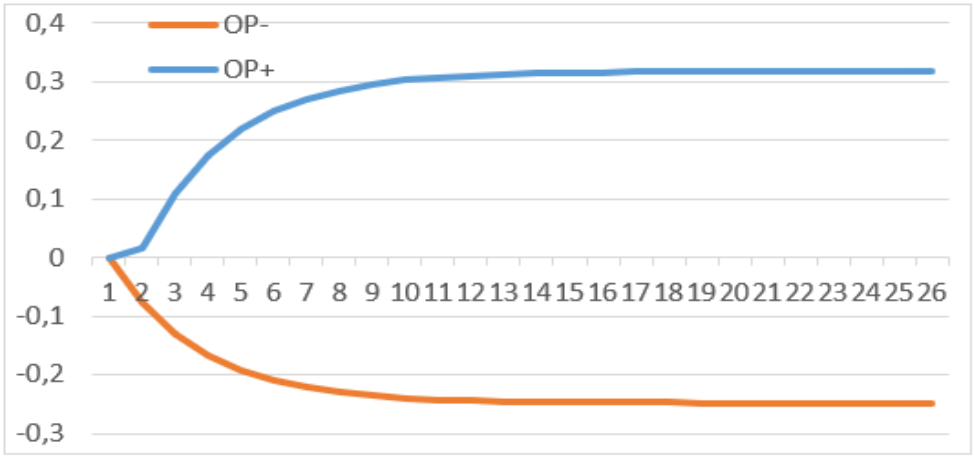
The dynamic multiplier of positive and negative oil price changes on food prices in Figure 2 also demonstrates this long run and short run asymmetric food prices' response to the changes of oil prices. While the prices of food after a positive shock in oil prices picks up from the second year according to model 1, the complete effect of oil price positive shock is felt between the eleventh to thirteenth year. Food prices also seem to respond immediately to the negative shock of oil prices. However, this response is relatively smaller than that in case of positive shocks.

The results of our study also show high pass-through effect of exchange rate into food prices. In both models, the effect of this variable is significant and considerably high where 1% appreciation of Saudi Riyal generates an increase in food prices by almost 0.7% to 0.76%. This corresponds to the fact that the bulk of foodstuffs in Saudi markets are imported. The effect of exchange rate could also reflect the indirect effect of oil prices on movements in food prices (Nazlioglu and Soytas, 2011; Ibrahim and Chancharoenchai, 2013; Idris et al., 2023). There is negative correlation between oil price and US exchange rate (Lizardo and André, 2010). As

Saudi Riyal is pegged to US dollar an increase in oil price will lead to decrease the nominal effective exchange rate and thus increase the cost of importing foodstuffs. In fact, since most of the foodstuffs are final products, the high direct effect of exchange rate on these commodities not unexpected.

As regards to the short run determinants of food prices, Table 5 demonstrates that output gap either measured by NOGDP or GDP has immediate positive impact on food prices. However, the effects of non-oil output gap and output gap for Saudi Arabia seems to differ in their magnitudes. Whilst 1% increases in non-oil output gap results in almost 0.16% immediate increase in domestic prices, 1% increases in output gap results in almost 0.064% increase in food prices. Giving that oil GDP accounts for considerable part of total GDP, the smaller than expected effect of GDP could be due to that oil GDP does not have a direct impact on private sector and has less impact on the food prices. Overall, the positive effect of output gap underlines the important role that large excess demand plays in food prices' instability and the existence of output-inflation trade off in the case of Saudi Arabia.

Figure 3. The dynamic multiplier of positive and negative shocks of oil price on food prices



Source: Primary data analysis output

The absence of the persistence in food inflation is indicated by the insignificant effect of first lag difference of food prices. This may represent the Saudi government effort to secure food imports and subsidizes essential food commodities in order to mitigate the burden of the food price inflation. This effort is most notable in 2008 when the food markets witnessed dramatic increase in prices of food commodities (Chatham house, 2013). This argument is enhanced by the negative effect of oil price on food prices in the short run as the one-year lagged difference of oil price as seen in Table 4.

In general, the results of food price analysis showed that oil price, devaluation of exchange rate and rise in excess demand have important role in explaining the recent hikes of food prices in Saudi Arabia. Given that these problems inflict real hardships on Saudi households, limit their ability to save and hence their ability to overcome other problems such as house ownership, our findings could be of high interest for policy makers.

5. CONCLUSION AND POLICY IMPLICATION

The objective of this study is to identify the relationship between oil price and food prices in Saudi Arabia in the context of the Phillips curve using annual data over the period 1979 -2020.

To examine the potential effect of market power and public policy schemes on the asymmetric behavior of food prices in its response to the oil price, the NARDL model is used in this study. Despite government subsidies for fuel and foodstuffs, the results show the significant and asymmetric effect of oil prices on food prices. In addition, comparing the results of our study to the studies conducted on other economies, it is shown that this effect is high and significant in both cases downward and upward movement of oil prices. This indicates that while higher oil prices are beneficial on the revenue side as they led to greater revenue, they also entail a challenge for the Saudis economic welfare. This is primarily because Saudi Arabia imports the bulk of its food products and thus the domestic food price is vulnerable to the global food prices' sensitivity to the changes in oil price. Another factor to be considered is the effect of expansionary fiscal policy associated with an increase in oil prices and consequently, the aggregate demand. In addition, with the Saudi riyal peg to the US dollar, the effect of oil prices increase on the US dollar infuses more pressure on food prices to rise during the increase in oil price. As the results show, the nominal effective exchange rate is an important factor in the food price equation. These results enhance the external channel of oil price's effect on food prices. Assuming that Saudi would keep maintaining its fixed exchange rate system, the capability of monetary policy to mitigate the inflationary pressure on food prices during the oil price increase is highly limited. In this case, the call is for the policy makers' attention to increase domestic food supply capabilities through the enhancement of agricultural productivity. Increasing domestic production of foodstuffs is expected to reduce the effect of external effect of oil prices on domestic food prices. In addition, to mitigate internal inflationary pressures associated with oil price shocks, the Saudi government should reassess its expansionary policy. The use of subsidies to contain inflation of essential foods must be balanced with the fiscal and efficient cost of subsidies. The evidence of asymmetric behavior of food prices in its response to oil prices; specifically, the downward rigidity of food prices, points towards the effect of market power on the behavior of retail food prices. This enhances the need for policy attention to contain market power. However, It is possible that market power amplifies the impact of oil shocks on food prices. Once a small number of retailers control a large share of the food market, they may be able to raise prices more easily than if the market were more competitive. Additionally, market power could make it more difficult for the government to implement policies to mitigate the impact of oil shocks on food prices. For example, if retailers have market power, they may be less likely to pass on government subsidies to consumers.

One way to combat market power is to promote competition in the food retail sector. This could be done by encouraging new market entrants and breaking up large monopolies. Additionally, the government could regulate the behavior of retailers to prevent them from abusing their market power.

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THE EFFECTS OF THE COVID-19 PANDEMIC ON CORPORATE SOCIAL RESPONSIBILITY AND BUSINESS PERFORMANCE IN COMPANIES LISTED ON THE WARSAW STOCK EXCHANGE

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ABSTRACT

The COVID-19 virus pandemic had an impact on all segments of life, including dally operations of companies. Companies had to adapt to market developments and change their business philosophy in order to survive in the market. This paper showed how the crisis caused by the COVID-19 virus pandemic affects the business of companies. This study aims to examine the business performance indicators (BPI) of companies listed on the Warsaw Stock Exchange (WSE) before and during the COVID-19 pandemic with a focus on corporate social responsibility (CSR). In order to examine this, a multivariate regression analysis was conducted. The findings show that there were no changes in the BPIs before and during the COVID-19 pandemic in companies in relation to CSR strategy. The only exception was found in the group of CSR companies that reported a lower profit margin during the COVID-19 pandemic. Companies with better BPIs may be willing to introduce CSR principles into their strategy and during the pandemic, intangibles influenced CSR strategy in a negative way. The limitations of the article are related to the study of only one market. Identified relationships allowed for a better understanding of the application of social responsibility principles among enterprises in Central Europe.

Keywords: *business performance indicators; COVID-19; CSR; ESG; sustainability*

1. INTRODUCTION

There is a lot of discussion about the negative impact of the COVID-19 pandemic on the economy and macroeconomic indicators, however, there are not many studies related to the effects of COVID-19 on a micro level or the performance of companies. In a period of sustainable development, when the market is not disturbed by any pandemic or war, the behavior and decisions of socially responsible enterprises may differ significantly from those that do not take such values into account.

The concept of corporate social responsibility (CSR) originates in the United States (Shemshad and Karim, 2023), where it was proposed at the end of the 18th century, referring to charity work at that time. However, it was not strictly related to the activities of the company itself. With time, organizations began to promote increasingly charitable activities, and as a result, companies enjoyed the respect of society. There are many definitions of CSR, and Dahlsrud (2008) concluded that most of them encompass economic, environmental, social, stakeholder,

and voluntarism dimensions. CSR refers to a company's voluntary initiatives to address embedded social and environmental issues within its operations. Although both sustainability and CSR aim at simultaneous economic development with social progress and equity while respecting the natural environment, the concept of CSR emphasizes more corporate business models. In contrast, the concept of sustainable development focuses on critical changes in the global environment (Fonseca et al., 2022). CSR is part of the wider ESG trend related to economic, governance, and social issues to which public enterprises should pay special attention.

The broad definition of ESG (Environmental, Social, and Governance) refers not only to corporations that consider these principles in their operations (CSR), but also to investors selecting assets for their portfolios under the same premise vit (SRI, Socially Responsible Investing, also called Sustainable and Responsible, Investing, Sustainable, Responsible and Impact Investing) (Starks, 2019). This concept is vital (Ahmić and Isković, 2023), and its importance is growing along with awareness of market participants, dwindling natural resources, and global changes in the political economy.

CSR enterprises stand for the concept that is increasingly being developed to improve their image in society (Dincer and Dincer, 2010). Additionally, as reported in many surveys, this approach to business influences the company's financial results (Barauskaite and Streimikiene, 2021), business performance, and reporting (Halkos and Nomikos, 2021). Companies are increasingly willing to implement the concept of corporate social responsibility by including it in their strategic plans (Vitolla et al., 2017). This idea can help solve social problems related to the company's environment. New CRS standards, codes, and guides are introduced, and more attention is paid to the protection of the natural environment (Fonseca et al., 2022).

CSR has related business activities (for example, environmental pollution) that can be improved to get the acceptance of stakeholders (Loureiro and Lopes, 2019). Furthermore, due to CSR activities, brand recognition increases (Liu et al., 2020), which can translate into higher profits, access to recruiting qualified employees, reduced costs, and increased shareholder confidence. However, the opponents' arguments state that the decisions can deviate from those adopted by the company (Štilić et al., 2023). CSR can be executed as a one-time advertisement to improve the image of an economic unit; it can often be a cynical and insincere game or greenwashing (Gatti et al., 2019).

The main goal of socially responsible enterprises on the capital market is to achieve positive financial results and increase value (Martin et al., 2009). During the COVID-19 pandemic, CSR could help maintain the market value of companies (Qiu et al., 2021).

This article aims to present social responsibility for the business performance of companies in times of health crisis. The empirical research presented in this article is twofold: to analyses whether different BPIs differ significantly before and during the COVID-19 pandemic in relation to the CSR strategy of companies belonging to the Respect Index in the WSE and to find the effects of different BPIs on the CSR orientation and to understand whether changes in these indicators during the COVID-19 pandemic affected an orientation towards principles and values.

The relationship between economic performances often leads to the question of ethical behavior that can result in a significant competitive advantage. Most authors (see, e.g., Berrone et al., 2007; Fonseca et al., 2016; Margolis and Walsh, 2003; Mattingly, 2017) argued that companies that implement a social responsibility policy gain greater economic benefits than companies that do not meet the expectations of stakeholders. However, other researchers found a neutral

or even negative relationship between social and economic performance and CSR (Aupperle et al., 1985; McGuire et al., 1988).

The article is divided into several sections where the authors present the review of the literature, data and methods, results, discussion, and conclusions. This article adds value to the literature and findings on social responsibility in corporate finance and shows the impact of the pandemic on CSR strategies.

2. REVIEW OF THE LITERATURE

The American industrialist Andrew Carnegie (2017; 1889) was the first to develop the idea of corporate social responsibility. In his opinion, it was the moral duty of every company to promote initiatives that would help society. This started a greater focus of the company on activities related to corporate responsibility (Stević et al., 2021; Kushnir et al., 2023). This phenomenon was further popularized in the 1960s and 1970s, and the term corporate social responsibility was first introduced by Carroll (1991), who presented a pyramid consisting of economic, legal, ethical, and philanthropic responsibility.

Today, socially responsible businesses benefit from the idea that has been developed as purely moral. The positive impact of the good environmental performance of companies on their financial situation was presented by Menguc et al. (2010), Russo and Fouts (1997), and Miroshnychenko et al. (2017). The negative impact of the good environmental performance of companies on their financial situation was presented by Cordeiro and Sarkis (1997), Filbeck and Gorman (2004), Lioui and Sharma (2012), Sarkis and Cordeiro (2001), and Wagner et al. (2002). The results are not unambiguous, and factors influencing social responsibility should be analyzed and answers to important questions about the role of CSR in the modern world should be sought.

The positive impact of the CSR principles implemented in companies on the results of their environmental activities was described by Apeaning and Thollander (2013). The negative impact of the financial situation of companies on the results of their environmental activities was presented by Gonenc and Scholtens (2017). The mutual positive relationship between the environmental performance of companies and their financial situation was presented by Clarkson et al. (2011). The non-linear dependence of the financial situation of enterprises on the result of their environmental activities was named by Tatsuo (2010). The lack of dependence between the results of the environmental activity of companies and their financial situation was presented in the research results of Dragomir (2013), Earnhart and Lizal (2007).

There have been three challenges related to social responsibility discussion in the literature since 1985. The post-letter period began with BlackRock CEO Lary Fink, advocating for a variety of issues and making specific public policy recommendations on the behavior of portfolio firms or disclosure choices of portfolio firms (Pawliczek et al., 2021).

Since then, the COVID-19 pandemic has significantly impacted the principles of ESG and investment strategies (Díaz et al., 2021). ESG disclosures based on firm practices are becoming more important as determinants (Joshi and Chauhan, 2021) and institutional investment in social factors (Park and Jang, 2021). In the analysis of the effects of the COVID-19 pandemic, the practices and principles of companies have changed, as well as business performance (Boffo and Patalano, 2020). New goals (shareholder rights, pollution, waste, greenhouse gas emissions, risks, and opportunity management) appear in the field of strategic management. Hoang et al. (2020) pointed out that environmental variables influence financial performance, with increasing importance attributed to the market after the global crisis period. Yang and others

with several studies are not more likely to corroborate this finding (Yang et al., 2021; Liu et al., 2022), especially in emerging markets. Although this may lead to assigning the benefits of ESG activities in doubt, it increases mainly to shareholders or creditors (Gregory, 2022).

When analyzing investments possibility on the BSE, Singh et al. (2021) concluded that there is no effect of the pandemic on the return and volatility of S&P ESG 100 index. Moreover, the results presented by Bangur et al. (2022) show that after COVID-19, the risk related to the market price of the S&P BSE 100 ESG Index has increased, and the certainty of investment decreased. Further findings indicate the presence of a large degree of persistency in the S&P BSE 100 ESG Index.

CSR activities significantly lower the cost of equity, the cost of debt, and the overall cost of capital (Yajymcuk et al., 2023). Companies that have the best application of ESG disclosure should also enjoy an advanced ranking in the index (Aboud and Diab, 2018). The scores of global activities show that there is a significant difference between 2009 and 2018 on behalf of European companies. Poland was in 2018 an average market for CSR application (Daugaard and Ding, 2022). Because the market plays a significant role in motivating CSR practises and the state and community reinforce the role of the 'free market' through the demand of social constituents, sanctions and boycotts, or mandatory requirements by the government (Eliwaab et al., 2021).

When taking into account financial instruments, Rozkov and Idema (2023) found that for investors the credibility of a green bond is a basic determinant for a purchase. The attractiveness of green bonds is influenced by financial factors such as tax incentives as well as interest rates (Vlasenko, 2023). In the German-speaking region of Europe, the environmental pillar is the most important for investors.

When corporate strategies are categorized according to quality and ease of assessment, it becomes clear that investors must often choose between those that are easy to understand but create little sustainable value and those that are hard to understand. but create sustainable value. The main issue is whether a company can derive positive benefits from social business in the name of social business maturity (Kane et al., 2014).

The latest research (Goh and Ang, 2021) writes that some internal stakeholders and boards of directors had backed because of higher operating costs instead of dampened sales caused by COVID-19. It is turning in the opposite direction and accepting refusing to maximize shareholder value but instead willing to move some benefits to other stakeholders (Soros, 2021).

Everyone is aware that business relationships are built on benefitted work and continuous investment to survive (Haenlein, 2017). The international market has made an interesting contribution to this relationship policy after COVID-19 (Adedotun, 2022; Badi and Elghoul, 2023), which tells that managerial initiatives completely support the adoption of CSR in innovative SMEs (De Falco et al., 2021). Some recent studies show that the pandemic had a negative impact on some sectors; for example, renewable electricity companies were suffering a sharper decline than traditional ones (Boldeanu et al., 2022).

It is also known that with the role of managerial attention and shareholder orientation, the governance and social dimensions of CSR can predict future distress (Dumitrescu et al., 2020). Long-term institutional ownership (IO) increases ESG performance, which leads to a higher IO ratio, and the demand for successful integration of key financial and CSR performance indicators (integrated reporting) is expected to increase (Velte, 2020). On the other hand, there are more studies on CSR to strengthen the relationship between corporate transformation towards Industry 4.0 (CTTI 4.0) and financial performance (Alkaraan et al., 2022). Some authors be-

lieve that this may be due to mandatory requirements taking away some opportunities for reputation-building via voluntary initiatives (Hoepner et al., 2021). Determinants, interactions, and pricing of sovereign credit risk accepted tools as critical determinants for macroeconomic dynamics should be considered and surveyed (Bajaj et al., 2022). Therefore, while macroeconomic indicators, including gross domestic product, show a decreasing trend after the COVID-19 pandemic, there are still not many recent studies on the effects at the micro level, and the fact that the disclosure of ESG has a positive influence on the competitive advantage at the firm level (Rabaya and Saleh, 2022).

According to neoclassical theory, the company's main goal is to make a profit (Vranceanu, 2014). Implementing such assumptions can be obtained because of reducing production costs or implementing new technological solutions that reduce costs and lead to the development of the enterprise. Recently, managerial theory has appeared that presents the separation of the value of a given economic unit from the management of this enterprise (Zhukevych and Zhuk, 2023). As a result, individual approaches blur in favour of a jointly developed goal.

Freeman (1984) defined stakeholders as any group or individual who can affect or is affected by the achievement of the organization's objectives. Stakeholder theory integrates business and social issues (Crane and Ruebottom, 2011), and according to Freeman (1984), the success of an organization depends on its collaboration with multiple stakeholders. Authors such as Fonseca et al. (2016), based on empirical research, found that competitive position is strongly correlated with shareholders, suppliers, partners, employees, and customer satisfaction, legitimating Freeman's stakeholder theory". It can be concluded that stakeholder theory is based on the role of philosophy, law, ethics, economics, and other fields of knowledge (Wheeler et al., 2002). An enterprise must consider many groups, i.e. potential investors; political groups, customers, society, employees, and suppliers, to develop its business, but the decision to adopt a responsible business strategy may be the result of good financial results.

The existing literature on empirical studies related to pre-COVID and post-COVID situations in terms of social corporate responsibility lacks a comprehensive analysis of how the pandemic has reshaped corporate sustainability practices. There is a noticeable gap in the literature regarding the long-term impact of the pandemic on companies' CSR strategies, making it challenging to understand how businesses have adapted to new societal and environmental challenges. Thus, this study is going to provide a valuable insight into this topic.

A critical need exists for research that delves into the evolving dynamics of social corporate responsibility in the context of COVID-19, offering insights into the effectiveness of CSR initiatives and their alignment with changing global priorities.

3. DATA AND METHODS

The research sample consists of 425 nonfinancial companies listed on the Warsaw Stock Exchange, and their BPIs based on quarterly financial statements and shares quotations. The pre-pandemic period consists of the years 2019, 2020 and the first quarter of 2021 and pandemic time is represented by the year 2021 (3 quarters), when its impact on the economy was the most visible. A total of 3080 observations are analysed in relation to the pre-pandemic and, pandemic periods, and moreover, the CSR strategy performance implemented by surveyed companies is taken into consideration.

The WSE Respect Index includes companies that implement social responsibility strategies (CSR companies). The index was first published on November 19, 2009, and is the first index

in Central and Eastern Europe that brings together companies implementing corporate social responsibility. It includes 31 companies that have implemented socially responsible strategies for the environment, the community, and employees.

The following hypotheses are tested to achieve the research goal.

The first hypothesis that there is a difference between BPIs in relation to the pandemic and social responsibility is divided into two subhypotheses stated as follows:

$H_{1(a)}$: There is a statistically significant difference in business performance indicators before and during the COVID-19 pandemic.

In the second subhypothesis, the differences in business performance indicators between the so-called CSR and non-CSR companies before and during the COVID-19 pandemic are analysed. Thus, the next hypothesis is stated as follows.

$H_{1(b)}$: There is a statistically significant difference in business performance indicators between types of business with CSR and non-CSR before and during the COVID-19 pandemic.

For this hypothesis, we compare two groups: the CSR group of companies (1) and the non-CSR group of companies (0).

Both hypotheses are tested with a t-test for independent samples.

For the second part of our research, another hypothesis is tested:

H_2: There is a statistically significant effect of business performance indicators on the company's orientation towards CSR in relation to the COVID-19 pandemic period.

To test this hypothesis, we developed a model and tested it with the multiple linear regression panel as follows:

$$CSR = a + b_1ROE + b_2MV + b_3CR + b_4D/E + b_5PM + b_6TQ + b7FCF / TA + b_8IN + ei \quad (1)$$

where;

a dependent variable that presents the CSR performance recognized as a discrete variable:

- CSR – is a company included in Respect Index (binominal variable)

CSR = 0, a company does not belong to Respect Index,

CSR = 1, a company belongs to Respect Index.

Independent variables that may influence the CSR strategy:

- ROE - Return on equity (X_1),
- MV - Market Value (X_2)
- CR - Current ratio (X_3)
- D/E – Debt/equity (X_4)
- PM - Profit margin (X_5)
- TQ - Tobin's Q (X_6)
- FCF / TA - Free cash flow from operations/ Total assets (X_7)
- IN – level of Intangibles (X_8)

Variables are calculated according to the following formulas:

$$ROE = \frac{NI}{SE} \tag{2}$$

Where: NI – net income, SE – shareholders' equity.

$$MV = P * SO \tag{3}$$

Where: P – market price of a share, SO – number of shares outstanding.

$$CR = \frac{CA}{SL} \tag{4}$$

Where: CA – current assets, SL – short term liabilities.

$$D/E = \frac{D}{SE} \tag{5}$$

Where: D – debt, SE – shareholders' equity.

$$PM = \frac{NI}{S} \tag{6}$$

Where: NI – net income, S – sales.

$$TQ = \frac{MV}{ARC} \tag{7}$$

where: TQ - Tobin's Q, MV - market value of capital invested in the company, ARC - asset replacement cost.

$$FCF/TA = \frac{FCFFO}{TA} \tag{8}$$

Where: FCFFO – free cash flow from operations, TA – total assets.

IN - intangible assets represented in the balance sheet as part of the company's fixed assets.

BPIs such as ROE, CR, D/E, PM, and FCF/TA are the most popular financial indicators indicating the strategic operation of the company in the area of profitability, net working capital, capital structure, operational efficiency, and cash efficiency of assets. MV represents the company's market value calculated by multiplying the share price by the number of issued shares. The TQ ratio, also known as Tobin's Q, equals the market value of a company divided by its assets' replacement cost. This indicator can be interpreted as a measure of the company's growth potential. IN represents the value of intangible assets in the company's balance sheet. On the basis of the analysis of issues related to CSR, it can be assumed that TQ and IN may be related to this area. CSR can contribute to a better assessment of the company by investors and be a consequence of investing in innovative solutions. Intangibles have not been linked in theory with CSR so far, but may affect corporate social responsibility.

Taking into account the purpose of the study and the assessment of how the COVID-19 pandemic affected these relations, hypothesis H2 was tested for two subsamples:

a) Subsample covering the period before the COVID-19 pandemic;

b) Subsample covering the period during the COVID-19 pandemic.

To detect whether there is a statistical difference in coefficients in two linear regressions from two subsamples, an added Chow test was applied to analyse the existence of a structural difference in some parameters of a model between two subsamples. Thus, an additional hypothesis is developed:

H_3: There is a structural difference between the parameters in two linear regression models that cover the effects before and during the COVID-19 pandemic.

4. RESULTS

In this section of the paper, the results of the tests and analysis are presented with respect to data statistics, differences between samples, and model parameters.

4. 1 STATISTICS OF THE SAMPLES

There are 2697 observations related to non-CSR companies (companies not included in the Respect Index) - (87.6%) and 383 observations related to CSR companies (companies included in the Respect Index) - (12.4%). For the period before the COVID-19 pandemic, there are 1155 observations (37.5%), and during the COVID-19 pandemic, 1925 observations (62.5%). The results of the descriptive statistics for the variables in the model are presented in Table 1.

Table 1. Descriptive statistics of a sample

	N	Minimum	Maximum	Mean
ROE	2826	-4.66	4.33	0.05
MV	3080	-80.07	118452608.96	9223.37
CR	3062	0.00	1815.39	7.91
D/E	3061	-62.07	9223.37	31.24
PM	2786	-649.03	873.69	-0.06
TQ	3062	-13.41	1511.86	3.85
FCF/TA	3062	-2.31	1.36	0.05
IN	2554	0.10	413715000.00	9223.37

Source: Author's calculation

Since we are interested to see the situation of different indicators for non-CSR and CSR companies before and during the Covid-19 pandemic, the results of descriptive statistics for sub-samples are given in Table 2.

Table 2. Descriptive statistics of sub-samples*

BD	CSR		N	Minimum	Maximum	Mean
1	0	ROE	930	-4,66	2,44	0,01
		MV	1011	0,00	118452608,96	797377,54
		CR	1004	0,00	1815,39	10,18
		D/E	1004	-62,07	166,32	0,53
		PM	916	-649,03	601,97	-0,90
		TQ	1004	0,00	420,95	2,78
		FCF/TA	1004	0,00	0,85	0,05
		IN	818	0,10	207964000,00	766022,98
		Valid N (listwise)	730			
	1	ROE	135	-1,30	2,31	0,17
		MV	144	0,00	41805267,35	5087145,94
		CR	141	0,05	28,64	2,84
		D/E	140	-7,23	14035,83	202,14
		PM	129	-9,16	3,80	0,09
		TQ	141	-4,34	22,55	3,33
		FCF/TA	141	0,00	0,62	0,07
		IN	135	74,00	4660000,00	190612,94
		Valid N (listwise)	118			
2	0	ROE	1534	-3,59	4,33	0,03
		MV	1686	0,00	86162075,90	595253,01
		CR	1680	0,00	1663,17	7,63
		D/E	1680	-42,41	218,90	0,59
		PM	1528	-191,99	873,69	0,37
		TQ	1680	0,00	1511,86	4,54
		FCF/TA	1680	0,00	0,95	0,05
		IN	1376	0,93	413715000,00	1283805,21
		Valid N (listwise)	1212			
	1	ROE	227	-0,62	2,67	0,24
		MV	239	-80,07	37558361,34	5072393,20
		CR	237	0,04	37,92	3,27
		D/E	237	-1,91	14501,11	277,62
		PM	213	-3,16	6,74	0,35
		TQ	237	-13,41	49,44	3,80
		FCF/TA	237	-2,31	1,36	0,06
		IN	225	15,00	4341000,00	191124,03
		Valid N (listwise)	191			

Source: Author's calculation

* BD-1, CSR-0 = Before Covid 19 for non-CSR companies; BD-1, CSR-1 = Before Covid 19 for CSR companies; BD-2, CSR-0 = During Covid 19 for non-CSR companies, BD-2, CSR 1 = During Covid 19 for CSR companies

4. 2 DIFFERENCES BETWEEN SAMPLES

An independent sample t-test was calculated to compare different indicators of business performance before and during the COVID-19 pandemic to test *hypothesis H1 (a).* The results are presented in Table 3.

Table 3. Independent Sample Test before and during the COVID-19 Pandemic

EVA: Equal variances assumed EVNA: Equal variances not assumed		Levene's test for Equality of Variances		t-test for Equality of Means				
		F	Sig. p-value	t	df	Sig. (2-tailed) p-value	Mean Difference	Std. Error Difference
ROE	EVA	3.298	0.069	-1.166	2824	0.244	-0.018645	0.0159844
	EVNA			-1.196	2419.101	0.232	-0.018645	0.0155956
MV	EVA	3.484	0.062	0.842	3078	0.4	9223.372	9223.372
	EVNA			0.765	1776.894	0.444	9223.372	9223.372
CR	EVA	3.012	0.083	0.842	3060	0.4	2.1874556	2.5969647
	EVNA			0.746	1634.665	0.456	2.1874556	2.9311209
D/E	EVA	0.633	0.426	-0.403	3059	0.687	-9.632073	23.921784
	EVNA			-0.417	2662.958	0.677	-9.632073	23.112174
PM	EVA	0.073	0.787	-0.792	2784	0.428	-1.147094	1.448407
	EVNA			-0.782	2111.251	0.434	-1.147094	1.4667981
TQ	EVA	4.211	0.04	-1.227	3060	0.22	-1.597958	1.3026823
	EVNA			-1.445	2915.388	0.149	-1.597958	1.1058015
FCF/TA	EVA	0	0.987	0.343	3060	0.731	0.0016868	0.0049125
	EVNA			0.353	2614.784	0.724	0.0016868	0.004779
IN	EVA	1.605	0.205	-0.64	2552	0.522	-9223.372	9223.372
	EVNA			-0.729	2546.592	0.466	-9223.372	9223.372

Source: Author's calculation

Differences for ROE, Levene's test for equality of variances with $p = 0.069$, indicate that equal variances are assumed. In that case, there is no significant difference (t (2,844) = -1.166, p=0.244) in ROE scores before the COVID-19 pandemic (M=0.034, SD=0.386) and during the COVID-19 pandemic (M=0.0529, SD=0.427). Therefore, there are no significant differences in ROE levels before and during the COVID-19 pandemic.

In the case of MV, Levene's test for equality of variances with $p = 0.069$ indicates that equal variances are assumed. There is no significant difference (t (3078) = 0.842, p=0.4) in MV before COVID-19 pandemic (M=9223.372, SD=9223.372) and during COVID-19 pandemic (M = 923.372, SD = 923.372). Therefore, the hypothesis for MV can be rejected and it can be concluded that there are no significant differences in MV levels before and during the COVID-19 pandemic.

In the case of CR, Levene's test for equality of variances shows that equal variances are assumed (p <0.05). It was found that (t (3060) = 0.842, $p = 0.4$) *and this result* does not show significant differences in CR scores before the COVID-19 pandemic (M=9.278, SD=90.122) and during the COVID-19 pandemic (M = 7.90, SD = 53.588). With this result, the hypothesis of the

difference in CR can be rejected and it can be concluded that there is no significant difference in the level of CR before and during the COVID-19 pandemic.

In the case of D/E, Levene's test for equality of variances shows that equal variances are not assumed p≥0.05. There are no significant differences (t (3059) = -0.403, *p*=0.687) in D/E scores before the COVID-19 pandemic (*M*=25.206, *SD*=585.102) and during the COVID-19 pandemic (*M*=34.838, *SD*=671.075). Based on this result, the $H_{1(a)}$ hypothesis H1 (a) for D/E can be rejected.

Equal variances are also assumed for PM using Levene's Test (p≥0.05). The t-test does not show significant differences (t (2744) = -0.792, p=0.428) in PM levels before the COVID-19 pandemic (M=-0.781, SD=38.177) and during the COVID-19 pandemic (M=0.365, SD=36.297). Based on this result, the $H_{1(a)}$ hypothesis H1 (a) for PE can be rejected.

Levene's test for TQ is equal to p≤0.05, thus equal variances are not assumed. Taking this into account, it was found that (t (2925.388) = -1.445, p=0.149) in the TQ for TQ before the COVID-19 pandemic (M=-2.846, SD=19.302) and during the COVID-19 pandemic (M=4.444, SD=41.477). Based on the result, t the hypothesis can be rejected, and it can be concluded that there are no significant differences in TQ before and during the COVID-19 pandemic.

For FCF/TA, Levene's test assumes equal variances (p <0.05). The t-test does not show significant differences (t (3060) = 0.343, p=0.731) in FCF/TA levels before the COVID-19 pandemic (M=0.051, SD=0.122) and during the COVID-19 pandemic (M=0.049, SD=0.137). As a result, the $H_{1(a)}$ hypothesis is rejected for FCF/TA.

Finally, for IN, equal variances are assumed based on Levene's test (p 0.05). There is no significant difference because (t (2552) = -0.64, p=0.522) before the COVID-19 pandemic (M = 923.372, SD = 11176576.911) and during the COVID-19 pandemic (M = 923.372, SD = 1908869.955). As a result, the $H_{1(a)}$ hypothesis is rejected.

In all cases, the mean values of the variables did not differ with respect to the periods before and during the COVID-19 pandemic. When all companies are considered, it is found that the pandemic did not influence PBI levels in a significant way on the WSE.

In the next step, the companies implementing or not the social responsibility principles (CSR companies and non-CSR companies) are tested for differences of BPIs.

Furthermore, using independent samples, business performance indicators between CSR and non-CSR types of businesses were analysed before and during the COVID-19 pandemic to test *hypothesis H1 (b).* The results are provided in Tables 4 and 5.

Table 4. Independent Samples Test for non-CSR companies (before and during the Covid-19 pandemic)

CSR (1) Non-CSR (0) EVA: Equal variances assumed EVNA: Equal variances not assumed			Levene's Test for Equality of Variances		t-test for Equality of Means				
			F	Sig. p-value	t	df	Sig. (2-tailed) p-value	Mean Difference	Std. Error Difference
0	ROE	EVA	2.331	0.127	-0.716	2462	0.474	-0.01191	0.016641
		EVNA			-0.733	2112.265	0.463	-0.01191	0.016239
	MV	EVA	3.927	0.048	0.966	2695	0.334	9223.372	9223.372
		EVNA			0.852	1421.801	0.394	9223.372	9223.372
	CR	EVA	3.205	0.074	0.862	2682	0.389	2.552374	2.960696
		EVNA			0.764	1433.221	0.445	2.552374	3.341399
	D/E	EVA	0.051	0.821	-0.218	2682	0.827	-0.05517	0.252877
		EVNA			-0.215	2021.116	0.83	-0.05517	0.25631
	PM	EVA	0.08	0.778	-0.77	2442	0.441	-1.27227	1.651324
		EVNA			-0.761	1848.913	0.447	-1.27227	1.672592
	TQ	EVA	4.168	0.041	-1.185	2682	0.236	-1.75705	1.48337
		EVNA			-1.396	2552.268	0.163	-1.75705	1.25885
	FCF/TA	EVA	0.048	0.826	0.128	2682	0.898	0.000611	0.004787
		EVNA			0.127	2091.329	0.899	0.000611	0.0048
	IN	EVA	1.621	0.203	-0.638	2192	0.523	-9223.37	9223.372
		EVNA			-0.728	2187.703	0.467	-9223.37	9223.372

Source: Author's calculation

If we independently compare non-CSR and CSR companies to verify the hypothesis of H2(a), the results are as follows. Levene's test for Equality of Variances shows in both types of companies with p<01, thus assuming equal variances. For non-CSR companies, there is no significant difference (t (2462) = -0.716, p=0.474) in the level of ROE for the period before the COVID-19 pandemic and during the COVID-19 pandemic. In the case of CSR companies, there is no significant difference (t (360) = -1.262, p=0.208) in ROE before the COVID-19 pandemic and during the COVID-19 pandemic. Therefore, H1 (b) should be rejected for both types of companies and it can be concluded that regardless of the type of company, no significant changes in ROE occurred before and during the COVID-19 pandemic.

For non-CSR companies, Levene's Test indicates that equal variances are not assumed (p≤0,05), while in the case of CSR companies, equal variances are assumed (p≥0.05). For non-CSR companies, it was found (t (0.852) = 1421.801, p=0.394) in ROE level before the COVID-19 pandemic and during the COVID-19 pandemic, so the $H_{1(b)}$ hypothesis can be rejected. For CSR companies, (t (381) = 0.019, p=0.985) no significant differences for MV before and during the COVID-19 pandemic were identified, and $H_{1(b)}$ hypothesis should be rejected also in this case.

Levene's Test for Equality of Variances shows that equal variances are assumed for both non-CSR and CSR companies (p≥0.05). In the case of non-CSR companies, the result (t (2682) = 0.862, p=0.389) indicated that there are no significant differences in CR before and during the COVID-19 pandemic. For CSR companies, the result (t (376) = -0.834, p=0.405) says a similar conclusion. For both types of companies, the $H_{1(b)}$ hypothesis should be rejected and it can be

concluded that there are no statistically significant differences in CR levels before and during the COVID-19 pandemic.

Table 5. Independent Samples Test for CSR companies (before and during the Covid-19 pandemic)

CSR (1) Non-CSR (0) EVA: Equal variances assumed EVNA: Equal variances not assumed			Levene's Test for Equality of Variances		t-test for Equality of Means				
			F	Sig. p-value	t	df	Sig. (2-tailed) p-value	Mean Difference	Std. Error Difference
0	ROE	EVA	2.807	.095	-1.262	360	.208	-.061	.048
		EVNA			-1.286	297.990	.199	-.061	.0478
	MV	EVA	.909	.341	.019	381	.985	9223.372	9223.372
		EVNA			0.018	286.467	0.985	9223.372	9223.372
	CR	EVA	1.705	0.192	-0.834	376	0.405	-0.4282	0.513202
		EVNA			-0.893	353.598	0.373	-0.4282	0.479655
	D/E	EVA	0.629	0.428	-0.39	375	0.696	-75.4756	193.2941
		EVNA			-0.403	321.69	0.687	-75.4756	187.0556
	PM	EVA	0.365	0.546	-2.171	340	0.031	-0.25803	0.118842
		EVNA			-2.041	220.203	**0.042**	-0.25803	0.126429
	TQ	EVA	1.084	0.298	-0.733	376	0.464	-0.46805	0.638727
		EVNA			-0.784	353.785	0.433	-0.46805	0.596822
	FCF/TA	EVA	0.098	0.755	0.454	376	0.65	0.009392	0.020699
		EVNA			0.513	376	0.608	0.009392	0.018313
	IN	EVA	0	0.998	-0.007	358	0.994	-511.09	9223.372
		EVNA			-0.007	265.466	0.994	-511.09	9223.372

Source: Author's calculation

For D/E Levene's Test with p≥0.05 for both, non-CSR and CSR types of companies, allows to assume equality of variances. For companies that do not implement CSR, the $H_{1(b)}$ hypothesis should be rejected since (t (2682) = -0.218, p=0.827). The same conclusion can be stated also for CSR companies based on (t (375) = -0.39, p=0.696). Therefore, there were no statistical differences in D/E before and during the COVID-19 pandemic for both types of companies.

For both types of companies, Levene's Test is characterised by p≥0.05 assuming equal variances. For companies that do not implement the CSR strategy, the result (t (242) = -0.77, p=0.441) shows no differences in PM levels before and during the COVID-19 pandemic. Since this result, the $H_{1(b)}$ hypothesis should be rejected. However, for companies that implement the CSR principles, different results (t (34) = -2.171, p=0.031) were achieved that confirm *hypothesis H1 (b)*. Therefore, in the case of CSR companies, there is a statistical difference in PM levels before and during the COVID-19 pandemic.

For companies not implementing the CSR strategy, Levene's Test does not assume equal variances (p≤0.05) for TQ while for CSR companies it assumes (p≥0.05). For both types of companies, $H_{1(b)}$ hypothesis can be rejected since for non-CSR companies it was found (t (2552) = -1.396, p=0.163) and for CSR companies (t (376) = -0.733, p=0.464). There is no significant differences in TQ before and during COVID-19 for both types of companies.

For FCF/TA in the case of non-CSR companies, Levene's Test does not assume equal variances (p≤0.05) while for CSR companies it is assumed (p≥0.05). Following this result, for

non-CSR companies, the result (t (2091.329) = 0.127, p=0.899) and for CSR companies, the result (t (376), = 0.454, p = 0.65) do not show any differences in FCF/TA before and during the COVID-19 pandemic; therefore, the hypothesis of H1 (b) should be rejected.

Regarding the Intangible Assets for non-CSR and CSR companies, Levene's Test ($p \geq 0.05$) assumes equal variances. For both types of companies, the hypothesis should be rejected, since for non-CSR companies the result is (t (2192) = -0.638, p=0.523), while for CSR companies the result is (t (358) = -0.007, p=0.994). It can be concluded that for both types of companies, there is no significant difference in IN before and during the COVID-19 pandemic.

The results show that significant differences were found before and during the COVID-19 pandemic in the case of PM in the CSR group of companies.

4. 3 FACTORS INFLUENCING CSR IMPLEMENTATION IN WSE COMPANIES

For the second part of this study, the effects of business performance indicators on the CSR strategy are analysed and the results are presented in Table 6.

Table 6. Summary of the entire sample

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.350[a]	0.123	0.12	0.32351351	0.123	41.034	8	2349	0
a. Predictors: (Constant), ROE, MV, CR, D/E, PM, TQ, FCF/TA, IN									

Source: Author's calculation

The model presented in Table 6 explains 12% of the variation in the level of CSR of companies listed on WSE. The general model of multiple linear regression is significantly useful for explaining the level of CSR for the dependent variable with the result *F (8, 2349) = 41.03, p <0.001. Therefore, Hypothesis H2* can be concluded that there is a statistically significant effect of business performance indicators on the orientation towards CSR principles.

The impact of individual BPI on CSR strategies is presented in Table 7.

Table 7. Effects of individual factors of business performance on CSR strategy for the entire sample

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.078	.008		9.290	**.000**
	ROE	.117	.018	.132	6.647	**.000**
	MV	9.313E-9	.000	.173	8.420	**.000**
	CR	.000	.001	-.009	-.432	.666
	D/E	.001	.001	.028	1.470	.142
	PM	.000	.001	.010	.480	.631
	TQ	.025	.002	.220	10.540	**.000**
	FCF/TA	-.078	.056	-.028	-1.393	.164
	IN	-8.832E-10	.000	-.045	-2.302	**.021**
a. Dependent Variable: CSR						

Source: Author's calculation

Based on the results presented in Table 7, the following results can be found.

- ROE has a significant effect on the CSR strategy, F (2349) = 6.647, p< .001
- MV has a significant effect on the CSR strategy, F (2349) = 8.420, p< .001
- CR does not have a significant effect on the CSR strategy, F (2349) = -.432, p= .666
- D/E does not have a significant effect on the CSR strategy, F (2349) = 1.470, p= .142
- PM does not have a significant effect on the CSR strategy, F (2349) = .480, p= .631
- TQ has a significant effect on the CSR strategy, F (2349) = 10.540, p< .001
- FCF/TA does not have a significant effect on the CSR strategy, F (2349) = -1.393, p= .164
- IN has a significant effect on the CSR strategy, F (2349) = -2.302, p< .05

For the subsample covering the period before the COVID-19 pandemic, the results presented in Table 8 show that the model covering the period before the COVID-19 pandemic explains 10% of the variation in the CSR group of companies. The model is still significant and useful in explaining the CSR for the dependent variable with the result *F (8, 885) = 12.47, p ≤0.001. Thus, the* H_2 hypothesis can be confirmed for this subsample, and it can be concluded that there is a statistically significant effect of business performance indicators on the orientation toward CSR principles prior to the COVID-19 pandemic.

Table 8. Model Summary for the Subsample Before COVID-19

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.318[a]	.101	.093	.32932

Source: Author's calculation

The results presented in Table 9 explain how individual performance indicators affect the CSR strategy in the period prior to the COVID-19 pandemic.

Table 9. Effects of Individual Factors of Business Performance on CSR the Subsample Before COVID-19

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	.078	.014		5.584	**.000**
	ROE	.129	.034	.127	3.830	**.000**
	MV	4.549E-9	.000	.106	2.949	**.003**
	CR	.000	.002	.003	.085	.932
	D/E	.001	.001	.041	1.277	.202
	PM	.001	.002	.013	.398	.691
	TQ	.028	.005	.226	6.258	**.000**
	FCF/TA	-.044	.091	-.016	-.481	.631
	IN	-1.089E-9	.000	-.036	-1.108	.268

Source: Author's calculation

As presented in Table 9 the following variables ROE, MV, and TQ have a significant effect on CSR at the level of $p< 0.05$.

For the subsample covering the period during the COVID-19 pandemic, the results presented in Table 10 indicate that the model explains 15% of the variation in the CSR strategy of WSE companies. The model is statistically significant with the result of the F statistics at the level (8, 1455) = 32.78, $p <0.001$ allowing us to confirm the hypothesis H2 for this subsample. Therefore, even during the period during the COVID-19 pandemic, there is a statistically significant effect of business performance indicators on the orientation towards CSR principles.

Table 10. Summary of the Model for the Subsample during the COVID-19

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.391[a]	.153	.148	.31777

Source: Author's calculation

During the period during the COVID-19 pandemic, there was a slightly different situation, and it is presented in Table 11.

Table 11. Effects of individual factors of business performance on the CSR subsample during COVID-19

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.070	.011		6.246	**.000**
	ROE	.112	.021	.135	5.391	**.000**
	MV	1.601E-8	.000	.240	9.483	**.000**
	CR	.000	.001	-.011	-.443	.658
	D/E	.005	.007	.018	.718	.473
	PM	.000	.001	.008	.337	.736
	TQ	.023	.003	.221	8.638	**.000**
	FCF/TA	-.102	.070	-.036	-1.450	.147
	IN	-1.057E-9	.000	-.063	-2.560	**.011**

Source: Author's calculation

For this subsample, ROE, IN, MV and TQ have a statistically significant effect on the CSR strategy at the level of $p < 0.05$.

4. 4 DIFFERENCES BETWEEN MODELS

Chow test results are presented in Table 12 with tests as follows F (8, 2340) = 3.539, $p \leq 0.05$. This result shows the presence of a structural difference between the parameters in two linear regression models covering the effects before and during the COVID-19 pandemic. This means that there is a break-point between two regression lines of the two different models. Practically, this indicates that the regression coefficients are statistically different between two subsamples, before and during the COVID-19 pandemic. In conclusion, the H3 hypothesis is confirmed.

Table 12. Chow test results

Dependent Variable: CSR					
Source	Sum of Squares	df	Mean Square	F	Sig.
Contrast	2.939	8	.367	3.539	.000
Error	242.902	2340	.104		

Source: Author's calculation

The contrast results (K-matrix) presented in Table 13, provide more detailed information. The results show that MV affects the CSR strategy as the only statistically different regression coefficient between the two subsamples, before and during the COVID-19 pandemic at the level of $p<0.05$. All other coefficients are not statistically different within the two models standing for two sub-samples. Although there was no difference in performance between periods, the market value (MV) changed its impact on CSR.

Table 13. Contrast results of the CHOW test

Contrast			Dependent Variable
			CSR
L1 BD * ROE	Contrast Estimate		.017
	Hypothesized Value		0
	Difference (Estimate - Hypothesized)		.017
	Std. Error		.039
	Sig.		.659
	95% Confidence Interval for Difference	Lower Bound	-.060
		Upper Bound	.094
L2 BD * MV	Contrast Estimate		-1.146E-8
	Hypothesized Value		0
	Difference (Estimate - Hypothesized)		-1.146E-8
	Std. Error		.000
	Sig.		.000
	95% Confidence Interval for Difference	Lower Bound	-1.594E-8
		Upper Bound	-6.987E-9
L3 BD * CR	Contrast Estimate		.000
	Hypothesized Value		0
	Difference (Estimate - Hypothesized)		.000
	Std. Error		.002
	Sig.		.777
	95% Confidence Interval for Difference	Lower Bound	-.003
		Upper Bound	.004
L4 BD * D/E	Contrast Estimate		-.004
	Hypothesized Value		0
	Difference (Estimate - Hypothesized)		-.004
	Std. Error		.007
	Sig.		.609
	95% Confidence Interval for Difference	Lower Bound	-.018
		Upper Bound	.010

L5 BD * PM	Contrast Estimate		.000
	Hypothesized Value		0
	Difference (Estimate - Hypothesized)		.000
	Std. Error		.002
	Sig.		.822
	95% Confidence Interval for Difference	Lower Bound	-.003
		Upper Bound	.004
L6 BD * TQ	Contrast Estimate		.005
	Hypothesized Value		0
	Difference (Estimate - Hypothesized)		.005
	Std. Error		.005
	Sig.		.338
	95% Confidence Interval for Difference	Lower Bound	-.005
		Upper Bound	.015
L7 BD * FCF/TA	Contrast Estimate		.058
	Hypothesized Value		0
	Difference (Estimate - Hypothesized)		.058
	Std. Error		.114
	Sig.		.612
	95% Confidence Interval for Difference	Lower Bound	-.166
		Upper Bound	.282
L8 BD * IN	Contrast Estimate		-3.194E-11
	Hypothesized Value		0
	Difference (Estimate - Hypothesized)		-3.194E-11
	Std. Error		.000
	Sig.		.976
	95% Confidence Interval for Difference	Lower Bound	-2.089E-9
		Upper Bound	2.025E-9

Source: Author's calculation

5. DISCUSSION

CSR disclosures based on firm practises are becoming more important as determinants of institutional investment in social factors (Joshi and Chauhan, 2021; Park and Jang, 2021). In this sense, the objective of this study was twofold, first to analyse whether different business performance indicators differ significantly before and during the COVID-19 pandemic as performing with or without CSR principles, and second to identify the effects of different business performance indicators on the CSR orientation, and, moreover, to understand whether changes in these indicators during the COVID-19 pandemic affected an orientation towards the principles and values. Data analysis showed that there were no significant differences in the level of all indicators before and during the COVID-19 pandemic. Comparable results on the lack of dependence between the results of the environmental activity of companies and their financial situation were also presented in other studies (Dragomir, 2013; Earnhart and Lizal, 2007).

When the CSR factor was added to the study, it was found that only the profit margin (PM) was significantly different in both analyzed periods in the group of companies included in the WSE Respect Index and it can be concluded that the pandemic influenced profitability in the CSR group in a negative way. Yang et al. and Liu et al. presented similar findings (Yang et al.,

2021; Liu et al., 2022), especially in emerging markets. Rabaya and Saleh (2022), while macroeconomic indicators were analyzed, showed a decreasing trend after the COVID-19 pandemic, there were still not many recent studies on the effects at the microlevel, and moreover, CSR had a positive influence on the competitive advantage at the firm level (Rabaya and Saleh, 2022).

While defining the effects of the COVID-19 pandemic in the world (Olviana et al., 2022; Rahmadana et al., 2022), companies are developing CSR orientation practises and principles (Boffo and Patalano, 2020). On the other hand, there are more studies on CSR to strengthen the relationship between corporate transformation toward Industry 4.0 (CTTI 4.0) and financial performance (Alkaraan et al., 2022). Furthermore, novel business models (such as the EFQM 2020 model) foster alignment and connections between purpose, strategy, and results while aligning with the United Nations Sustainable Development Goals (SDGs) and encompassing digital transformation. These models aim to deliver performance and ensure transformation, create lasting value for its key stakeholders and achieve remarkable results (Fonseca, 2022). In line with these emerging trends, in the second part of this study, the focus was on the effects of business performance indicators on CSR orientation. The general model of multiple linear regressions is significantly useful for explaining the CSR strategy for the dependent variable, thus concluding that there was a statistically significant effect of business performance indicators on the orientation towards CSR principles. Profitability, market value, and growth potential positively influenced CSR orientation positively in both periods, but in the COVID-19 period, intangibles negatively influenced it. Regression models differ in these two periods, and the MV coefficient is statistically different (Puška et al., 2018). Thus, it can be concluded that the COVID-19 pandemic affected CSR strategies (Díaz et al., 2021).

6. CONCLUSION

Although statistical data confirmed the negative effects of the COVID-19 pandemic on macroeconomic indicators, the findings of this research present a different view related to the microeconomic approach. The results show that there were no changes in business performance indicators before and during the COVID-19 pandemic for companies listed on the Warsaw Stock Exchange. The study also does not show differences in business performance indicators regardless of their membership in the Respect Index. The only exception was found in CSR companies that reported a significantly lower profit margin during the COVID-19 pandemic. These results show the resilience of Polish companies to the consequences of the COVID-19 pandemic.

The results presented show that business performance indicators, particularly ROE, Market Value, Tobin's Q and Intangible Assets, affect the level of application of environmental, social and governance principles. Profitability, Market Value, and growth potential as measured by TQ influenced the orientation of CSR in a positive way, showing that social responsibility is related to better-performing companies. Intangibles negatively affected the orientation of CSR during the COVID-19 period, and it can be concluded that during the health crisis, innovative companies stopped thinking about social responsibility. Although there was no difference in performance between periods, the market value (MV) changed its impact on CSR. Given the importance of these principles for long-term sustainable development, government policies should aim to preserve the ability of companies to achieve and maintain positive business performance.

Future research will discuss on the possible influence of COVID-19 in different industries regarding CSR. Sectors that have been significantly impacted by the sharp decreases in demand and supply shortages include Transportation (airlines, cruise operators, Shipping companies),

Tourism (Hotels, Restaurants, Hospitality), Oil, Gas, Mining, and Metals (with a decrease in demand and commodity prices), Manufacturers (e.g., those with complex supply chains such as Automotive and Technology) and Retailers, and they will be surveyed to add value to the knowledge about CSR on a micro level related to corporate finance.

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FORMATION OF THE MODEL OF SUSTAINABLE ECONOMIC DEVELOPMENT OF RENEWABLE ENERGY

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ABSTRACT

The article considers the use of sustainable energy as a potentially effective alternative energy source capable of replacing traditional natural fuels. The aim of the research is to develop a complex model of sustainable economic development able to promote introducing and expanding sustainable power engineering as potential alternative energy source, providing sustainable economic development, energy efficiency and reducing damages to the environment. The hypothesis lies in introduction of a model for sustainable economic development due to expansion of renewable energy which will result in economic growth, rise in energy efficacy and reducing hazards to the environment. A comparative analysis of costs and revenues of various types for using energy sources was carried out to estimate the economic efficiency and feasibility of renewable energy. The data analysis toolkit uses MS Power BI software, in which the data model was created. The conducted regression analysis provided valuable nu-merical and practical results on formation of the model of sustainable economic development of renewable power engineering. The research is based on the analysis of the impact "share of energy" on the level of electric energy import and CO_2 emissions. It is recommended to intensify efforts to develop renewable energy as a key direction for sustainable economic development to ensure energy security, reduce negative environmental impact and achieve global sustainable development goals.

Keywords: *renewable energy sources, model, sustainable development, investment, technology, ecology, energy efficiency, energy market*

1. INTRODUCTION

The use of renewable energy sources can become an important component of sustainable economic development. The formation of a model of sustainable economic development involves ensuring the development of the economy without damage to the environment and preserving natural resources for future generations.

The sufficient research in the different aspects of stable economic development refers to Gro Harlem Brundtland notes in his research growth with environmental protection and resource conservation. It is about finding innovative ways to meet our present needs without compromising the ability of future generations to meet their own needs (Brundtland, 1987).

One of the key factors contributing to sustainable economic development is restraining the dependence on unstable energy sources such as oil, gas, and coal, which in turn require additional resources for production, maintenance, processing, etc.

Dr. Jessica Smith suggests, that dependence on instable energy sources puts country's economic stability and security at risks. The way towards steady economic development consists in switching to a more balanced and steady energy system based on renewable energy sources and energy efficient technologies (Smith & Tidwell, 2016).

The use of renewable sources does not require a constant intermediary of processing and conversion, which reduces, and in many cases does not require at all, dependence on these sources and provides a stable source of energy, which can positively affect the sustainability of the economy. They say that "renewable sources be first built to make the system work in automatic mode in the future". Moreover, the usage of renewable energy sources can reduce the emission of harmful substances into the atmosphere, which contributes to preserving the environment and public health, ensures economic stability for many years, since environmental pollution can seriously deteriorate the environment.

However, some factors hinder the implementation of alternative renewable energy. To them refer: high installation costs – renewable energy sources such as solar, wind, geothermal, and hydropower, usually require significant investment; dependence on changeable weather conditions. This can result in insufficient stability of the electricity supply, especially in the case of reduced energy production due to technical problems or worsening weather conditions.

At present, modern digital technologies provide control of production and network loads, which can enable a smooth transition to alternative energy.

Digital technologies enable integration of numerous renewable sources into the power engineering system. Due to automatization and control these technologies help balance production and consumption of energy, which makes the switch to alternative energy sources more effective and stable. Certain directions in digitalization of power engineering require "blockchain" technology which implies decentralized energetic transactions, accounting of renewable energy source, its volume, current price and billing (Avenston, 2019).

Modern industry produces electronic devices "Grid tie inverter" for installation of alternative energy stations for the whole districts or households, automatically tuned to the general power grids. This approach is used to deal with infrastructure issues related to renewable energy. Accordingly, the construction of infrastructure for storing and transporting energy from renewable sources is carried out step by step with large power grids.

The development of a "smart" network system helps to separate energy production from its consumption. This will permit more flexible energy management and ensure more precise coordination between production and energy consumption, which will eventually ensure both the efficient use of renewable energy sources and a more sustainable and reliable energy supply. Also, political and social problems also hinder the development of renewable sources. For example, renewable energy is often associated with regulation and legislation. The absence of relevant legislation may become an obstacle to the introduction of renewable energy in various sectors of the economy. The introduction of renewable energy creates social conflicts, for instance, related to the use of land for equipment and infrastructure projecting, ownership conflicts or fear of income loss in agricultural sectors.

The development and implementation of new technologies and the production of highly efficient systems for electricity production from hydrogen, wave, wind, and geothermal energy

provide a balance between these sources under climatic changes.

Thus, the aim of this research lies in developing a model of steady economic development of renewable power engineering. We pursue to define effective strategies and policies to promote stable and sustainable economy based on the use of renewable energy sources.

Our contribution lies in the analysis of the factors that determine the effectiveness of the renewable power engineering development and its interconnection with conventional fossil fuels. We aim to consider current trends, technologies and innovations in the sphere of renewable power engineering, taking into account social, environmental and economic factors of influencing the stability of the development model.

Respectively engagement Investments from private economic agents and the government significantly promotes the development of renewable energy, has a positive effect on the environment which in its turn increases the availability of renewable energy sources, improves new technologies and infrastructure to reduce the costs of energy production.

According to F. La Camera, CEO of IRENA, investment into renewable energy is stable, cost-effective, and attractive. It provides consistent and predictable efficiency and, at the same time, provide benefits to the global economy (IRENA, 2020).

The transition to renewable energy also poses some economic and social challenges that must be addressed to ensure sustainable development (Lyeonov et al., 2021):

1) cost: renewable energy often requires significant investment costs and infrastructure projecting. This can reduce company profits and increase the cost of energy for consumers;

2) instability: renewable energy sources such as wind and solar depend on weather conditions. This can lead to fluctuations in the production and supply of energy, which makes it difficult to ensure a stable energy supply and can affect the economy;

3) infrastructure: the development and construction of the necessary infrastructure for renewable energy require significant costs and time. This can be done under effective coordination between different industries and regions to ensure efficient resources usage;

4) development of markets: renewable energy is a new industry, so there is a need to develop advertising and market organization.

Since February 2022 because of warfare in Ukraine, the issue of establishing steady economic development of renewable power engineering have become of secondary importance. Ukraine's economy is currently internationally subsided. But the issues of developing this energy branch have not lost their importance, because they deal with the country's strategic development in post-war period. Ukraine studies foreign experience of developing renewable power engineering. Considering the situation with blackouts during 2022-2023 due to shelling of Ukrainian energy infrastructure points in winter and damage to energy systems and lines, Ukraine managed to rely on renewable energy sources which reduced the negative impact of destruction. This put renewable power engineering at an advantage.

The National Action Plan for the Development of Renewable Energy in Ukraine for the Period until 2030 considers indicative goals of electricity and heat production and the development of transport. In particular, the Law of Ukraine "On Renewable Energy" sets a national goal to increase the share of renewable energy sources in the total amount of electricity produced to 25% and the production of renewable energy at 25 GW by 2035 (Ministry of Energy of Ukraine, 2021).

Unfortunately, currently (2023) the development of the steady model of renewable power engineering of Ukraine has been suspended. Nevertheless, it calls for further profound research of the corresponding foreign experience.

The world's experience in the introduction of alternative energy is relevant and investment effective. For example, Germany is known for its ambitious "Energy Turnaround Plan", which implies a transition to 80% renewable energy by 2050. It includes the construction of wind and solar power plants, as well as the development of hydroelectric power plants and biofuels. Denmark leads in the use of wind energy. More than half of all wind turbines in Europe are in Denmark. In addition, Denmark also has a significant number of solar power plants and biomass power plants. Iceland uses geothermal energy for heating and electricity. More than 80% of the energy produced in Iceland comes from geothermal sources. China is the largest producer of solar panels and wind turbines in the world. Moreover, China also has a significant number of hydroelectric and biomass power plants. The United States has many wind and solar power plants, as well as hydroelectric and biofuel power plants. Some states, such as California and Texas, are actively working on the development of renewable energy.

Respectively, considering the positive experience of renewable energy in the world, experts consider and build a sustainable model of economic development based on renewable technologies. For example, biochar is a technology based on plant material to produce fuel and can replace coal, oil, and gas. Hybrid systems are a combination of different sources of renewable energy, such as solar panels and wind turbines to provide a constant source of energy. Energy storage systems are technologies that allow us to store energy for later use. Such systems can replace renewable solar and wind energy sources in case of their failure. Geothermal energy is the use of heat generated by the inner layers of the Earth. Hydrogen can serve as machine fuel.

The world experience in renewable energy shows certain problems in its production related to instability of its generation and accumulation of generated energy. These problems are deeply studied (Pavlova & Pavlov, 2020; Buratynskyi, 2019; Albertus et al., 2020) and the ways of partial solution to these problems are proposed. But the issue of stability/instability of generating this energy lies above of our research, though requires profound scientific research of developing technological systems.

From a technical point of view, the stability of the power system is a key factor for the safe and uninterrupted operation of the system. The stability of the energy system is defined as the ability to restore the working balance after injury or destruction (Mazur et al., 2023; Kaletnik et al., 2022). One of the most important parameters during the simultaneous operation of energy systems is the inertia of the system. The smaller the inertia of the system, the more sensitive the system is to frequency deviations (Impram & Nese, 2020).

Renewable energy sources (RES) power plants do not contribute to system inertia, as they are connected to the grid by power electronics, and they are electrically isolated from the grid.

Power grids are one of the most complex dynamic networks ever designed, and ensuring their synchronization is critical, as their absence can lead to any disturbances leading to persistent oscillations and loss of stability.

Synchronization in the power grid can be interpreted as a stable state, when the rates of evolution of the electric angle in all generators throughout the network are the same. Stability is crucial for the reliable and continuous operation of the energy system. Levels of wind and solar penetration, topologies of their connection, types of wind turbines define voltage stability, stability of transient processes, small signals and frequency stability of power systems containing

renewable energy sources (Jiang et al., 2019).

Thus, the growth of renewable energy in the world economy has provoked the need for an interdisciplinary approach to the formation of a sustainable model of its economic development, which will consider legal, economic, and organizational factors. The use of modern economic and mathematical methods and logic will consider both quantitative and qualitative factors of influence on socioeconomic processes.

The study is devoted to the implementation of this approach to building an effective model for the renewable energy development, which will facilitate the solution of the problems of its development and contribute to the creation of a sustainable and long-term economic model.

The aim of this research is to develop a complex model of stable economic development on the basis of introducing and expanding renewable energy, providing stable economic growth, energetic efficiency and reduction of environmental hazards.

2. THEORETICAL BACKGROUND

One of the key approaches to greening is the concept of sustainable development, which involves meeting the current needs of mankind without compromising the ability of future generations to meet their needs. This concept involves the balanced use of natural resources to ensure economic development and environmental protection. At the basis of renewable energy concept there is the use of renewable energy sources such as solar, wind, hydropower, etc. The main idea is to reduce dependence on fossil fuels, reduce emissions and reduce environmental impact. The technological paradigm of renewable energy is a global trend. The International Renewable Energy Agency (IRENA) produces comprehensive, reliable datasets on renewable energy capacity and its usage worldwide. 2022 Renewable Energy Statistics provides data on electricity generation capacity for 2012-2022, actual electricity generation for 2012-2020, and renewable energy balances for more than 150 countries and districts for 2019-2020 (IRENA, 2020).

It is important to mention that economic growth based on distortions of ecologic services is not stable. This is also evident from the oil crisis of 1973 which taught us the importance of overcoming dependence on fossil fuels which led to environmental and economic profits (Sajadi et al., 2022).

The scientific research "Understanding multidimensional ties between renewable energy, pollution, economic growth and urbanization in modern economies: qualitative estimations in certain countries with various income levels" incorporating statistical methods studied the interrelations between renewable energy and economic growth, CO_2 emissions and urbanization in the period 1990–2014. It was statistically proven that "high income countries showed commonality between the use of renewable sources and CO_2 emissions, renewable and nuclear power energy, energy consumption and urban population". This is explained by the interest of these countries in environmental protection. Besides, the by conducting Granger causality testing the authors defined the causality relation between the economic growth and power intensity in the low-income countries, while there are many bidirectional relations between the variables in high-income countries, especially between power intensity and CO_2 (Jiang et al., 2019).

The Sustainable Development Goals, also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to reduce poverty, preserve the planet and ensure that by 2030 all people live in peace and prosperity. However, as the population continues to grow, so will the demand for cheap energy, and an economy dependent on fossil fuels is

dramatically changing our climate.

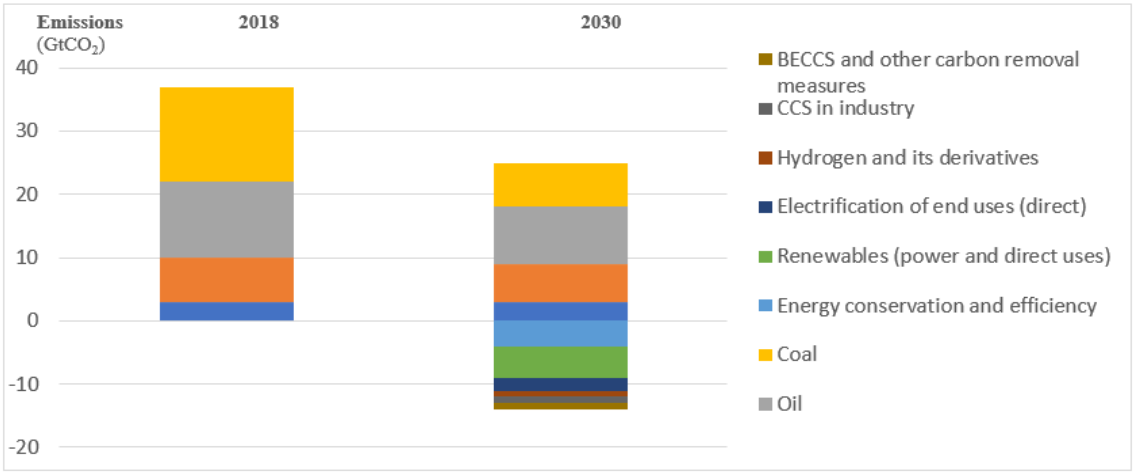
Investing in alternative energy, increasing productivity and providing energy for all are vital goals for future green growth by 2030. Expanding infrastructure and modernizing technology, respectively, will contribute to the growth of clean and more efficient energy in all countries and help the environment (Armeanu & Joldes, 2021).

Therefore, clearing and preserving the environment are important determinants of sustainable development, as they are directly related to energy consumption. This explains the shift of attention towards environmentally friendly energy sources during the last few decades, caused partially by the development of technology.

According to the International Renewable Energy Agency (IRENA), in 2021, renewable energy provided about 29% of global production capacity (Renewable Energy Statistics, 2022).

Increasing the pace of switch to renewable energy sources with a simultaneous aggressive strategy to improve energy efficiency is the most realistic way to reduce emissions by half by 2030, as recommended by IPCC (Fig. 1). In the electricity sector, renewables can be deployed faster and at a lower cost than alternatives (Global Energy System Transformation Forecast, 2022). But to achieve the goal outlined by the IPCC, the annual increase in renewable energy capacity should be three times higher than the current rate. Such an increase is possible if there are proper conditions. Technology-specific goals and policy tools are especially needed to support less mastered technologies such as ocean energy.

Figure 1. The prospects for global energy transitions 1-5C



Source: (World Energy Transitions Outlook, 2022)

To increase sustainability of the system (Koziuk et al., 2020; Shevchuk et al., 2023; Kozlovskyi et al., 2017) and ensure the flexibility of a diversified and integrated energy system capable of operating with a large variable renewable energy volume, it is necessary to update, modernize and expand the infrastructure. The idea is that integrating more variable solar and wind energy would require only fossil natural gas, quickly supplanted by improved economics of alternative sources of energy. But in addition to numerous technological solutions, markets will need to adapt, both in liberalized and regulated systems. The modern structure was formed in the era of fossil fuels to reduce the operating costs of large, centralized power plants with various fuel and alternative costs (Trofymenko et al., 2022).

In research Jacobson et al. (2022) stick to the opinion that the US can meet its energy demands by 2050 with 100% wind, water, and solar. His models use no fossil fuels, carbon capture, direct air capture, bioenergy, blue hydrogen, or nuclear power. Jacobson's 100% renewables plan uses hydropower as a clean, flexible resource to backstop the days when wind and solar don't produce enough to supply the country.

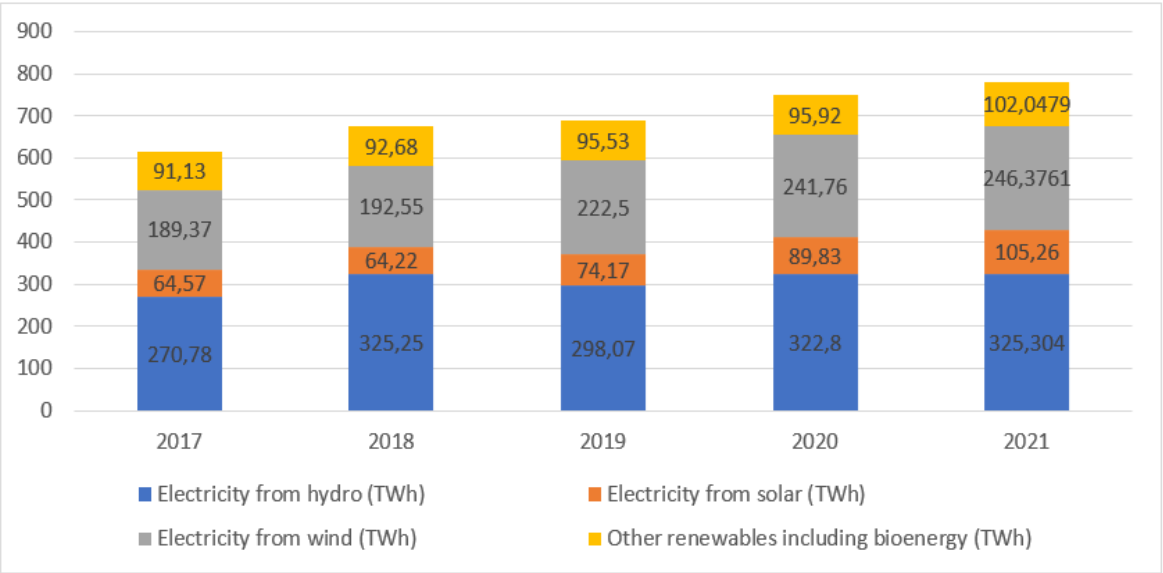
An American economist and sociologist who studies sustainable energy systems and the interaction between the economy and energy Rifkin (2013) has written books "The Third Industrial Revolution" and Rifkin (2015) "The Zero Marginal Cost Society", which argue for a transition to a sustainable and decentralized energy system. According to Rifkin, industrial revolutions are driven by the convergence of changes in the type and availability of energy and in how people connect and share information.

The Kammen & Sunter (2016) in research in the field of renewable energy and sustainable development, argues that renewable energy can provide a future for energy security and reduce greenhouse gas emissions. The transition to renewable energy can act as a catalyst for economic development and the creation of new workplaces. Renewable energy should be perceived as global issue that requires cooperation and joint action of countries and the public.

An American physicist and environmentalist Lovins (2022) who has been promoting energy efficiency, renewable energy sources, energy production close to its consumption sites also advocated a "megawatt revolution" arguing that utility customers don't want kilowatt-hours of electricity; they want energy services. According to the International Energy Agency (IEA), in 2019 global energy production per unit of GDP was 2.5 kilowatt-hours per dollar, which in 2010 was three times higher. In 2020 the use of renewable energy provided a reduction in CO_2 emissions by 2 billion tons compared to this energy generation via coal usage (International Energy Agency, 2022).

According to official data from OurWorld (Fig. 2), we can see that hydropower is by far the largest modern renewable source. But we also see that wind and solar energy are growing rapidly.

Figure 2. Renewable energy generation



Source: (Our World in Data, 2021)

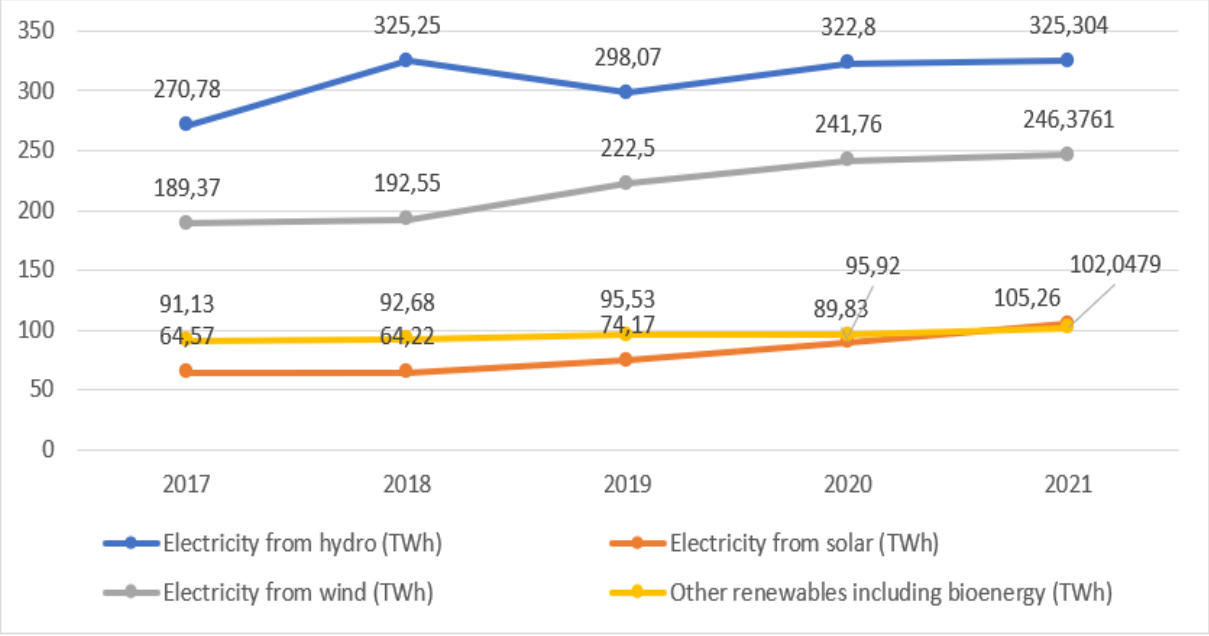
Fig. 3 shows constant growth of renewable wind, solar and biotechnology sources. One of the advantages of solar energy is its availability and versatility. Solar panels can be installed in any area that receives enough sunlight, which allows their use in almost all regions of the world (Statista, 2023; World Bank, 2023). In addition, the relatively simple design of solar panels reduces the cost of production and ensures their durability.

Wind turbines possess more power than solar panels, so wind energy is used to produce high-capacity electricity. However, wind turbines depend on wind, while solar panels can generate electricity throughout the day (Chygryn et al., 2021; Soulaf et al., 2022). Besides, some countries have greater potential for generating energy from the sun, while others have wind or hydropower.

Therefore, when designing a model of energy development based on the theory of sustainable development, we combine the concept of building economic and social development with environmental protection. According to this theory, sustainable economic growth should be based on three components: economic development, social progress, and environmental conservation.

To form a model of sustainable economic development (Kaya, 2019; Lavrov et al., 2022) of renewable energy, the theory of sustainable development (Kozlovskyi et al., 2018) should ensure a balance between the provision of energy needs of mankind and the preservation of the natural environment. Renewable energy is a key element of this model because it enables sustainable energy provision and reduces environmental impact.

Figure 3. Modern renewable energy generation by source



Source: (International Energy Agency, 2022)

The study aims to develop strategies and policies aimed at supporting the sustainable development of renewable energy following the requirements of the modern economy and ecology. The study aims to develop models that will ensure the use of renewable energy sources with the greatest possible economic and environmental benefits, reduce dependence on imported energy resources, and contribute to increasing the level of competitiveness of the country in the pro-

duction and use of renewable energy. On its basis it is proposed to develop recommendations on the promotion of renewable energy use and development of new energy technologies.

3. METHODOLOGY

3.1. ALGORITHM OF MODEL CONSTRUCTING FOR SUSTAINABLE ECONOMIC DEVELOPMENT OF RENEWABLE ENERGY

The algorithm shows extended arguments for the research, but it is not necessary, while building a model can incorporate only the available data on regions or countries.

1. Identifying the main factors: collecting data on technological innovations in energy production (such as conversion coefficients, capacity and costs), costs of installation and exploiting renewable sources, ecological standards, the share of alternative energy sources and restrictions that influence the development of renewable power engineering.
2. Gathering data on sustainable energy and economy: to obtain and update the date on the quality and types of available sustainable energy points, renewable energy production, its cost and consumption, employment in this industry, dependence on imported resources, economic indices (GNP, indices on energy efficiency, investments etc.).
3. Integrated model development: to build a model that considers relation between the development if renewable energy and economic growth. To consider the influence of renewable power engineering on reducing dependence on import, pollution reduction, increasing competitiveness and creation of new vacancies.
4. Use of regression model for forecasting the development of renewable power engineering and its probable economic outcomes. The regression model enables to establish statistical relations between the input factors such as technological innovations, production costs, ecological standards, use of alternative sources of energy and others and output data such as energy production, employment, economic indices and others.
5. The analysis of the obtained results and continuous improvement: analyze the obtained modeling results and keep improving it on the basis of new data and emerging tendencies. This iterating process allows to improve the accuracy of the model.
6. Defining the optimal development strategy: estimate the obtained results for defining the optimal strategy of development of renewable power engineering considering different factors such as ecologic stability, economic expediency and social appropriateness. Put forward proposals including definition of the optimal share and quantity of alternative energy sources to sustain stable development.

The measure units can vary depending on the indices in each country. For instance, energy production can be measured in megawatt, its price/value in UAH or USD, the number of power stations/points - in units, employment – in the number of employees etc.

While using regression model it is important to have enough quantitative and qualitative data on factors of influencing g the development of renewable energy.

3.2. CONCEPTUAL BASIS FOR A MODEL CONSTRUCTION

The conceptual research of the sustainable development of the stable energetic system implies finding interrelation between the factors affecting the sustainable economic development of renewable energy. The regression model defines how one or more independent factors affect the dependent variable, which in this case is the share of renewable energy consumption of each

country out of the total consumption.

The model considers different types of dependent and independent variables, for example, the level of state support of renewable energy development, the level of competition in the energy market, the use of the latest technologies in the production of renewable energy, available developed infrastructure for storing and transporting renewable energy to determine the sustainability factor.

Accordingly, the regression model can help in assessing the effect of each factor separately and in combination with other variables on the dependent variable (Carr & Thomson, 2022). This determines the degree of influence of each variable on the dependent variable, which allows us to draw conclusions which variables have the greatest impact on the sustainable development of renewable energy and what measures can be taken to its increase (formula 1):

$$St = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \varepsilon, \quad (1)$$

where St – sustainable economic development of renewable energy, i.e. a fraction of the electricity that comes from renewable technologies; β_0 – intercept or initial level St, when all other input variables (X_1, X_2, X_3, X_4, X_5, X_6, X_7) are zero, i.e. β_0 shows the expected value of Y when other influencing variables are absent (this can usually be interpreted as a baseline or starting point from which any changes to other variables can affect Y); X_1 – production of Geo Biomass Other into renewable energy; X_2 – production of Solar Generation into renewable energy; X_3 – production of Wind Generation into renewable energy; X_4 – production of Hydro Generation into renewable energy; X_5 – the level of investment in alternative energy in countries containing financing is aimed at the development and implementation of various types of renewable energy sources that can replace traditional fossil fuels; X_6 – innovative potential of the country, i.e. an available developed infrastructure for storage and transportation of renewable energy (energy networks, means of transportation, storage sites, and other infrastructure facilities necessary for the efficient use of renewable energy sources); X_7 – annual CO_2 emissions (per capita) – indicator measures the amount of carbon dioxide emissions (CO_2) per person in the country for one year (it is expressed in metric tons (thousand kilograms) per person per year); β_0, β_1, β_2, β_3, β_4, β_5 β_6, β_7 – regression coefficients that reflect the influence of each of the independent variables on St; ε – model error that takes into account all other factors that can affect Y, but are not taken into account in the model.

Correspondingly $\varepsilon = Y - \hat{Y}$, where Y is the observed quantity, and $\hat{Y}$ is the predicted quantity for a given value of X (formula 2):

$$\beta_0 = \bar{Y} - \beta_1 X_1 - \beta_2 X_2 - \beta_3 X_3 - \beta_4 X_4, - \beta_5 \bar{X}_5 - \beta_6 \bar{X}_6 - \beta_7 \bar{X}_7, \quad (2)$$

where $\bar{Y}$ – the average value of the variable Y.

To calculate the regression model, we use the least squares method, which consists in finding the coefficients β_0, β_1, β_2, β_3, β_4, β_5 β_6, β_7, which minimize the sum of the squares of the differences between the actual values St and the predicted values St, calculated by the regression model.

3.3. CHARACTERISTICS OF MODEL ELEMENTS

The initial index St is a dependent variable in the regression model, influenced by the values of independent factors X_1, X_2, X_3, X_4, X_5, X_6, X_7 and reflects the level of development of renewable energy.

X_1 – production of Geo-Biomass-Other is considered as a combination of three different types of renewable energy: geothermal energy (Geo), biomass (Biomass), and other sources (Other).

Unit of measure – terawatt-hour (TWh). Geothermal energy uses the heat of the earth's crust to produce electricity or for direct heating. Geothermal power plants convert earth heat into electricity, and geothermal heating systems use earth heat to heat buildings. Biomass is an organic material obtained from plants and animals that can be used for energy production. This includes plant waste, wood pulp, agricultural waste, and even sewage. Biomass can be turned into biofuels that can be converted to produce electricity or heat or used as gas for various industrial processes. Other sources – other types of renewable energy that do not fall to the main categories, such as solar, wind, hydropower, geothermal, or biomass (technologies of tidal and outflow energy, wave energy, or even energy from electrostatic charges).

X_2, X_3, X_4 – solar generation, wind generation, and hydro generation respectively belong to the three main types of renewable energy. Unit of measure – terawatt-hour (TWh).

X_5 – level of investment and government support for the development of renewable energy. It characterizes the number of approaches to calculating the level of state support and includes an assessment of the number of state initiatives in the field of renewable energy, such as the creation of state support programs, benefits, and subsidies for renewable energy. It determines the degree of implementation of such initiatives (formula 3), as well as the level of financing of these initiatives in comparison with other energy sectors:

$$Ri = Sf / Sz \tag{3}$$

where Sf – the amount of funding for the initiative's implementation (a total amount of funds that allocated for a particular initiative); Sz – the total amount of funds allocated for financing (a total amount of funds that were allocated to finance all initiatives). The unit of measure is millions of dollars.

X_6 – the country's innovation potential is a composite index that takes into account several key indicators related to renewable energy sources (formula 4):

$$IPC\_AE = w_1*R\&D\_AE + w_2*HC\_AE + w_3*I\_AE + w_4*C\_AE + w_5*B\_AE + w_6*P\_AE \tag{4}$$

where R&D_AE – expenditures on research and development in the field of alternative energy (as a percentage of GDP); HC_AE - the number of highly educated personnel working in the field of alternative energy (as a percentage of the total population); I_AE – the number of patents for inventions in the field of alternative energy per country's inhabitant; C_AE – communication between research institutions and industrial enterprises in the field of alternative energy; B_AE – the level of state support and stimulation of alternative energy development (for example, subsidies, tax incentives, loans, etc.); P_AE – the share of alternative energy at the national level (for example, the percentage of renewable energy from total energy consumption). Also, the coefficient considers the level of competition in the country's market; w_1, w_2, w_3, w_4, w_5, w_6 – weighting coefficients that reflect the importance of each indicator for the overall innovative potential of alternative energy. Weighting factors are used in alternative energy and innovation. The unit of measure is an index (1-100).

X_7 – annual CO_2 emissions (per capita) is an energy, climate change, sustainable development, and innovation-related indicator in the field of alternative energy. This indicator helps to assess the responsibility of each country for greenhouse gas emissions that cause global warming. It can also serve as an indicator of the effectiveness of energy policy and the degree of implementation of alternative and energy-efficient technologies. Unit of measurement – tons of carbon dioxide per person per year.

4. RESULTS

4.1. THE STUDY FORMATION OF THE CONCEPTUAL BASIS OF THE MODEL USING MS POWER BI

To automate the acquisition and processing of research data, we will use MS Power BI tools to create a sustainable renewable energy model.

A similar approach provides an opportunity to analyze and visualize data using MS Power BI tools to develop a model for the sustainable economic development of renewable energy. Grouping data and building an information model opens the conceptual basis of the model as well as tools and methods used to form it. With the capabilities provided by MS Power BI, it is possible to process large amounts of data quickly and efficiently and analyze them from different perspectives. Using MS Power BI allows valuable insights and model processes of effective use of renewable energy and propose ways of its further increase. Visual reports also help to quickly understand complex data and, accordingly, make productive conclusions.

The data set shown in Table 1 contains a set of data on the indicators of alternative energy production sources as of 2021, the share of use, the level of attractiveness to investment, and so on. Therefore, the information data model (Fig. 4) groups the data from sources (Khadka & Chandra, 2021) based on the ties between the key fields of the tables.

The study of the economic development of renewable energy production of alternative energy, the purpose of which is to analyze the production of alternative energy, in particular wind, solar, hydropower, and others. The study reflects the investigation of the dynamics of production, establishing the ratio between different types of alternative energy, and assessing the level of investment and competitiveness in the market.

Table 1. Renewable energy statistics and environmental indicators of countries

Country	Geo-Bio-mass-Other (tWh)	Solar generation (tWh)	Wind generation (tWh)	Hydro generation (tWh)	Investment level ($ millions)	Country's innovational potential, index	Annual CO_2 emissions (per capita)	Share of renewable energy sources, %
	x1	x2	x3	x4	x5	x6	x7	y
Austria	4.3925185	2.1249056	6.751889	42.851505	2.60	21.00	7.24	36.45
Belgium	4.916279	5.608193	11.8788595	0.37435636	2.70	25.00	8.24	13.14
Bulgaria	1.694698	1.4895724	1.4332225	4.5625234	0.60	40.00	6.18	17.15
Denmark	8.734226	1.2779185	16.031755	0.0163087	4.40	7.00	5.05	34.78
France	11.1924715	14.605709	36.96734	57.966537	20.60	12.00	4.74	19.34
Greece	0.17746587	5.1679754	10.470926	5.8237925	1.90	37.00	5.39	21.92
Hungary	2.217125	3.793289	0.651231	0.208048	0.90	33.00	4.99	14.11
Iceland	5.787858	0	0.006083361	13.824003	0.10	26.00	9.11	85.78
Ireland	0.9686464	0.06360574	9.712766	0.7478114	3.80	15.00	7.53	12.54
Italy	25.756252	25.066978	20.618114	43.05632	10.10	30.00	5.55	19.03
Lithuania	0.5536734	0.12369155	1.3614266	0.3850306	0.20	36.00	4.98	28.23
Luxem-bourg	0.38976282	0.22130644	0.33903947	0.105368376	0.18	24.00	13.07	11.73
Poland	7.616	3.949	16.203	2.339	3.30	29.00	8.58	15.62
Portugal	3.742	2.208	13.225	11.853	1.30	31.00	3.96	33.98
Romania	0.70867634	1.701	6.576	16.900232	0.80	49.00	4.10	23.59
Slovakia	2.0455492	0.672096	0.003989071	4.2292657	0.17	42.00	6.48	17.41
Slovenia	0.29847902	0.302205	0.005535	4.706957	0.01	27.00	5.92	25.00
Spain	6.615242	26.806072	62.353806	29.566423	6.70	32.00	4.92	20.72
Sweden	13.329401	1.449	27.306503	71.458435	2.10	2.00	3.42	62.57
Ukraine	0.77824664	6.326277	3.9034183	10.418119	1.10	37.00	4.64	14.04

Source: compiled by the authors based on World Bank "International Renewable Energy Agency" (IRENA)

To automate the study, we will create an information data modeling using MS Power BI. The data model for the development of renewable energy comprises charts with the country's data on the economy and energy, renewable energy sources and key indicators, and others (Fig. 4).

According to the data model, the data chart relations were created on the basis of the key fields in Power Pivot to provide further reporting and accountability as well as visualization from these combined charts.

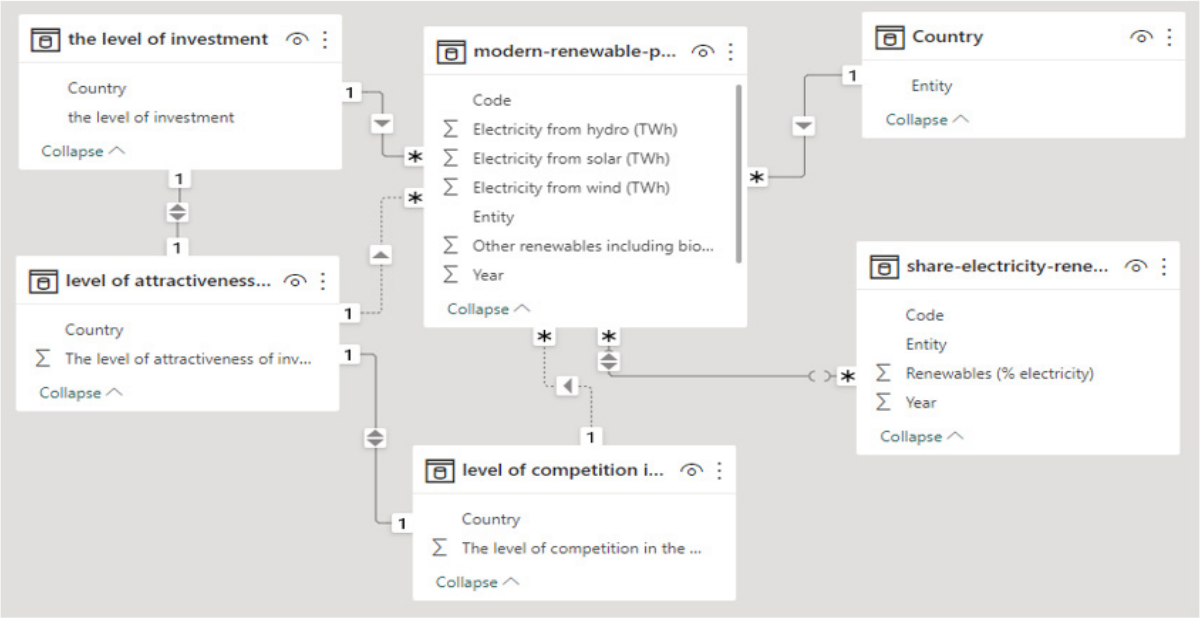
The data model contains the following tables:

1) modern-renewable-prod - production of alternative energy by types of energy (electricity from wind, electricity from hydro, electricity from solar, other renewables including bio-energy) by the country for the period 1965-2022;
2) share-electricity-renewables - hours of alternative energy in the world related to the total energy consumption of the country;
3) share-vehicle-electric - the number of electric vehicles in countries that are among the largest consumers of electricity;
4) level of investment in alternative energy - the level of investment in alternative energy in

different countries;

5) level of competition in the alternative energy market by country;
6) level of attractiveness of investors - the level of attractiveness of investors in alternative energy by country;
7) country – a list of countries selected to analyze the renewable energy market.

Figure 4. Renewable Energy Development Data Model (MS Power BI)



Source: authors' development

To calculate the regression coefficients, we construct "Regression Coefficients" measurement of calculations based on the formula of regression coefficients using the LINEST function using the Python programming language, the main parts of program code 5 are given see Appendix 1.

Apply a regression model to predict St values, namely the regression coefficients found to calculate predicted St values based on independent variables in your dataset or for new data.

According to the regression coefficients, we apply a regression model to predict St values based on independent variables in your dataset or for new data. To do this, use the measure in Power BI using the DAX formula 5:

$$Predicted\_St =$$
$$VAR\ Intercept = <data>[Intercept]$$
$$VAR\ X1\_Coeff = < data >[coef\_solar]$$
$$VAR\ Ri\_Coeff = < data >[\ coef\_wind]$$
$$// \text{-------- reduction ----------}$$
$$RETURN$$
$$Intercept + coef\_hydro\ * [Electricity\ from\ hydro\ (TWh)] + coef\_wind\ * [Electricity\_from\_wind\_TWh]\ ....\quad (5)$$

The result of code execution is a measure in our DataSet with predicted St values, which can be used to visualize, compare with actual values, or analyze the effect of independent variables on St.

4.2. FACTOR SYSTEMATIZATION OF THE PROPOSED MODEL

The systematization of model factors justifies and implements the relationships between different variables in the study. Since the process of selecting and including relevant variables in our model is multi-factorial based on different data types, it can further provide a clearer and more consistent representation of the results.

Systematization of factors of sustainable economic development of renewable energy:

- identification of possible impact factors that may affect the sustainability of the economic development of renewable energy;
- classification of factors – division into groups according to their characteristics, such as economic, technical, environmental, social, etc.;
- selection of factors considering the statistical study of each group for inclusion in the model based on the theoretical background, data availability, and previous studies;
- verification of multicollinearity – verification of the existence of multicollinearity between selected factors to identify and remove problems associated with high correlation between independent variables;
- model construction – incorporate selected factors into the regression model and perform the analysis;
- systematization of factors to improve the quality of the model and optimal selection of appropriate variables for building a model based on renewable energy.

4.3. SYSTEMATIZATION OF DATA ARGUMENTS AND MODELING RESULTS

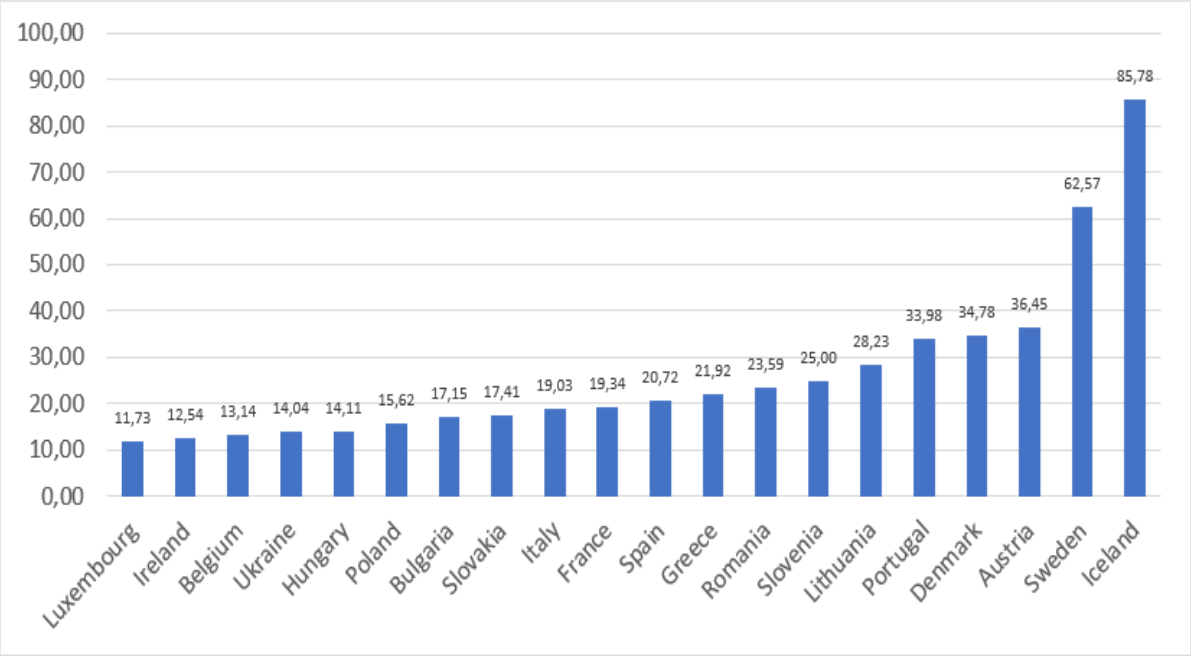
Modeling of sustainable economic development of renewable energy is carried out according to the following stages: 1) Collection and preparation of data on the economic development of renewable energy; 2) Checking data quality and balance for the model; 3) Construction of a formal model; 4) Parameterization and evaluation of the model, i.e., determination of model parameters using statistical methods that allow drawing conclusions about the statistical significance and influence of variables; 5) Analysis of results, that is, conclusions from the obtained parameters, their interpretation and comparison with hypotheses.

Accordingly, the analysis of renewable energy types in the world practice and the implementation of the model in stability of economic development should be reflected relatively positively.

The data consolidation (Table 1) contains electricity production by type of production, information on the share of energy use, the investment level, state support, the country's innovation potential, etc.

Fig. 5 shows an increase in the development of alternative energy sources, namely the share of renewable sources such as wind, hydropower, solar energy as well as other types of renewable energy, including bioenergy. This indicates that the world community is focusing on reducing dependence on traditional energy sources such as oil and gas and moving to more environmentally friendly and sustainable energy sources. It should be noted that many countries have different levels of alternative energy development, but in general, the trend towards increasing their role in the energy system of the world is obvious.

Figure 5. The share of electricity generation from total consumption by the country, %



Source: (International Energy Agency, 2022)

According to the International Energy Agency (IEA), in 2021, alternative energy sources provided about 29% of global electricity production. Solar power provided about 4% of production, wind power – 7%, hydropower – 16%, and other sources of renewable energy, such as biomass, geothermal energy, and wave energy, provided 2% of electricity production. In Fig. 5 indicators depend on the country and region of the world. For example, in developed countries such as the European Union and Japan, the share of renewable energy in electricity production is higher than in countries that have a lower level of development. It should also be kept in mind that the development of infrastructure of alternative energy sources may require significant investments and time, so the speed of their development may be different in different countries.

According to the data in Table 1 and the computer program in Appendix 1, we determine the quality of the data and their balance for correct processing in the model. In case of imbalance, data will not be entered into the table.

We will conduct a study based on regression analysis incorporating a linear multifactor model.

The multicollinearity that arose in the independent variables in this regression model (Table 2 factor X_5) indicates a natural relationship between them, namely the level of investment in alternative energy. Therefore, the regions in which multicollinearity is observed should be considered separately during individual calculation. Large values of correlation coefficients between some variables may indicate their endogeneity.

Table 2 and Table 3 show the geothermal and hydropower indicators which have a moderately strong positive direct correlation (0.651). If one variable grows, the other does as well. Accordingly, these factors are associated with the natural seasons, which enables us to consider the timing of energy from other alternative sources.

Factors x_2 and x_3 solar and wind energy are usually correlated with each other depending on weather conditions.

The factors of geothermal, bioenergy technologies x_1, and innovation potential x_6 have a moderate negative correlation (-0.407), which indicates an inverse correlation between them. If

one variable increases, the other decreases, which is about the development of other sources of alternative energy. The factors of wind energy x_3 and, accordingly, annual CO_2 emissions (per capita) x_7 have a moderate negative correlation (-0.328), which indicates a decrease in CO_2 emissions with the development of wind energy.

Table 2. Correlation analysis of impact factors

	x1	*x2*	*x3*	*x4*	*x5*	*x6*	*x7*
x1	1						
x2	0.533124	1					
x3	0.489907	0.374308	1				
x4	0.49109	0.447906	0.470933	1			
x5	0.602292	0.658741	0.651315	0.580007	1		
x6	-0.40744	0.027107	-0.32678	-0.45306	-0.38964	1	
x7	-0.1866	-0.23827	-0.32785	-0.37152	-0.20744	-0.06329	1

Source: authors' development

Table 3. Linear regression statistics

Regression Statistics	
Multiple R	0.890136
R Square	0.776288
Adjusted R Square	0.170789
Standard Error	10.71539
Observations	20

Source: authors' development

In Table 4 the F-statistic value indicates a statistically significant contribution of independent variables to the regression model. The Significance F (α-level) is 0.043807, which is less than the 0.05 lower limit. This suggests that there are statistical grounds to reject the null hypothesis of no relationship between independent variables and dependent ones. It makes the model statistically significant.

Based on these findings, it can be argued that the model of sustainable economic development of renewable energy has statistically significant interconnections between the factors under study.

Table 4. Variance analysis (ANOVA) for linear regression

	df	SS	MS	F	Significance F
Regression	7	3049.237	435.6052	15.59051	0.043807
Residual	12	3352.849	279.4041		
Total	19	6402.086			

Source: authors' development

Thus, the results of the study substantiate the importance of forming a model of sustainable economic development of renewable energy. The development of renewable energy sources contributes to reducing CO_2 emissions, as well as improving economic stability and sustainable development of the country.

In this regard, it is recommended to focus on policies and initiatives that contribute to the development of renewable energy, such as government incentive programs, scientific and technical cooperation, and training programs for training specialists in the field of renewable energy sources.

Encouraging investment in renewable energy, supporting, and expanding research and development of new technologies, and improving energy efficiency can be key to achieving sustainable economic development and reducing dependence on traditional forms of energy (Table 5).

Table 5. The regression result of stable economic development

Observation	Share of energy	Predicted Y	Annual CO_2 emissions (per capita)	Predicted CO_2	ε
Austria	36.45	40.52711	7.24	5,9758	1,26
Belgium	13.14	20.59024	8.24	7,2462	0,99
Bulgaria	17.15	22.88782	6.18	6,0322	0,15
Denmark	34.78	29.52983	5.05	4,9111	0,14
France	19.34	14.39399	4.74	4,5218	0,22
Greece	21.92	17.16038	5.39	5,2016	0,19
Hungary	14.11	17.80192	4.99	4,3743	0,62
Iceland	85.78	98.81764	9.11	6,7636	2,35
Ireland	12.54	21.30986	7.53	6,7917	0,74
Italy	19.03	24.25472	5.55	5,0813	0,47
Lithuania	28.23	22.32876	4.98	4,4941	0,49
Luxembourg	11.73	24.64375	13.07	7,9237	5,15
Poland	15.62	27.17532	8.58	5,8193	2,76
Portugal	33.98	30.0599	3.96	2,9995	0,96
Romania	23.59	26.7108	4.10	4,0372	0,06
Slovakia	17.41	24.57254	6.48	5,8053	0,67
Slovenia	25.00	24.25736	5.92	6,4858	-0,57
Spain	20.72	13.87847	4.92	4,5564	0,36
Sweden	62.57	72.08306	3.42	3,2969	0,12
Ukraine	14.04	17.13954	4.64	4,6147	0,03

Source: authors' development

To analyze the heteroskedasticity of the regression data, we will apply the Breusch-Pagan test using the Python pandas and statsmodels libraries, which provides information about the presence of heteroscedasticity of the model according to the data in Table 5 and Table 1.

Test result:

p-value: 0.11753293583732878

Lagrange multiplier p-value: 2.315675876765868

F-statistic p-value: 0.12900446008797137

Conclusion – there is no statistically significant heteroskedasticity.

Interpretation of results – according to the results of the Breusch-Pagan test, we have the following p-values: 0.11753293583732878 for the test statistic, 2.315675876765868 for the

Lagrange p-value, and 0.12900446008797137 for the F-statistic p-value. All these values are greater than the 0.05 significance level.

Therefore, taking into account the chosen level of significance, we can conclude that there is no statistically significant heteroskedasticity in the regression model. This means that the variance of the regression residuals (residuals of the model) is uniform and stable.

To conduct an autocorrelation test, we will use the Python pandas and matplotlib.pyplot libraries, according to the data in Table 5 and Table 1.

Test result:

Autocorrelation for 'A share of energy': -0.3344502816168777

Autocorrelation for 'Predicted Y': -0.33732386405279796

Interpretation of results – the autocorrelation values we obtained for Table 5 "Share of energy" and "Predicted Y" values are -0.334 and -0.337, respectively. These values range from -1 to 1, indicating the presence of weak negative autocorrelation in the data.

As mentioned above, this is due to seasonal natural influence and investment in renewable sources (wind, solar, hydro), namely, the volume of alternative electricity production increases (or decreases) in one period, then the opposite shift is observed in the next period.

Since we are working with regression data on the development of alternative energy, one of the factors of its progress is the reduction of CO_2. We will conduct a test for the normality of the residuals, such as the Anderson-Darling test:

Test Statistic: 0.2975405678835789

Critical Values: [0.557 0.632 0.759 0.885 1.053]

Significance Level: [15. 10. 5. 2.5 1.]

The residuals are almost normally distributed at the 5% significance level.

From the results of the Anderson-Darling test, it can be seen that the residuals (the difference between the actual and predicted values) are almost normally distributed at the 5% significance level. This suggests that the regression model reflects the relationship between the variable «Annual CO_2 emissions (per capita)» and the variable «Predicted CO_2».

Countries around the world are increasingly focusing on reducing carbon emissions and energy dependence by switching to alternative energy sources. This leads to increased demand for technologies and equipment related to renewable energy, as well as increased investment in this sector.

It is also important to note that the development of alternative energy contributes to the creation of new workplaces and promotes economic growth in general. Therefore, investing in this sector is considered an important step in dealing with climate change and creating sustainable development.

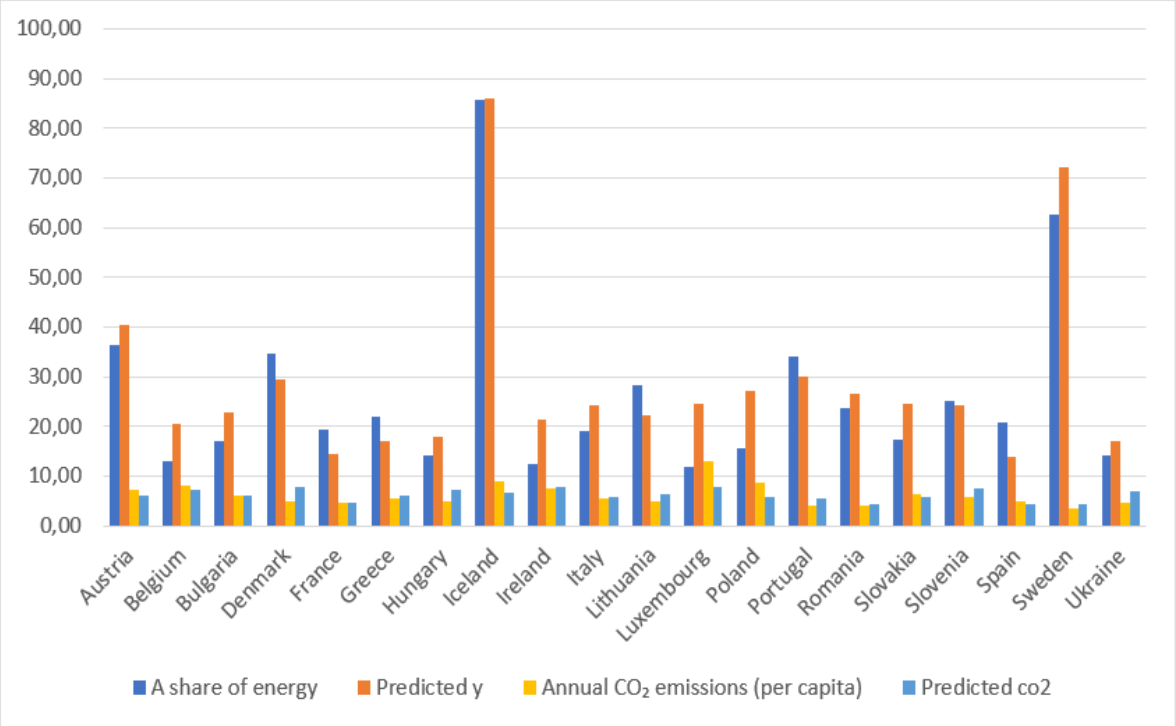
Therefore, in the first stage of the study, the sustainable development of alternative energy sources, such as solar, wind, hydro, and others, is obvious, which reduces the dependence on complex and expensive coal, oil, and gas sources (Fig. 6).

Moreover, the development of alternative energy sources is a key factor in preventing climate change, as it reduces emissions of greenhouse gases and other pollutants into the atmosphere. The use of alternative energy sources can also reduce the cost of electricity production and en-

sure sustainable economic development.

It is expected that the development of alternative energy sources will continue to grow in the future (Fig. 7). By 2040, according to forecasts of the International Energy Agency, more than 40% of electricity production in the world will be provided by renewable energy sources, such as wind energy, solar energy, and others.

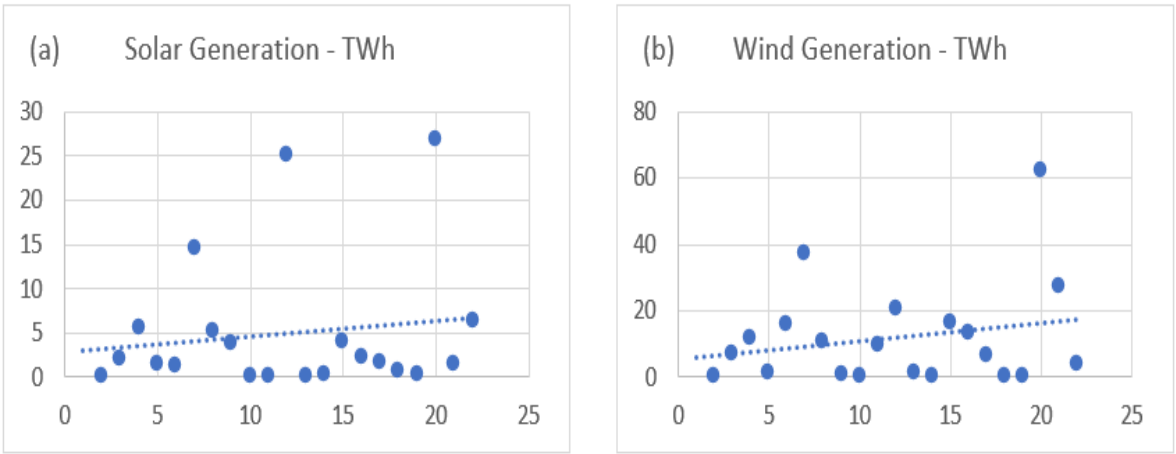
Figure 6. Growth of the share of alternative energy and reduction of CO_2 emissions



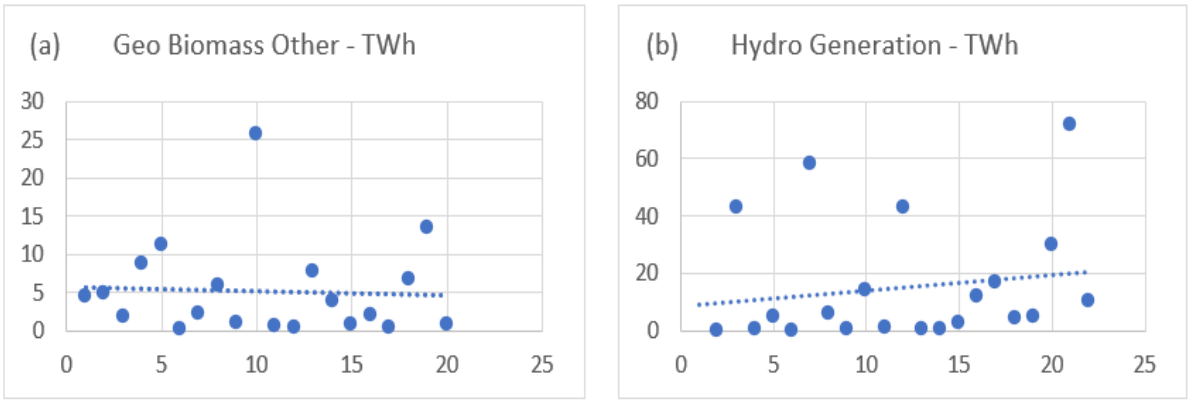
Source: (International Energy Agency, 2022)

Figure 7. The expectation of the development of alternative sources by types: (A) (a, b) increase in solar and wind energy; (B) (a, b) stable geo-biomass-other and hydro generation growth

(A)



(B)



Source: (International Energy Agency, 2022)

Based on results, possible creations of management measures include:

1) development of investment strategies in the development of renewable energy sources aimed at increasing the share of renewable energy in the overall energy balance of the country;
2) stimulating the country's innovative potential by supporting research and development in the field of renewable energy;
3) implementation of energy efficiency and energy saving measures to reduce CO_2 emissions per capita;
4) development and modernization of infrastructure for the generation and distribution of energy from renewable sources (geothermal, biomass, solar, wind, and hydropower);
5) attracting private investments and international financing for the renewable energy development;
6) work out and implementation of legislative acts and regulatory mechanisms to support renewable energy and sustainable economic development;
7) promote international cooperation and knowledge sharing in the sphere of renewable energy to extend best practices and innovative technologies.

The model of the establishment of sustainable economic development of renewable energy is considered as an important component of the management decision-making system concerning improvements of the situation in alternative energy development, including appropriate measures at the state level.

5. DISCUSSION

This study suggests a model of sustainable economic development of renewable energy, which has certain advantages over existing approaches. The basic concept is to use fuzzy logic systems to analyze the internal and external factors influencing the development of the industry.

Internal factors cover various aspects of renewable energy, such as equipment condition, the efficiency of energy conversion processes, the availability of skilled personnel, and environmental indicators (Koziuk et al., 2020). External factors include legislative regulation, investment flows, scientific and technical achievements, and global trends in the development of alternative energy sources.

The proposed model is based on the principles of efficiency, optimal management, adaptability to changes in the internal and external environment, legality, responsibility, and complexity. This allows us to develop strategies, programs, and projects that will contribute to the sustainable development of renewable energy while ensuring rational decision making on investment, modernization, and expansion of production.

Analyzing the experience of leading countries in the development of renewable energy, such as Germany, Italy, France, Austria, and others, we can conclude that the active application of such a model of sustainable economic development of renewable energy can contribute to improving energy security, reducing dependence on imported energy carriers and reducing the negative impact on the environment.

Incorporating this model involves development of various sources of renewable energy, such as solar, wind, hydropower, biomass, and geothermal energy. This implies the development of appropriate infrastructure, creating a favorable investment climate, training skilled personnel, and conducting research.

Particular attention within the framework of the formation of a model of sustainable economic development (Yousuf et al., 2022) of renewable energy should be paid to supporting innovations that will increase the efficiency of energy production, storage, and distribution processes, as well as developing new technologies that will ensure the sustainable development of the industry.

Similar research of international companies reflects stable economic development while resorting to renewable energy sources that results in reducing environmental pollution. The research conducted by the International Energy Agency (IEA) shows that by 2050 the use of renewable sources can reduce the world CO2 emissions by 70% as compared to the scenario with fossil fuel energy consumption. It can also increase the GNP and create economic advantages such as reduction of import dependence in energy (Ukrhydroenergo, 2021).

The research conducted by the International Renewable Energy Agency (IRENA) proves that the development of alternative energy sources such as solar and wind energy can boost economy by creating new work places and attracting investments (IRENA, 2020).

Successful implementation of the sustainable economic development model of renewable energy requires interaction between government agencies, businesses, scientific institutions, and the public. This implies the development and implementation of a comprehensive state policy in the field of renewable energy, aimed at stimulating investment, infrastructure development, supporting innovation and training, and ensuring social and environmental responsibility.

The implementation of the sustainable economic development model of renewable energy will open new opportunities for creating workplaces, promoting the export of technologies and services, strengthening energy independence, and improving the quality of life of the population.

Another important aspect is the development of international cooperation in the domain of renewable energy, joint projects with leading countries, and the experience exchange on innovative technologies. This will contribute to the integration of the national energy system into the world market and ensure the competitiveness of domestic companies.

As a result, the formation of a model of sustainable economic development of renewable energy is an important task that requires an integrated approach, active participation of all stakeholders, and constant monitoring of implementation results. This will ensure sustainable, safe, and environmentally friendly energy supply, promote economic growth, and ensure a high quality

of life for future generations.

6. CONCLUSIONS

The result of this study is the formation of a model of sustainable economic development of renewable energy, which requires the active assistance of states, the private sector, and international organizations. Based on the data analysis, it was found out that countries with a higher level of investment, innovative potential, and a percentage of renewable energy sources in the energy balance have lower levels of CO_2 emissions.

Countries with higher levels of investment and innovation potential have a greater share of renewable energy in total energy consumption. Increasing the share of renewable energy contributes to reducing CO_2 emissions per capita, thus indicates the positive impact on the environment.

The development of geothermal, solar, wind, and hydropower depends on the geographical, climatic, and other characteristics of each country, which requires an individual approach to the formation of strategies for the development of renewable energy.

Considering these conclusions, it is proposed to intensify efforts to develop renewable energy as a key area for sustainable economic development, to ensure energy security, reduce negative environmental impact and achieve global sustainable development goals.

Priority areas for achieving sustainable development of renewable energy are:

- expanding the research and development base to support innovation in renewable energy;
- stimulation of the private sector for the development of renewable energy;
- improving the regulatory and legislative framework to ensure the reliable, efficient, and safe functioning of the renewable energy market;
- infrastructure development for the distribution and storage of energy from renewable sources. This involves modernization and development of power grids, creation of energy storage systems, as well as the development of transport infrastructure using renewable energy sources;
- raising public awareness of the importance of renewable energy and its benefits for sustainable development, namely raising awareness of the environmental, economic, and social benefits of renewable energy, as well as encouraging consumers to choose “green” products and services.

In conclusion, this study has presented a model for sustainable economic development of renewable energy, highlighting the need for active involvement from states, the private sector, and international organizations. The analysis of data revealed that countries with higher levels of investment, innovative potential, and a greater percentage of renewable energy in their energy balance tend to have lower levels of CO_2 emissions. Additionally, countries with higher investment and innovation potential have a higher share of renewable energy in total energy consumption, indicating a positive impact on the environment.

It is clear from the findings that the development of geothermal, solar, wind, and hydropower depends on the unique geographical, climatic, and other characteristics of each country. Therefore, it is crucial to adopt an individual approach when forming strategies for the development of renewable energy.

Based on these conclusions, it is recommended to intensify efforts towards the development of renewable energy as a key driver for sustainable economic growth, energy security, and re-

duction of negative environmental impacts. To achieve these goals, several priority areas have been identified.

Firstly, expanding the research and development base to support innovation in renewable energy is crucial. This includes investing in scientific research, fostering collaborations between academia and industry, and providing financial incentives for technological advancements in the renewable energy sector.

Secondly, stimulating the private sector to actively participate in the development of renewable energy is essential. This can be achieved through financial incentives, tax breaks, and the creation of favorable business environments that encourage investment in renewable energy projects.

Thirdly, improving the regulatory and legislative framework is vital for ensuring the reliable, efficient, and safe functioning of the renewable energy market. This involves implementing clear and transparent regulations, streamlining administrative procedures, and establishing standards for the integration of renewable energy into the existing energy infrastructure.

Furthermore, infrastructure development for the distribution and storage of energy from renewable sources is crucial. This requires the modernization and expansion of power grids, the development of energy storage systems, and the integration of renewable energy sources into transportation infrastructure.

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7.

APPENDIX 1

Program calculation code of "regression coefficients" on the basis of the coefficient regression formula incorporating function LINEST in program language Python for MS Power Bi.

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.linear_model import LinearRegression

# Create a dataframe wirh data
data = pd.DataFrame({'Solar_Energy': dataset['Electricity from solar (TWh)'],
'Hydro_Energy': dataset['Electricity from hydro (TWh)'],
'Wind_Energy': dataset['Electricity_from_wind_TWh'],
'Bio_Energy': dataset['Other renewables including bioenergy (TWh)'],
'investment': dataset['(investment )'],
'Innovative potential': dataset['(Innovative potential )'],
'AnnualCO': dataset['(Annual CO2)'],
'Y': dataset['Share of renewable energy sources']})

# Initialize and train linear regression
regression_model = LinearRegression()
regression_model.fit(data[['Solar_Energy', 'Hydro_Energy', 'Wind_Energy', 'Bio_Energy']], data['Y'])

# Prediction of  Y based on X
data['Y_pred'] = regression_model.predict(data[['Solar_Energy', 'Hydro_Energy', 'Wind_Energy', 'Bio_Energy']])

# Displaying data and regression lines for Solar_Energy
plt.subplot(2, 2, 1)
plt.scatter(data['Solar_Energy'], data['Y'], label='Actual')
plt.scatter(data['Solar_Energy'], data['Y_pred'], color='red', label='Predicted')
plt.xlabel('Solar Energy')
plt.ylabel('Y')
plt.legend()
# ------ code reduction for other components -----

# Lines regression adding to the graphs
x_solar = np.linspace(data['Solar_Energy'].min(), data['Solar_Energy'].max())

# Saving coefficients for regression lines
coef_solar = np.polyfit(data['Solar_Energy'], data['Y'], 1)

# Regression lines calculation
y_solar = np.polyval(coef_solar, x_solar)

# Displaying of the lines regression in the graphs
plt.subplot(2, 2, 1)
plt.scatter(data['Solar_Energy'], data['Y'], label='Actual')
plt.plot(x_solar, y_solar, color='red', label='Regression Line')
plt.xlabel('Solar Energy')
plt.ylabel('Y')
plt.legend()
plt.tight_layout()
plt.show()
```

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DOES FINANCIAL INCLUSION IMPROVE INCOME EQUALITY? THE CASE OF TÜRKİYE

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ABSTRACT

Income inequality has become an important economic and humanitarian problem for both advanced and emerging economies, especially with the increase in financialization trends. The equitable distribution of income has garnered attention in both developed and developing nations, given the rise in global trade and production. However, limited research has explored the impact of financial inclusion on income inequality. To address this gap, this study investigated the effect of financial inclusion on income inequality in Türkiye, contributing to the very limited literature. In this study, the financial inclusion variable is measured using a six-dimensional index encompassing financial institutions and financial markets with depth, access, and availability sub-dimensions. During the time frame spanning from 1980 to 2021, estimations of parameters are conducted employing cointegration regression techniques, including FMOLS, DOLS, and CCR. The analysis revealed that inflation, per capita income, urbanization, and financial inclusion have a negative impact on income equality, whereas education has a positive impact. A 1% rise in financial inclusion is associated with a proportional rise in income inequality of approximately 0.012%. Contrary to the findings of previous empirical studies in general, the increase in financial inclusion in Türkiye has a distorting effect on income equality. The findings of this study offer important implications for Türkiye. While the relationship between the financial inclusion indicator and income inequality is not negative, increasing the income of low-income groups across all financial sectors is likely to improve income equality.

Keywords: *Financial Inclusion, Income Inequality, FMOLS, DOLS, CCR*

1. INTRODUCTION

Türkiye has emerged as the 19th largest economy globally, owing to its strategic location in the Middle East and a youthful demographic. The country has maintained an average growth rate of 5% since the post-1980 period (The World Bank, 2023). Although the main drivers of economic growth have been consumption expenditures and exports, it is undeniable that the financial liberalization reforms made in 1980 transformed the Turkish economy and contributed to economic growth. With the January 24, 1980 decisions, Türkiye removed the legal obstacles for capital flows and opened its economy to the outside world, integrating itself to the global capital. While an important feature of the post-1980 period in which neo-liberal policies were adopted is the increase in trade volumes, the increase in financialization trends was another im-

portant reflection of the paradigm shift. The free entry of foreign capital flows into the country has undoubtedly been the main trigger of financialization in Türkiye. The establishment of the Capital Market in 1981, making the Turkish Lira convertible against other currencies with the decision taken in 1989, selling government securities to foreigners and allowing banks to borrow freely from abroad were important practices that accelerated financialization (Heydarova, 2020). Especially in the post-1990 period, with the acceleration of globalization movements all over the world, the increase in credit volumes in Türkiye accelerated, and the share of the finance sector in GDP gained a significant momentum.

Although it is clear that the financial liberalization and deepening efforts in Türkiye after 1980 contributed significantly to economic growth, it is difficult to state that this growth is shared fairly among different classes of society since the share of the richest 10% received 54.47% of total income in 2022, causing Türkiye rank as the 34th most unequal country in the world (World Inequality Database, 2022). According to Dabla-Norris et al. (2016), income inequality is an important factor affecting growth and sustainability. The proposition put forth by the researchers posits that augmenting the proportion of income allocated to the lowest 20% of the population will result in a corresponding upsurge in economic growth. They also state that high level of income inequality leads to macroeconomic instability and prepares the ground for financial crises. Considering that in addition to economic problems, income inequality causes an increase in crime rates, corruption, misuse of resources and nepotism, it is clear that this problem will have social and political outcomes. Therefore, establishing income equality in the economy as well as stable economic growth is vital for a healthy society.

A substantial body of literature exists on the determinants of income equality, encompassing economic, financial, and social factors. When the current literature is examined, it is seen that the variable whose relationship with income equality is most investigated is economic growth, especially in developing countries (Digdowiseiso, 2009; Shahbaz, 2010; Baloch et al., 2018). However, as in the case of Türkiye, it is obvious that economic growth does not guarantee income equality. Conversely, empirical investigations that consider the era following 1990, during which financialization surged worldwide, primarily assess the effect of financialization on income inequality within advanced economies (Lin & Tomaskovic-Devey, 2013; Van Arnum & Naples, 2013; Alvarez, 2015). In these studies, it has been concluded that financialization reduces the income share of the working class and increases the share of the financial sector in the economy which eventually worsens income inequality. With the understanding that financialization alone cannot contribute to all segments of society, the concept of "financial inclusion", which means a kind of "financial equality", entered the literature. Studies investigating the link between income inequality, which has become a global problem, and financial inclusion began to enter the literature in the late 2000s. The first empirical findings that income equality can be achieved with "financial inclusion", which means the spread of financialization to all segments of society, is based on the study of Kim (2016). The researcher presented findings that financial inclusion can improve income equality, especially in low-income and high-vulnerability countries. The relationship between the two variables has recently started to be investigated for Türkiye as well. In the study conducted by Çalış & Gökçeli (2022), it was revealed that financial inclusion reduces income inequality. In another study on Türkiye, no clear relationship was found between the two variables (Takmaz et al., 2022). The limited number of studies is not sufficient to reveal the effect of financial inclusion on income inequality in Türkiye. This study, which empirically investigates this effect, aims to fill an important gap in the literature. Revealing the relationship between income inequality and financial inclusion, which is one of the most important problems of Türkiye, will offer important implications for both policy makers and decision makers of the financial sector.

2. THEORETICAL AND EMPIRICAL LITERATURE

According to Leeladhar (2005), who was one of the first to define the concept, financial inclusion is the provision of banking services to all segments of society, including disadvantaged and low-income groups, at reasonable costs. In other words, it is to officially include the unbanked in the financial system. On the other hand, income inequality is the situation where the income created in the economy and the resources owned are not distributed equally among the citizens of the country (Atkinson, 1997). According to Brune et al. (2011), by increasing their saving ability individuals can get stronger against financial shocks, continue their consumption, and invest in their health and education. Therefore, access to financial resources has the potential to improve income distribution by eliminating poverty. In the theoretical model built by Kling et al. (2022) to investigate the relationship between financial inclusion and income inequality, it was tested whether individuals' increased access to credit leads to education investments, thus more human capital and higher income. According to the result of the theoretical estimation, only informal loans can create an income increase for low-income individuals. Therefore, it can be argued that certain financial products may not be efficacious in mitigating the issue of income inequality.

According to intensive and extensive margin theories, the relationship between financial participation and income inequality may vary depending on whether economic agents have been involved in the financial system before. The intensive margin theory predicts that wealthy individuals and powerful companies that already have access to financial instruments can increase their financial resources more and affect income inequality (Chipote et al., 2014). On the other hand, the extensive margin theory argues that income inequality can be eliminated by incorporating those who have not had access to financial resources before into the financial system (Chiwira et al., 2016).

Greenwood & Jovanovic (1990) posit that the impact of financial inclusion on income inequality is non-linear, which contradicts the margin theories. Researchers have proposed the presence of a Kuznets-type correlation between financial inclusion and economic development. They argue that financial inclusion can solely benefit the entire society during the advanced stages of economic development, as individuals with elevated income levels are the only ones capable of accessing financial services during the initial stages of economic development. However, this view can be easily refuted when the United States of America, which has a high income inequality since the 1970s, is taken into account (Piketty & Saez, 2003). According to Menyelim et al. (2021), in the OECD report of 2008, income inequality deepened in developed countries, which are well above the Kuznet curve, causing the margin theory to be questioned.

Upon analyzing empirical studies that assess the link between financial inclusion and income inequality, it becomes apparent that diverse financial inclusion variables are employed for different countries and groups of countries. Agyemang-Badu et al. (2018) conducted an analysis of 48 African countries and developed a financial inclusion index that incorporates specific characteristics of each country. The fixed-effect panel regression estimator was utilized by researchers to gauge the interactions between financial inclusion, poverty, and income inequality. The research revealed that financial inclusion is inversely related to both poverty and income inequality in African countries. Khan et al. (2022) conducted a study utilizing the multiple regression method to examine the relationship between financial inclusion and poverty, income inequality, and financial stability in 54 African nations. The research indicates that financial inclusion is a vital mechanism for alleviating poverty and income inequality in these states.

The study conducted by Kim (2016) aims to evaluate the potential impact of financial inclusion, specifically in terms of financial accessibility, on the reduction of income inequality for

40 countries consisting of OECD and European Union (EU) members. The first outcome of the analysis is that the income inequality exerts a detrimental impact on the growth. There exists a robust inverse link between income inequality and income growth, particularly in nations with lower income levels. Furthermore, the effect of income inequality on diminishing economic growth is more pronounced in nations with high levels of fragility. Secondly, progressivity does not appear to be a significant determinant in mitigating income inequality in nations with low-income or those with high levels of fragility. Moreover, Kim (2016) argues that financial inclusion may strengthen the relationship between economic growth and income equality in general. Thus, it transforms the previously negative relationship between income inequality and economic growth into a positive relationship. Thus, the formerly adverse association between income inequality and income growth is now transformed into a positive as a direct result of this. The above-mentioned trend is more prevalent in countries with high levels of vulnerability as opposed to countries with low levels of vulnerability. Le et al. (2019), in their research on 22 transition countries, revealed that financial inclusion reduces income inequality.

Menyelim et al. (2021) examined the potential for financial inclusion in the context of Kuznets Curve to mitigate the negative effects of income inequality on the economic growth of 48 Sub-Saharan African countries. The results of the study show that promoting financial inclusion can have a short-term effect in reducing income inequality. The study revealed that inclusive financial access has a positive net effect in reducing the impact of income inequality on economic growth.

Neaime and Gaysset (2018), who tested the effect of financial inclusion on income inequality, poverty and financial stability for MENA countries, revealed that financial inclusion reduces income inequality, while population size and inflation increase income inequality. Omar & Inaba (2020) measured the impact of financial inclusion on poverty and income inequality in 116 developing countries by devising a unique financial inclusion index. The results of the empirical study demonstrated conclusively that financial inclusion lessens poverty and income inequality in emerging states. Similarly, Ouechtati (2020), who analyzed for developing countries, demonstrated that income inequality can be reduced if a high bank penetration rate and inclusive loans are made available to low-income individuals. Park & Mercado (2018) conducted a study utilizing a sample of 176 countries, which included 37 emerging Asian economies. The researchers developed a financial inclusion indicator and determined that financial inclusion has a significant impact on reducing poverty and income inequality across the entire sample. However, no significant relationship was found between these variables in developing Asian countries. Çalış & Gökçeli (2022), who analyzed Türkiye with the VAR approach, found an inverse relationship between financial inclusion and income inequality. Researchers who questioned the direction of causality between the variables revealed that financial participation is the granger cause of lower income inequality.

The present literature review reveals a notable void in empirical research pertaining to the correlation between financial inclusion and income inequality in nations with varying degrees of development. The existing body of literature on Türkiye appears to be limited.

3. EMPIRICAL ANALYSIS

This research explores the relationship between financial inclusion and income inequality from 1980 to 2021 in the case of Türkiye. The empirical part of the research commences with Model Specification. This section, titled “Empirical Analysis,” provides an account of the theoretical underpinnings of the empirical methods employed as well as the results obtained through these methods. The study commences with examining the stationarities of the series through the ap-

plication of the Augmented Dickey-Fuller (1979), Phillips-Perron (1988), and Zivot-Andrews (1992) techniques to ascertain the appropriate model specification. After determining the optimal lag-length, The Johansen cointegration approach is used in order to calculate the number of cointegrating relationships. This serves the purpose of confirming the existence of a long-term connection between the variables. The long-term coefficients are subsequently computed through the employment of FMOLS, DOLS, and CCR estimation techniques.

3.1. ECONOMETRIC METHODOLOGY

3.1.1. UNIT ROOT TESTS

Time series data mostly exhibit trending behavior, which is known as a scholastic trend; to put it another way, there may be an issue with the lack of stationarity. In order to acquire unbiased findings, it is vital to eliminate this kind of trending behavior. Therefore, determining the stationary level of a series is a prerequisite for time series analysis. The results of this unit root test are critical in choosing appropriate parameter estimation methods. The literature on econometrics has a variety of different unit root tests. This research makes use of the Augmented Dicky- Fuller (ADF) unit root test and the Philips Perron (PP) unit root test, both of which are used often in the applied economics.

The expression for ADF is presented in Equation (1) with a constant term, and in Equation (2) with both a constant term and a trend component.

$$\Delta Y_t = \gamma_0 + \gamma_1 Y_{t-1} + \sum_{i=1}^{n} \alpha_i \Delta Y_{t-i} + \mu_t \quad (1)$$

$$\Delta Y_t = \gamma_0 + \gamma_1 t + \gamma_2 Y_{t-1} + \sum_{i=1}^{n} \alpha_i \Delta Y_{t-i} + \mu_t \quad (2)$$

$$H_0: \gamma_1 = 0\ (unit\ root)\ \ H_1: |\gamma_1| < 0 \ \ ; \ \ H_0: \gamma_2 = 0\ (unit\ root)\ \ H_1: |\gamma_2| < 0$$

Using ADF regression, which is represented by equations (1) and (2), the existence of a unit root of is investigated. The terms "t" and "n" are the number of time and the number of lags respectively. ΔY_{t-i} stands for the first difference of the series with "n" lag. As it is expressed in Eq. (2) "the null hypothesis of series has a unit root" is examined.

PP unit root test equation can be expressed as $\Delta Y_t = \vartheta_0 + \gamma Y_{t-1} + \alpha_t$ and hypothesis tested as H_0: $\gamma = 0$ (*unit root*); $H_0: \gamma < 1$. By directly altering the test statistics $t_{\gamma=0}$, the PP tests ensure that any potential serial correlation as well as heteroscedasticity in the errors at of the test regression are eliminated.

3.1.2. COINTEGRATION

If the two series in the cointegration system exhibit similar behaviors or trends, there is a non-random link, or a common stochastic trend. Long-term relationships exist between series exhibiting similar stochastic trend behavior. In this direction, the concept of a long-term relationship, which implies the existence of equilibrium between variables, can be tested by the presence of a common stochastic trend. If it is determined that the two integrated series share a common stochastic trend, we can say that they are cointegrated. In this research the existence of cointegration tested by Johansen tests for cointegration

$$Y_t = \delta D_t + \phi_1 Y_{t-1} + \cdots + \phi_p Y_{t-p} + \varepsilon_t \quad Eq.(3) \quad (3)$$

The basis of Johansen's methodology is the vector autoregression (VAR) of order p given by y_t is a (nx1) vector of variables, which is typically represented as I(1) that stands for "integra-

tion of order one ε_t and is a (nx1) vector represent residual called innovations vector."

If $det(I_n - \phi_1 Z - \cdots - \phi_p Z^p) = 0$ all of the model's roots are located outside the unit circle, then the VAR(p) model is stable. Considering the VECM we can rewrite the Johansen's cointegration equation is specified in Eq.(4)

$$\Delta Y_t = \Gamma_1 D_t + \Pi y_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta Y_{t-j} + \varepsilon_t \quad (4)$$

where,

- D_t is a vector comprising of deterministic variables, which may include constants, trends, and/or seasonal dummy variables.
- $\Gamma_j = -I + \sum_{i=1}^{p-1} \phi_j$ are mxm matrices;
- The long-run impact matrix is represented by the equation $\Pi = \gamma A$, where A and γ are matrices of dimensions (m×k), and ε_t represents the errors.
- All roots of $det(I_n - \sum_{j=1}^{p-1} \Gamma_j B^j)$ are located outside the unit circle.

In this framework, cointegration happens when Π has reduced rank. This is the basis of the test: By checking the rank of Π, we can determine if the system is cointegrated. Equations (5) and (6) depict the trace and maximum eigenvalue test, as proposed by Johansen (Hjalmarsson and Österholm, 2007).

$$J_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \widehat{\lambda_i}) \quad (5)$$

$$J_{max} = -T \ln(ln(1 - \widehat{\lambda_{r+1}})) \quad (6)$$

3.1.3. ESTIMATION METHODS - FMOLS, DOLS AND CCR

FMOLS, DOLS and CCR techniques are all capable of producing valid findings even with very small sample sizes. Phillips & Hansen (1990) introduced the FMOLS, which is an instrumental variable estimate with non-stationary regressors. FMOLS endeavors to address the endogeneity issue by utilizing kernel estimators of the parameter in question. Furthermore, the FMOLS method utilizes the error term's covariance matrix to tackle issues arising from the correlations between cointegration equations and stochastic processes in the long-term.

Thus, the FMOLS initially modifies the variables and estimates to eradicate the extant nuisance parameters. The FMOLS estimators rectify the OLS estimation method's inadequacy so that it is possible to determine the optimum value for cointegrating regressions. The FMOLS estimator uses an assumption that is asymptotically biased while yet being strictly exogenous (Chen ve Huang, 2013). The FMOLS estimator can be expressed in the following way:

$$y_t^* = y_{t-1} \bar{w}_{12} \Omega_{22}^{-1} u_{2t} \quad (7)$$

the biased correlation term can be express as $\gamma_{12} = \gamma_{12} - \bar{w}_{12} \Omega_{22}^{-1} \xi_{2t}$ (8)

The long-run covariance coefficients Ω and ξ are computed utilizing the residuals $u_t = (u_{1t} u_{2t}')'$. The equation (9) can be utilized to conduct FMOLS estimation in this instance.

$$\widehat{\theta_{FMOLS}} = \begin{bmatrix} \alpha \\ \beta \end{bmatrix} = \left(\sum_{i=1}^{T} s_t \; s_t' \right)^{-1} \left(\sum_{i=1}^{T} s_t \; y_t^* - T \begin{bmatrix} \gamma_{12} \\ 0 \end{bmatrix} \right) \quad (9)$$

here $(s_t = x_t' d_t')'$

$$\widehat{\theta_{FMOLS}} = \left(\left(\sum_{i=1}^{T} x_t' \; d_t' \right)' \left(\sum_{i=1}^{T} x_t' \; d_t' \right)^{-1} \; y_t^* - T \begin{bmatrix} \gamma_{12} \\ 0 \end{bmatrix} \right) \tag{10}$$

In Equation (10), the terms y_t^* and γ_{12} correspond to the correction terms for endogeneity and serial correlation, respectively. This asymptotically unbiased estimator has a completely efficient mix-normal asymptotic distribution, allowing for the use of asymptotic chi-square inference in traditional Wald test (Adom et al., 2015).

Another approach, referred to as CCR, was presented by Park (1992). The statistical theory behind this method is basically the same as that which underpins the Phillips & Hansen (1990). The main difference between the two models is that CCR is only concerned with the transformation of data, whereas FMOLS is concerned with the transformation of both data and parameters. CCR is a single equation regression that is capable of applying multivariate regression without requiring any modifications or sacrificing its effectiveness (Park, 1992). In accordance with the findings of Adom et al. (2015), the CCR estimator is shown as in Equation (11)

$$\widehat{\theta_{CCR}} = \left(\sum_{t=1}^{T} Z_t^* Z_t^{*1} \right)^{-1} \sum_{t=1}^{T} Z_t^* Z_t^* \tag{11}$$

The third estimation method employed in this research is DOLS which is developed by Stock and Watson (1993). They suggested that it would be advantageous to include the lag and lead values of the independent variables in addition to the level values of the independent variable in order to rectify the deviation and endogeneity problem of OLS method. This DOLS (Dynamic Ordinary Least Squares) method is an effective estimator that that are resistant to autocorrelation and heteroscedasticity. In this regard, it is deemed superior to other estimators (Esteve & Requena, 2006).

The DOLS technique offers an estimator that is asymptotically efficient and eradicates the feedback effects present in the cointegration equation. The DOLS approach can be mathematically represented by the Equation (12).

$$y_t = x_t' \beta + d_{1t} \Psi_1 \sum_{j=q}^{r} \Delta \; x_{t+j}' \, \delta + \; u_{1t} \tag{12}$$

Here, “q” and “r” allow the difference of the explanatory variables, which allows to eradicate the long-run correlation between the error terms. The DOLS methodology’s estimation procedure yields parameter estimates that possess an asymptotic distribution, similar to the FMOLS and CCR approaches. The DOLS approach incorporates the first difference of the independent variables, thereby enabling the inclusion of time lags in the estimation process, while the CCR approach enables the asymptotic execution of the $\chi 2$ test.

3.1.4. MODEL SPECIFICATION AND FINDINGS

In the model, income inequality is defined as the dependent variable, while financial inclusion, education, income, inflation and urban population are defined as independent variables. The variables that are used in the model, along with their abbreviations and proxies for those variables, are listed in Table 1.

Table 1. Variables

Variables	Abbr.	Proxy	Source
Income inequality	GINI	GINI coefficient	World Bank
Financial inclusion	FDI	Financial development index	IMF
Education	ED	School enrollment, tertiary (% gross)	World Bank
Income	GDP	GDP per capita (constant LCU)	World Bank
Inflation	CPI	Inflation, consumer prices (annual %)	World Bank
Urban population	POP	Urban population (% of total population)	World Bank

Source: World Bank (2023); IMF (2023)

A significant corpus of scholarly literature exists that provides estimations of the impact of financial inclusion on economic activity and inequality. In academic literature, the most commonly used indicators for measuring financial development are the private credit to GDP ratio and the stock market capitalization to GDP ratio. These indicators are often utilized as proxies for financial development in empirical research. Nevertheless, the proxies utilized fail to consider the intricate and diverse nature of financial inclusion.

As per the Staff Discussion Paper (Sahay et al., 2015), the "financial development index" offers a comprehensive evaluation of the development of financial institutions and markets based on their depth, access and efficiency. Depth is assessed by measuring size and liquidity, access by evaluating the accessibility of financial services to individuals and businesses, efficiency by examining the capability of institutions to deliver financial services at a sustainable cost, and level of activity by analyzing the degree of participation in financial markets.

The following Eq. 13 depicts the functional formulation of the model that will be employed in empirical analysis.

$$\begin{aligned} &Income\ Inequality = \\ &f(Financial\ Inclusion, Education, Income, Inflation, Polulation) \\ &GINI = f(FIN, \quad ED, \quad GDP, \quad CPI, \quad POP) \end{aligned} \tag{13}$$

Equation 1 is the functional representation of the model. We can express our model in the form of cointegration regression as in Eq. 14

$$\begin{aligned} lnGINI_t = a + \beta_1 lnFIN_t + \beta_2 lnED_t + \beta_3 lnGDP_t + \beta_4 lnCPI_t + \beta_5 lnPOP_t + \varepsilon_t \\ - \lambda ECT_{t-1} \end{aligned} \tag{14}$$

Where, is the error term, λ is the speed of adjustment parameter, and is the lagged error correction term. The cointegrating vectors are incorporated into the model as the coefficients on the independent variables, β_1, ..., β_5. These coefficients represent the long-run relationship between the variables. The error correction term, λECT_{t-1}, captures the short-run dynamics that drive the adjustment process towards the long-run equilibrium. The speed of adjustment parameter, λ, represents the extent to which the dependent variable adjusts to deviations from the long-run equilibrium in the previous period.

Table 2 displays the results of ADF and PP, which test the null hypothesis of "series contains a unit root". The output of the report indicates that all series contain unit roots in levels, but exhibit stationary in the first difference. Thus, GINI, FIN, GDP, CPI, ED, and POP are integrated order of one $Yt \sim I(1)$.

Table 2. ADF and PP unit root test

H0: series contain unit root	ADF				PP			
	I(0)		I(1)		I(0)		I(1)	
Variable	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
GINI	-1.168	0.687	-5.004***	0.000	-1.226	0.662	-5.067***	0.000
FIN	-0.990	0.757	-7.373***	0.000	-0.977	0.7617	-7.674***	0.000
GDP	2.166	0.999	-5.072***	0.000	2.769	1.0000	-5.011***	0.000
CPI	-2.061	0.261	-7.479***	0.000	-2.158	0.2219	-7.717***	0.000
ED	0.165	0.970	-6.558***	0.000	0.222	0.9735	-6.559***	0.000
POP	-1.908	0.328	-3.995**	0.0014	-1.701	0.4306	-5.233***	0.000

Source: Authors' calculation. *** p<.01, ** p<.05, * p<.1

Unit root tests that do not account for structural breaks may produce biased results. By considering the numerous internal and external disruptions experienced by the Turkish economy during the review period, it would be appropriate to employ the unit root tests allowing for structural break. For this purpose, Zivot-Andrews (1992) unit-root test which is considered structural break is employed to robust the output of ADF and PP Test. The outcomes displayed in Table 3 confirms the ADF and PP findings that all variable are $Y_t \sim I(1)$.

Table 3. ZA Test Results

H0: series contain unit root	I(0)	I(1)	Decision
Variable	Stat.	Stat.	
GINI	-3.111	-6.239***	I(1)
FIN	-4.597	-7.581***	I(1)
GDP	-2.153	-6.088***	I(1)
CPI	-4.550	-8.770***	I(1)
ED	-4.458	-9.152***	I(1)
POP	-4.012	-6.979***	I(1)

Source: Authors' calculation. *** p<.01: (-5.34), ** p<.05: (-4.80), * p<.1: (-4.58)

The selection of the lag length is a fundamental issue in applied time series analysis. In time series analysis, lag refers to the number of time periods between the current observation and a past observation. Rarely is there an immediate response or interaction between dependent variable, Y, and independent variable, X. Most of the time, it takes a considerable period of time before Y responds to X. In general, having an excessive number of lags causes the standard errors of coefficient estimates to be inflated, which in turn implies an increase in the amount of error associated with the prediction. The model may become overly complex, leading to overfitting and poor generalization to new data. If the lag length is too short, the model may not capture all the relevant information from the past, leading to poor predictions. Therefore, selecting an appropriate lag length is crucial for building accurate and reliable time series models.

Table 4 summarizes the findings of the variety of information criterions that determined the optimal lag length. BIC indicates that the optimal lag length is 1, while LL, FPE, AIC, and HQIC all determined as 4. As a result, it has been concluded that lag length of four is the optimal choice.

Table 4. Optimal lag-length selection

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	233.527	0.000			2.5e-13	-11.975	-11.883	-11.717
1	555.807	644.560	36	0.000	7.4e-20	-27.043	-26.398	-25.2325*
2	615.811	120.010	36	0.000	2.4e-20	-28.306	-27.110	-24.9445
3	652.395	73.169	36	0.000	3.6e-20	-28.337	-26.589	-23.4238
4	719.142	133.49*	36	0.000	1.9e-20*	-29.9549*	-27.655*	-23.4907

Source: Authors' calculation

The Johansen test is a statistical procedure utilized to ascertain the existence and quantity of cointegrating associations between the series. The trace statistic is one of two test statistics used in the Johansen test, the other being the maximum eigenvalue statistic. The choice between the two statistics depends on the number of variables and the order of integration of the variables under consideration. The trace statistic is more appropriate when the variables are integrated of the same order, while the maximum eigenvalue statistic is more appropriate when the variables are integrated of different orders. Therefore, trace statistics are employed to ascertain the existence and quantity of cointegrating relationships among the series. The outcomes of the test reported in Table 5.

Table 5. Johansen tests for cointegration

No. of CE(s)	parms	LL	Eigenvalue	Trace Statistic	%5 Critical Value
0	114	613.37185	.	211.5408	94.15
1	125	662.27554	0.92376	113.7334	68.52
2	134	685.14911	0.69997	67.9863	47.21
3	141	704.66283	0.64193	28.9588*	29.68
4	146	711.73162	0.31067	14.8212	15.41
5	149	716.50462	0.22214	5.2752	3.76

Source: Authors' calculation

The Johansen test posits a null hypothesis "there is no cointegration among the variables" against the alternative hypothesis of "there is at least one cointegrating vector". As the calculated trace statistic exceeds the critical values from the tables provided by Johansen, then the null hypothesis is rejected indicating the variables are cointegrated. As it is "3 cointegrating equations at the 0.05 level" indicated we can estimate the long-run parameters by employing FMOLS, CCR and DOLS cointegration regression techniques. The FMOLS, CCR and DOLS estimator yielded the following results, as shown in Table 6.

The outcomes of FMOLS, CCR, and DOLS estimators, respectively, are as follows

- The coefficient for financial inclusion exhibits a positive sign and is statistically significant at the 0.01 level. An increase of 1% in financial inclusion results in increase in income inequality of approximately 0.012%, 0.012%, and 0.07%, respectively.
- The coefficient for tertiary education exhibits a negative sign and is statistically significant at the 0.01 level. A 1% increase in tertiary education is associated with a decrease in income inequality of -0.114%, -0.098%, and -0.114%, respectively.
- The coefficient for GDP per capita exhibits a positive sign and is statistically significant at the 0.01 level. An increase of 1% in GDP per capita increases income inequality by 0.116%, 0.115%, and 0.163%, respectively.
- The coefficient for inflation, specifically consumer price inflation, exhibits a positive sign and is statistically significant at the 0.01 level. An increase of 1% in inflation results in a distortion

of income inequality by 0.0205%, 0.0210%, and 0.0297%, respectively.
• The coefficient for the urban population displays a positive sign and exhibits statistical significance at the 0.01 level. Moreover, a 1% rise in urban population leads to distortions in income inequality of 0.406%, 0.342%, and 0.313%, respectively.

Table 6. Cointegration Regression Estimations

LnGINI	FMOLS	CCR	DOLS
LnFIN	0.0115***	0.0116***	0.0660***
	(3.87)	(5.21)	(6.76)
LnED	-0.114***	-0.0984***	-0.114***
	(-35.24)	(-34.01)	(-3.83)
LnGDP	0.116***	0.115***	0.163***
	(16.84)	(16.19)	(4.67)
LnCPI	0.0205***	0.0210***	0.0297***
	(40.21)	(43.65)	(4.13)
LnPOP	0.461***	0.342***	0.313***
	(41.70)	(49.12)	(7.48)
_cons	1.034***	1.483***	1.106**
	(13.61)	(21.27)	(3.17)
R2	.799	.950	.982
N	41	41	41

Source: Authors' calculation. * p<0.05, ** p<0.01, *** p<0.001 - t statistics in parentheses

The CCR and DOLS estimators are utilized to enhance the robustness of the FMOLS estimation outcomes. Based on the results obtained from the three estimation techniques, it has been concluded that the parameter estimates exhibit a high degree of proximity and that the direction of the relationship between the dependent and independent variables is consistent. Table 7 presents a summary of the results obtained from three estimations.

Table 7. Summary of estimations

Income inequality –Gini-	**FMOLS**		**CCR**		**DOLS**		**Impact on Gini**
	Sign	Signific.	Sign	Signific.	Sign	Signific.	
Financial inclusion	+	√	+	√	+	√	Distort
Education-tertiary	-	√	-	√	-	√	Improve
Income-GDP per capita	+	√	+	√	+	√	Distort
Inflation-CPI	+	√	+	√	+	√	Distort
Urban Population	+	√	+	√	+	√	Distort

Source: Authors' evaluation

3.1.5. MODEL VALIDATION

The LM test, also referred to as the Lagrange-multiplier test, is a diagnostic tool employed to ascertain the presence of autocorrelation in the residuals of a regression model. Autocorrelation is a statistical phenomenon that occurs when the residuals of a model display a correlation with one another, indicating the existence of an identifiable pattern in the model's errors that has not been appropriately addressed. The test's null hypothesis posits the absence of autocorrelation at the specified lag order. The initial step in conducting the LM test involves estimating the regression model and acquiring the residuals. The subsequent step involves conducting a regression analysis of the squared residuals against the lagged values of the squared residuals,

with consideration of a predetermined lag order. The test statistic denoted as LM is derived by multiplying the R-squared value obtained from the regression analysis with the sample size. The null hypothesis assumes the absence of autocorrelation and the distribution of the test statistic follows chi-squared distribution.

Table 8. LM Test

lag	$\chi 2$	df	Prob > $\chi 2$
1	36.5457	36	0.44332
2	27.4017	36	0.84783
3	46.6648	36	0.10982
4	30.5180	36	0.72655

Source: Authors' calculation

Upon scrutiny of Table 8, it is evident that the p-values surpass 0.05 for every lag duration. The null hypothesis stating the absence of autocorrelation cannot be rejected.

Normality tests are utilized as diagnostic instruments to evaluate whether a given dataset conforms to a normal distribution, which is a crucial assumption of our statistical model. Non-normal distribution of data can result in biased parameter estimations, imprecise p-values, and erroneous conclusions. Consequently, it is crucial to verify the normality assumption prior to utilizing statistical techniques that are dependent on it.

The Jarque-Bera (JB) test is a statistical method utilized to ascertain whether a given dataset conforms to a normal distribution. The JB test relies on the sample skewness and kurtosis as statistical measures of the extent to which the sample distribution deviates from a normal distribution. Skewness quantifies the degree of asymmetry of the distribution, while kurtosis measures the heaviness of the tails of the distribution. In a Gaussian distribution, the measures of skewness and kurtosis are both equal to zero.

Table 9. Normality

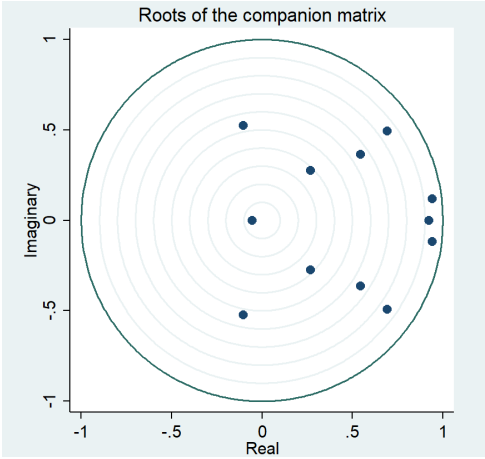
	Jarque-Bera test		Skewness test		Kurtosis test	
Eqs.	$\chi 2$	Prob > $\chi 2$	$\chi 2$	Prob > $\chi 2$	$\chi 2$	Prob > $\chi 2$
LnGINI	2.024	0.36350	1.952	0.16234	0.072	0.78889
LnFIN	2.848	0.24073	2.842	0.09186	0.007	0.93497
LnED	1.773	0.41209	1.246	0.26424	0.527	0.46803
LnGDP	6.565	0.03753	0.681	0.40920	5.884	0.01528
LnCPI	1.014	0.60221	0.082	0.77493	0.933	0.33420
LnPOP	3.188	0.20315	2.023	0.15491	1.164	0.28054
ALL	17.412	0.13473	8.826	0.18359	8.586	0.19822

Source: Authors' calculation

Table 9 presents the results of the normality test, which consisted of JB-Skewness and Kurtosis. Given that the p-value corresponding to the test statistic is greater than 0.05, we are unable to reject the null hypothesis. Thus, we can infer that there is insufficient evidence to support the claim that the sample data does not conform to a normal distribution.

Table 10. Eigenvalue stability

Eigenvalue		Modulus
.9408056	+ .118923i	.948292
.9408056	- .118923i	.948292
.9231298		.92313
.6934538	+ .4937039i	.851247
.6934538	- .4937039i	.851247
.5438024	+ .3648882i	.654877
.5438024	- .3648882i	.654877
.1045889	+ .5235808i	.533925
.1045889	- .5235808i	.533925
.268261	+ .2745281i	.383835
.268261	- .2745281i	.383835
.053905		.053905



Source: Authors' calculation

If a given matrix A is characterized by eigenvalue stability, then its solutions exhibit stability even when subjected to minor perturbations. The concept of eigenvalue holds significant importance in the domain of matrices, as it plays a crucial role in ensuring the precision and stability of numerical computations. As demonstrated in Table 10, all of the roots of the companion matrix are situated within the unit circle. The relationship between the roots of a polynomial lying inside the unit circle and the absolute value of the eigenvalues of the companion matrix being less than one is a result of the principles of linear systems and the spectral theorem. The stability and convergence of specific numerical methods and systems, such as difference equations and dynamical systems, are significantly impacted by this phenomenon. The diagnostic tests conducted on the model's results suggest that the model is valid.

4. DISCUSSION AND CONCLUSION

The issue of income inequality has gained significant attention in both developed and developing nations, primarily due to the emergence of financialization trends resulting from globalization. The issue of income distribution remains a crucial topic on the political and economic agenda, given the rise in global trade volume and production output. Despite being limited in scope, academic research has demonstrated a keen interest in investigating the effects of financial inclusion on the equitable distribution of income. In this regards, this study investigated the impact of financial inclusion on income inequality in Türkiye, contributing to the very limited literature. Financial inclusion indicators in the literature mainly cover the number of ATMs per capita, the number of bank branches and the share of credits in GDP. Unlike the literature, in this study, indicators including the depth, access and effectiveness of financial markets and institutions were incorporated in the analysis by using the IMF's financial development index. In addition to financial inclusion, variables such as education, income, inflation and urban population, which are thought to affect income inequality, were also added to the model as control variables.

According to the results of the analysis, the increase in financial inclusion creates a distorting effect on income equality in Türkiye. This result, which seems to contradict the findings of previous studies, may be partly due to measurement differences. While the representative variable of financial inclusion was narrowly defined in previous studies, the financial development

index employed as a proxy for financial inclusion in this study is a much broader indicator that includes depth, access and efficiency of stock exchange and other debt markets. Considering the studies in which stock exchange markets deteriorate income inequality or do not contribute to income equality, especially in developing countries (Das & Mohapatra, 2003; Seven & Coskun, 2016; Blau, 2018), the finding obtained from this study is not surprising. This result can also be explained by the economic structure of Turkey. Considering the growth composition, it can be easily said that Türkiye is a consumption-based economy. As orthodox economists emphasize, the use of credit facilities by individuals for consumption rather than investment opportunities can also contribute to income inequality.

An important variable that has been agreed upon in influencing income distribution is education. Consistent with previous studies, this study confirms that education can help to cope with income inequality in Türkiye. Education enables individuals to acquire the knowledge and skills necessary to find better paying jobs. Therefore, the contribution of education to income equality is an expected result for this study. Another variable whose effect on income inequality was measured in the study is GDP per capita. There is no consensus in the literature on how GDP per capita affects income distribution. In this study, findings reveal that increase in GDP per capita distorts income inequality. It has been determined that inflation is another important macroeconomic variable that distorts income equality in Türkiye. Similarly, the increase in the urban population aggravates income inequality in Türkiye.

To conclude, it is not possible to solve income inequality in any economy with just one variable. Income inequality is a complex problem with economic, social and institutional dimensions. Therefore, the approach to the solution of this problem should include a solution beyond just considering financial factors. The findings of the study provide important implications to solve income inequality in Türkiye. First of all, although there is no negative relationship between the financial inclusion indicator and income inequality, inclusion of low-income groups in all areas of the financial world by increasing their income will likely improve income inequality. Another macroeconomic indicator that will contribute to the solution of income inequality is inflation. Although inflation causes chronic problems in many areas of the economy, its greatest impact is reducing the purchasing power of individuals. Considering that the low-income group is the most affected by inflation, it can be predicted that ensuring price stability in the economy will improve income equality. Based on the findings of the study, policies aimed at raising the level of education and bringing more individuals into education will also ensure a more equitable distribution of income in Türkiye.

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DEVELOPMENT OF CIRCULAR ECONOMY IN MODERN CONDITIONS

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ABSTRACT

The concept of a circular economy in the world arose in response to growing consumption and, as a result, to the accumulation of a mass of waste that cannot be quickly processed in the natural environment and has a harmful effect on the environment. The introduction of a circular economy along with the modernization of production will provide Ukrainian society with double benefits. First, the reuse of already consumed resources allows you to obtain significant benefits both in terms of savings in their purchase and in reducing the costs of waste disposal. Secondly, the burden on the environment is reduced and the problems of waste disposal are solved, which positively affects the country's ecosystem.

The essence and types of decoupling as a strategic basis for the development of the green economy are analyzed. The actualization of the use of decoupling for Ukraine in the context of highlighting issues of its environmental and economic security is shown. Calculations of the integral decoupling factor for Ukraine were carried out.

Based on the results of the calculations, conclusions were made regarding the effectiveness of the system of nature management and management of the socio-economic development of the state, directions for solving problems and prospects for further research were determined. The conducted analysis made it possible to draw conclusions that at this stage of economic development there is an urgent need to transition to an inclusive and circular economy. The results of the conducted research can be used in the development of the strategy of green economy and sustainable development of countries.

Keywords: *circular economy, environmental safety, balanced development, decoupling, efficiency*

1. INTRODUCTION

The development of circular economy models is currently being promoted in many countries around the world to counter global environmental threats, especially climate change. The development of the circular economy also has enormous potential for creating new business models that can ensure sustainable economic growth and create attractive employment opportunities at the regional level.

At the current stage of Ukraine's economic development, solving environmental problems is extremely relevant and important (Podlevska, Krasovska, 2017). The burden on the environment increases linearly with the growth of society's needs.

In today's world, rapid technological development and population growth, as well as active human activity, have a significant impact on the environment, requiring us to be conscious and responsible about our consumption of resources and emissions of unnecessary waste. Each of us can act in the interests of the environment by consciously choosing products and services, including by considering environmental safety labels on packaging, using environmentally friendly materials in our homes and workplaces. In order to preserve natural resources and ensure the environmental safety of our planet, we need to focus on promoting conscious consumption and appropriate behavior, considering the impact of human activity on the environment and minimizing the negative impact of our activities on the environment.

Due to the growing environmental concerns, it is necessary to pay more attention to and promote more conscious consumption and environmental behavior. This may include changing consumer habits, raising environmental awareness, and introducing green technologies. Rising levels of environmental pollution, climate change, and other environmental issues stem from major global challenges. The transition to a more environmentally friendly lifestyle can help reduce the negative impact of people on nature and ensure the sustainability of life on the planet.

One of the solutions is to conduct an expanded information campaign to build environmental awareness and skills in environmental behavior among the general population. To achieve this goal, it is necessary to implement various approaches, such as the use of mass media, trainings and seminars, and the development of web resources containing materials on environmental issues and advice on ecological consumption. Other solutions will also be relevant: the use of environmentally friendly technologies and materials, support for environmental policies by governments and businesses, reducing the use of plastic packaging and waste, and supporting green initiatives.

Ukraine also faces the problem of low resource and energy efficiency in industry and construction. This has serious consequences for the country's economy, environment, and social well-being. First, low resource efficiency potentially leads to unnecessary consumption of fuel, water and other materials in production processes, which in turn affects the competitiveness of Ukrainian enterprises. In addition, this leads to an excessive burden on natural resources, which can cause their depletion and environmental problems. Second, low energy efficiency in construction and industry leads to high energy consumption for heating, cooling, and lighting. This, in turn, leads to higher energy costs and environmental pollution. Insufficient insulation of buildings and outdated production technologies lead to energy loss and increased emissions of harmful substances.

To solve these problems, more work is needed to create new energy efficiency standards and environmental regulations in construction and industry. This means establishing mandatory requirements for energy efficiency in buildings, using environmentally friendly materials and technologies in production, and raising awareness of the importance of energy conservation and rational use of resources among businesses and other market participants. In addition, it is important to conduct research and development on energy efficiency and introduce innovative technologies that reduce energy and resource consumption, disseminate information on reducing energy and resource consumption opportunities, and the benefits of energy efficient technologies and environmentally friendly materials. It is also necessary to create favorable conditions for the use of energy efficient technologies and materials. For example, taxes can be imposed

on the use of materials and technologies that are harmful to the environment, and benefits and subsidies can be provided for the use of energy efficient technologies and materials. In general, the efficient use of resources and energy in industry and construction is an important component of the country's sustainable development.

Addressing the problem of low resource and energy efficiency is a comprehensive approach that includes the development and implementation of new technologies, creation of favorable conditions for the use of energy efficient materials and technologies, and information and education among industrial enterprises.

In addition, it is important to develop global trends in sustainable development and energy, such as the transition to renewable energy, reduction of carbon emissions, energy efficiency, etc. Ukraine's participation in such initiatives as the Paris Agreement and the UN Sustainable Development Goals requires the country to change its approach to resource and energy use, as well as to introduce modern technologies that ensure the sustainability of the nation's development.

One of the ways to solve the existing environmental problems and, as a result, to increase the competitiveness of the national economy in the long run is intensive, maximally efficient, waste-free resource consumption, as well as systematic reduction of all types of anthropogenic pressure on the environment through the "green" modernization of modern industries and the introduction of new technological processes (Ukraine 2030).

The development of modern innovative entrepreneurial activity and the creation of innovative enterprises is one of the main directions of economic development and its movement towards a circular, innovative economy.

Innovation, as „a key element of economic activities of the present time" (Minster, 2015, p.ix), is essential for overcoming the significant challenges which the mankind is facing, especially related to economic development and welfare of almost entire, growing global population (Mašić B., Vladušić Lj., 2018).

Only those countries that implement resource-saving, innovative and waste-free technologies, systematically reduce all types of environmental pollution can achieve high production rates without deteriorating the state of the ecological system. It is the circular economy that represents a new economic model associated with green growth and ensures the movement from mass consumption to responsible consumption.

In order to determine how successfully a country is moving towards sustainable development and the implementation of the circular economy, scientists use decoupling analysis of the economy (Podlevskyi, Podlevska, 2021). The circular economy adheres to three main principles, namely, the reduction, reuse, and recycling of resources. Preference is given to reducing the use of materials, i.e. the theory of decoupling is an important factor in the circular economy that significantly affects its development. Decoupling makes it clear whether an economic activity is efficient in terms of minimizing environmental damage. The task of decoupling is to assess the difference between anthropogenic pressure on the environment and resource consumption from economic growth.

Decoupling theory is a basic theory proposed by the Organization for Economic Cooperation and Development to describe the decoupling between economic growth and resource consumption or environmental pollution (OECD, 2002). This means that economic growth can be decoupled from resource consumption or environmental pollution to realize decoupling. In the development of the circular model of economic growth, the decoupling effect is precisely that

economic growth occurs with the help of resource-saving technologies and, accordingly, a reduction in the impact of emissions into the environment.

2. LITERATURE REVIEW

The problems of implementing a circular economy are in the focus of attention, first and foremost, of governments, international organizations, foundations, and financial institutions that predict the emergence of new promising markets. However, this issue is also of interest to both economic and environmental scholars. Among the scientists who have considered the essence, basic principles of the circular economy and ways to improve waste management are H. Nguyen, M. Zils, M. Stuchtey (Nguyen, Stuchtey, Zils, 2014), N. Pakhomova, P. Williams (Williams, 2005) and many others.

The problems of the "circular economy", global changes and their impact on national economies have been studied by Zvarich 2019, Loyko 2019, and others, who identified the basic principles of sustainable development in the national economy, environmental and economic problems, and proposed ways to solve them, including through the use of best foreign practices. Waste management has become the main subject of research by leading scientists (V. Mishchenko, H. Vyhovs'koyi 2009), who studied the European experience and directions of state policy on solid waste management.

Interesting, in the context of our study, are the views of foreign scholars on the definition of the "circular economy". In the context of the development of the circular economy, the authors' definition is worthy of attention (Korhonen J., Nuur C., Feldmann A., Eshetu Birkie S. 2018): "...a sustainable development initiative aimed at reducing the linearity of societal production and consumption systems. Applying material cycles, renewable and cascading energy flows to a linear system. The circular economy promotes the development of high-value material cycles alongside more traditional recycling and develops systemic approaches to cooperation between producers, consumers and other public actors in the field of sustainable development."

The definition of the "circular economy" as an economic system based on the creation of innovative enterprises that act as entities that create high-tech and knowledge-intensive products in the circular economy is defined by (Kirchherr J., Reike D., Hekkert M. 2016): "an economic system based on business models that replace the concept of "end of life" with the reduction, alternative reuse, recycling and recovery of materials in the production/distribution and consumption process, operating at the micro level (products, companies, consumers), meso-level (eco-industrial parks) and macro-level (city, region, nation and beyond), in order to achieve sustainable development that creates environmental quality, economic prosperity and social justice for the benefit of present and future generations."

The definition of the "circular economy" in the context of the decoupling phenomenon given by (Peters et al. 2007) is worthy of attention: "the main idea is to close material loops, reduce the amount of input materials and reuse or recycle products and waste to achieve a higher quality of life by increasing the efficiency of resource use".

The analysis of the scientific literature on the circular economy shows that the following terminology is used worldwide: green economy, circular economy.

3. AIM OF THE RESEARCH

The purpose of this study is to determine the existence of the decoupling phenomenon as an important factor in the circular economy, which significantly affects its development in Ukraine, as well as to analyze the decoupling values of the index of balanced development of Ukraine and determine the degree of environmental orientation of economic development.

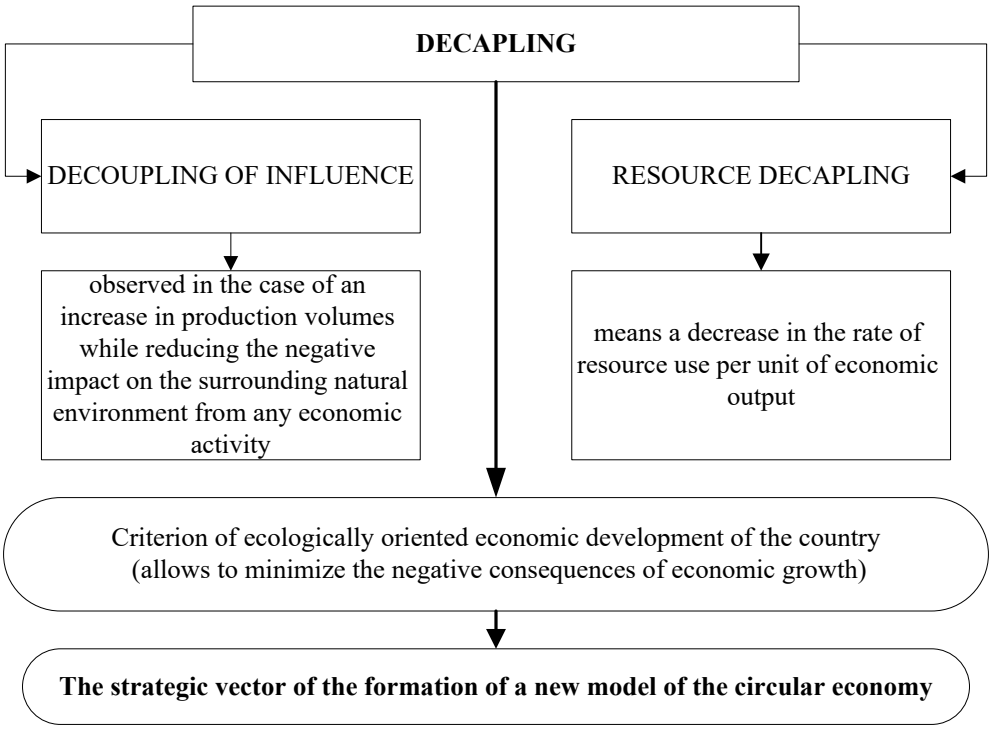
4. METHODS

The environmental threats and challenges that Ukraine faced before February 24 have not been resolved on their own, but have only become deeper. The war has had a global impact on Ukraine's environment. It has resulted in the decline and deterioration of natural ecosystems, chemical and industrial pollution, mining, and devastating damage to biodiversity.

The Ukraine Recovery Conference, which took place on July 4-5 in Lugano, Switzerland, was an important contribution to the future of environmental restoration. One of the conference programs to be implemented in the future is "Rebuilding a Clean and Protected Environment." Switzerland's experience in environmental policy is exemplary. Switzerland will invest in projects that will reduce greenhouse gas emissions, as Ukraine's reconstruction will require intensive use of various sectors: mining, industry, transportation, and others, which will be accompanied by an increase in carbon emissions. Therefore, Switzerland's experience and support are valuable to us in terms of implementing green economic principles and transitioning to a circular economy in the process of rebuilding the country without harming the global environment.

Effective waste management is another reform on the path to European integration. The first step has already been taken. In June, the Verkhovna Rada adopted a framework draft law on waste management (No. 2207-1-d). Addressing the issue of waste is especially important now, when its amount is growing significantly as a result of the military operations. A large amount of construction waste is generated during the cleanup of territories, rubble removal, and restoration of residential buildings and businesses. Therefore, in the context of the new model of the "circular economy", decoupling should become a key principle that provides for meeting growing needs while minimizing the consumption of natural capital (UNEP, 2011), and it is decoupling that allows us to assess the effectiveness of institutions in minimizing environmental damage. Fig. 1 shows the types of decoupling as a basis for implementing a circular economy model.

Figure 1. Decoupling as a basis for the formation of circular economy model



Source: (Tur, O.M., 2012)

The definition of resource decoupling should help to solve the problem of shortages and respond to the challenge of sustainability and intergenerational equality to reduce the rate of resource depletion while reducing costs by increasing the efficiency of resource use. Domestic scientist O. Tur (Tur, O.M., 2012), in continuation of foreign developments, proposed to calculate resource decoupling using the following formulas:

Resource decoupling factor:

$$\text{Decoupling Index} = \frac{N_E}{DF_E} / \frac{N_B}{DF_B} = \frac{N_E}{N_B} / \frac{DF_E}{DF_B} = \frac{I_N}{I_{DF}} \quad (1)$$

$$\text{Decoupling Factor} = 1 - \text{Decoupling Index} \quad (2)$$

where N_B, N_E – the amount of natural resources consumed (mineral, forest, land, water, and other resources) in the final (end of measurement) and baseline (beginning of measurement) periods, in natural units;

$\frac{N_E}{N_B}$, I_N – growth rate, or an index of the physical volume of natural resources consumed;

I_{DF} – GDP physical volume index (or another macro indicator).

The author interprets the obtained values as follows:

1. If $DF \geq 1$ then the growth rate of resource consumption or pollutant emissions is not lower than the rate of economic growth, which demonstrates dependence. At the stage of full dependence, the higher the decoupling factor, the higher the dependence of economic development on resources and the greater the environmental damage.

2. If $0 < DF < 1$, the growth rate of resource consumption or pollutant emissions is lower than the growth rate of economic growth, indicating relative decoupling, which shows relatively efficient use of resources or relatively low environmental damage.

3. If $DF \leq 0$, then the increase in resource consumption or pollutant emissions is less than 0, which is absolute decoupling and means that resource consumption or pollutant emissions are decreasing with economic growth.

In our work, for further calculations of decoupling indicators by environmental impact factors and by resource factors, among a wide range of indicators that exert pressure on the environment and reflect the level of resource use, we have selected the following: emissions of pollutants into the atmosphere from stationary and mobile sources, volumes of wastewater disposal (discharge), volumes of waste generation of hazard classes I-III, mineral resources extraction, volumes of used water consumption and volumes of waste disposal.

We used the following formula to calculate the integral decoupling factor:

$$F = 1 - \left(\sqrt[n]{\frac{N_{E1}}{N_{B1}}} * \frac{N_{E2}}{N_{B2}} * \ldots * \frac{N_{En}}{N_{Bn}} / \frac{DF_E}{DF_B}\right) \quad (3)$$

where n is the number of types of pollution, 1, 2, ... n are the types of pollution.

The decoupling effect at the macroeconomic level occurs when economic growth does not deteriorate primarily the environmental component (indicators of negative environmental impact).

The results of the calculation of the decoupling factor can be interpreted as follows (Tur, O.M., 2012):

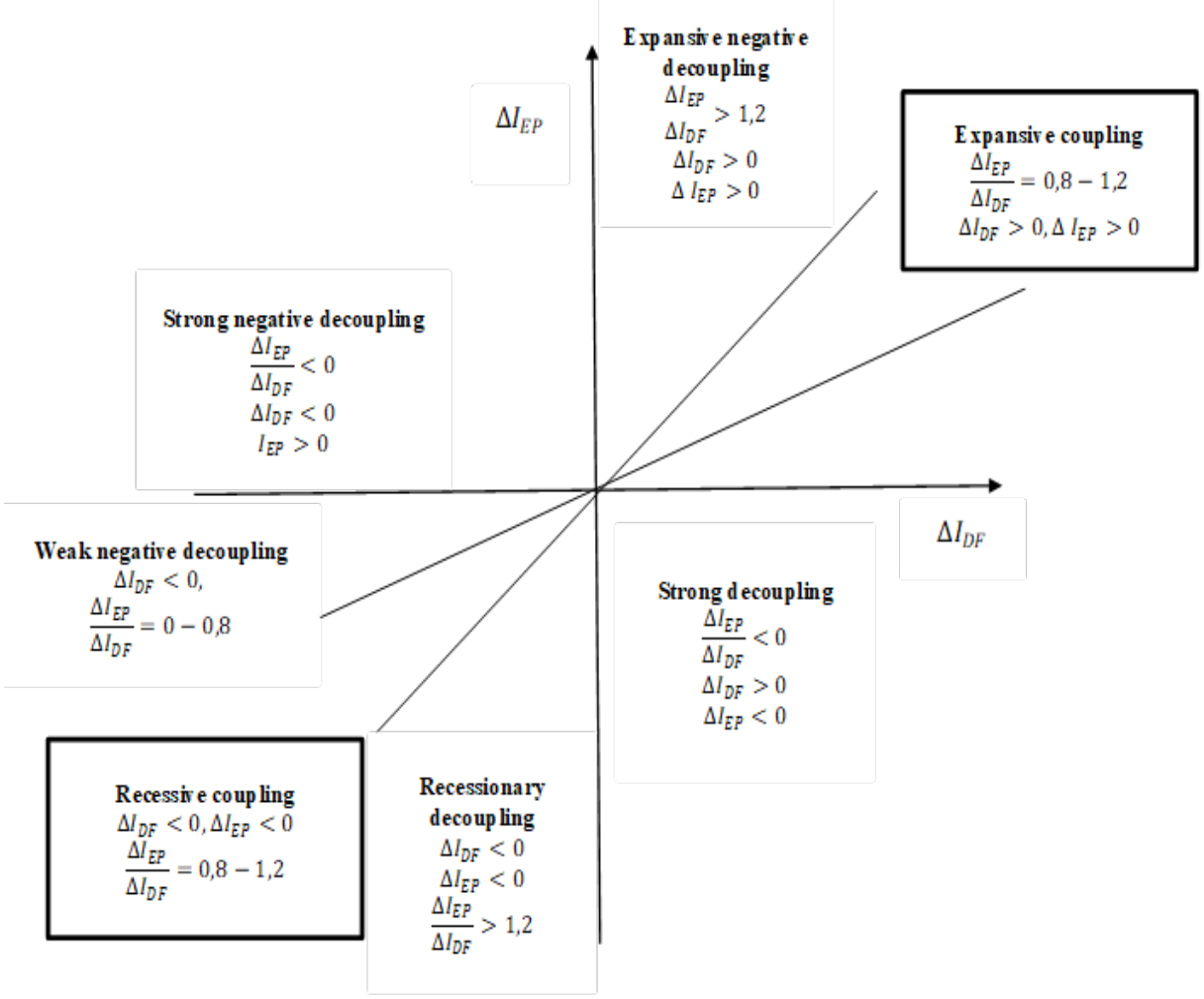
1. Decoupling Factor > 0 and this indicator is growing in the dynamics - there is a decoupling effect, i.e. there is a decrease in anthropogenic pressure on the environment or natural resource savings with GDP growth;

2. Decoupling Factor < 0 and decreases in the dynamics - economic growth leads to a significant increase in anthropogenic pressure or depletion of natural resources;

3. Decoupling Factor = 0, indicates the equality of economic growth and anthropogenic pressure or natural resource use, and is possible under the following conditions: a) GDP growth and anthropogenic pressure (resource consumption) are both equal to 100%, b) GDP growth and anthropogenic pressure (natural resource consumption) are greater than 100%, c) GDP growth and anthropogenic pressure (natural resource consumption) are less than 100%.

There are also eight logical levels of the decoupling index. Thus, the GDP growth rate and the indicator of anthropogenic pressure on the environment (or the amount of consumed resource) can be coupled, decoupled, or negatively decoupled. These values will be coupled if the value of the decoupling index is in the range from 0.8 to 1.2. Such a relationship between the indicators can be positive or negative, so depending on this, expansive coupling and recessive coupling are distinguished (Tapio P., 2005).

Figure 2. Degrees of decoupling index



Source: (Tur, O.M., 2012)

The decoupling index should be divided into three subcategories:

- weak decoupling, when GDP growth outpaces the growth rate of environmental pressure (0 < Decoupling Index < 0.8);

- strong decoupling - is observed when GDP growth is increasing and environmental pressure is decreasing (Decoupling Index < 0);

- recessive decoupling - when the GDP and environmental pressure rates are decreasing (Decoupling Index > 1.2).

Similarly, negative decoupling includes three subcategories:

- Expansive negative decoupling, when GDP growth and environmental pressure are increasing (Decoupling Index > 1.2);

- strong negative decoupling - is observed when GDP growth is decreasing and environmental pressure is increasing (Decoupling Index < 0);

- weak negative decoupling - occurs when both indicators decrease simultaneously (0 < Decoupling Index < 0.8).

Another method we will use to assess the decoupling effect is to determine the correlation between national production and environmental emissions. The multivariate linear regression model is the most common type of dependence between indicators. This process of constructing mathematical dependencies between a factor attribute and a dependent variable allows not only to determine the existing close relationship between these indicators, but also to predict one variable (y) based on other variables (x). Thus, regression analysis allows you to draw reasoned conclusions about the development of a given economic process, based on and supported by specific mathematical calculations.

The simplest form is linear multivariate regression, which describes a linear relationship between the data under study:

$$Y=a_0+a_1 x_1+...+a_n x_n \quad (4)$$

Where y is the dependent variable, function;

a_0, a_n - regression coefficients;

x_1, x_n - dependent variables.

In this case, GDP was chosen as the resultant indicator, and the following indicators of anthropogenic impact were chosen as factor variables:

x_1 - emissions of pollutants into the atmosphere, thousand tons;

x_2 - wastewater discharge (discharge), million m3;

x_3 - generation of hazardous waste of I-III categories, thousand tons;

x_4 - fresh water consumption, million m3;

x_5 - volume of waste disposal of hazard classes I-IV, thousand tons.

x_6 - volume of mineral resources extraction, thousand tons

To characterize the closeness of the relationship between the selected indicators, a linear correlation coefficient is used, which takes values from +1 to -1. A positive value of the correlation coefficient indicates a direct relationship between X and Y, and a negative value indicates an inverse relationship.

5. CUSTOMER CHURN MODELING RESULTS

It is known that the level of each economic indicator is formed under the influence of many factors and conditions, and depending on the combi**T**nation of these conditions, the value of the indicator changes. Correlation analysis is used to study the relationships between indicators that are stochastic in nature. Let's calculate the correlation coefficient. The results of the calculations are presented in Table 1.

A positive correlation coefficient ($r > 0$) indicates a "direct" relationship between the attributes (i.e., one where an increase in the value of one attribute increases the value of the other attribute), and a negative correlation coefficient ($r < 0$) indicates an "inverse" relationship (i.e., one where an increase in one attribute leads to a decrease in the other attribute). The assessment of the closeness of the relationship between the studied attributes is evaluated using the Chaddock scale.

Table 1. The results of determining the decoupling effect in Ukraine for 2010-2021 based on the calculation of the correlation coefficient between GDP and indicators of anthropogenic impact on the environment

Decapping effect indicators	Correlation, r_{XY}	Communication
$Y = 1112,78 - 0,996X_1 - 0,7402X_2 - 2,568X_3 + 1,783X_4 + 0,0162X_5 - 0,0389X_6$ Coefficient of determination R^2=0,901 – in 90,1% of cases, a change in GDP leads to a change in pollutant emissions		
1. The decoupling effect on emissions of pollutants into the air	-0,85602	close connection
2. The decoupling effect on discharged natural waters	-0,82774	close connection
3. The decoupling effect on hazardous waste generation	-0,87011	close connection
4. The decoupling effect on the use of fresh water	-0,80511	close connection
5. The decoupling effect on waste utilization	-0,8063	close connection
6. The decoupling effect on the extraction of mineral resources	-0,83702	close connection

Source: compiled by the author based on own calculations

The calculation of the decoupling effect in Ukraine for 2010-2021, based on the calculation of the correlation between GDP and indicators of anthropogenic impact (Table 1), shows the presence of the decoupling effect during the study period.

Further calculations will be carried out in accordance with the approach to calculating the decoupling factor described above.

Table 2. Indicators of the decoupling factor in Ukraine for 2010-2021[1]

Indexes	Years										
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Indicators of decoupling by environmental impact factors											
Decoupling factor for the formation of hazardous waste	0,022	0,132	0,167	0,255	0,316	0,347	0,350	0,378	0,422	0,476	0,515
Decoupling factor for emissions of pollutants	0,062	0,156	0,214	0,247	0,308	0,301	0,406	0,354	0,380	0,448	0,453
Decoupling factor for discharged natural waters	0,212	0,327	0,454	0,504	0,573	0,546	0,553	0,544	0,626	0,666	1
Decoupling factor for extraction of mineral resources	*-0,416*	*-0,265*	*-0,197*	0,0267	0,1964	0,1657	0,203	0,202	0,2689	0,334	-
Integral decoupling factor	**0,757**	**0,867**	**0,911**	**0,937**	**0,9589**	**0,956**	**0,9665**	**0,963**	**0,9769**	**0,986**	**0,926**
Indicators of decoupling by resource factors											
Decoupling factor for the use of fresh water	0,025	0,090	0,149	0,174	0,267	0,259	0,284	0,243	0,299	0,350	0,405
Decoupling factor for waste disposal	*-0,007*	0,158	0,159	0,280	0,355	0,407	0,291	0,278	0,299	0,395	1
Integral decoupling factor	**1**	**0,996**	**0,993**	**0,985**	**0,968**	**0,964**	**0,972**	**0,977**	**0,972**	**0,960**	**0,872**

Source: calculated by the author based on statistical data

[1]Excluding the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and a part of temporarily occupied territories in the Donetsk and Luhansk regions.

Analyzing the data obtained, we draw the following conclusions: the integral decoupling factor for both environmental impact and resources in the period 2011-2021 in Ukraine had a positive value, which was in the range of $0 < DF < 1$, i.e. the growth rate of resource consumption or pol-

lutant emissions is lower than the rate of economic growth, which indicates relative decoupling, which shows a relatively efficient use of resources or a relatively low degree of environmental damage.

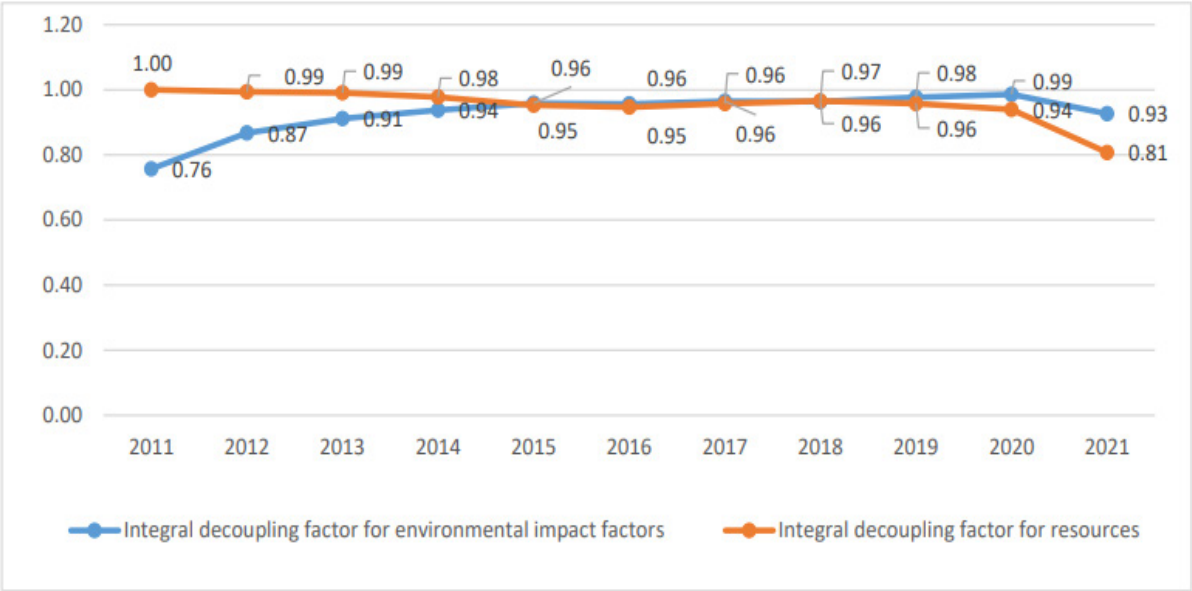
It is worth noting that the decoupling factor for mineral resources extraction in 2011-2013 and the decoupling factor for waste disposal in 2011 demonstrate a negative value, which indicates a situation where economic growth leads to a significant increase in anthropogenic pressure or depletion of natural resources.

As for the ratio of the indices of physical volume of consumed resources to the index of physical volume of GDP for the first four factors (emissions of pollutants into the atmosphere, discharge of waste water, generation of hazardous waste of I-III categories, and the volume of waste disposal of I-IV hazard classes), starting from 2013, it has been in the range of 0-0.8, i.e. we can speak of the presence of weak decoupling.

It is worth noting that the decoupling index for pollutant emissions and water discharge during 2011-2012 demonstrates an expansive relationship when GDP and environmental pressure increase.

As for the ratio of the indices of physical volume of consumed resources to the GDP index for mineral resources extraction in 2011-2013, we have a ratio of more than 1.2, which indicates the existence of recessionary decoupling, i.e. when the GDP and environmental pressure decrease.

Figure 3. Dynamics of integral decoupling factors of Ukraine by components 2011-2021



Source: constructed by authors based on results of own calculations

Let's pay attention to the dynamics of the integral decoupling factor over the entire period under study. It is worth noting a clear downward trend in the indicator throughout the period, i.e. economic growth leads to a significant increase in anthropogenic pressure or depletion of natural resources.

This situation can be explained, first of all, by the existence of still old approaches to resource use, i.e., based on the principles of sustainable development, overexploitation of natural resources, which contradict the principles that are extracted from ecosystems and processed into

products that are used frequently for a very short period of time and then returned to the environment as waste. Such a system of using exhaustible resources cannot be sustainable in the long term, especially given the scale of wastefulness observed today.

The circular economy is a model based, on the contrary, on the example of the closed cycle of substances in nature and aimed at maximizing the value of goods and raw materials that are in them at the end of their use. The transition to such a system promises not only environmental but also economic benefits by creating new jobs, saving costs, and preventing environmental pollution.

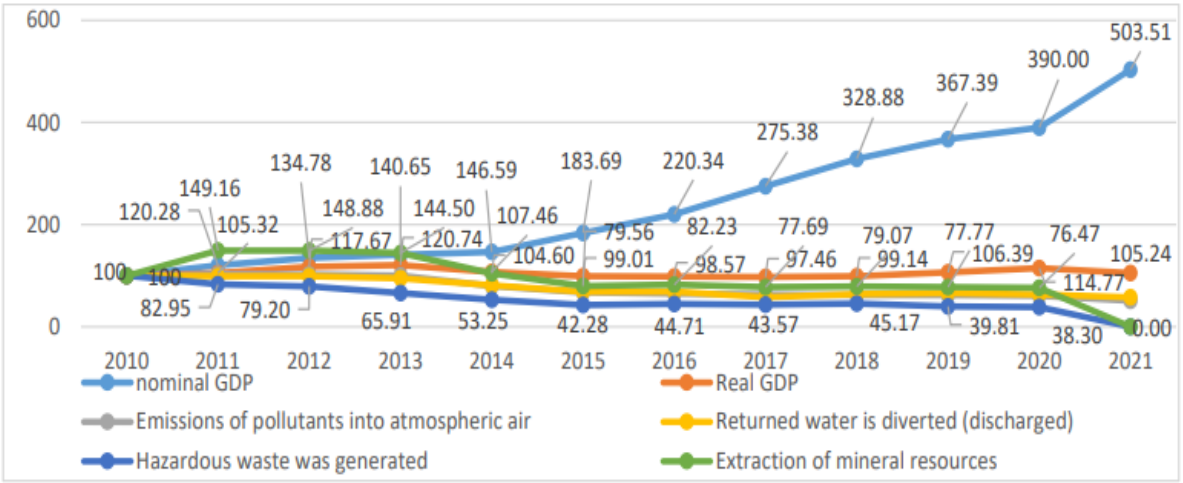
6. DISCUSSION

The article calculates the decoupling factor by the components of anthropogenic impact on the environment, namely, emissions of pollutants into the air, generation of hazardous waste of the I-III stages, discharged (discharged) waste water, fresh water use and waste disposal.

To determine the decoupling effect, the correlation between the volume of national production and environmental emissions for 2010-2021 was calculated using the correlation coefficient.

Indicators of the decoupling factor, both in terms of individual components and the integral one in the dynamics, have shown unstable behavior in Ukraine as a whole. Against the background of positive values, certain fluctuations are observed, namely a decrease in the index throughout the entire period under study. This indicates the lack of balanced development of the state. Therefore, it is reasonable to talk only about the possibility of relative decoupling. This can be seen more clearly in Fig. 2, which shows the trend lines separately for each of the analyzed factors (nominal GDP, Real GDP, Emissions of pollutants into the atmosphere, returned water is diverted (discharged), Hazardous waste was generated).

Figure 4. Trend lines according to the main indicators of decoupling factor calculation (2010 – 100%).



Source: constructed by authors based on results of own calculations.

Based on the calculations made, it is possible to draw conclusions about the general trends of decoupling in Ukraine. It is advisable to consider that, considering more indicators of anthropogenic impact on the environment, the decoupling index may have even lower values than the calculated ones. In general, the decoupling index is a tool for determining whether countries or regions are really moving towards sustainable development.

7. CONCLUSIONS

Decoupling is an important condition for the transition to a circular economy not only for developed countries, but also for emerging economies such as Ukraine. Ukraine has a significant potential to reduce resource and energy consumption, which will reduce the negative impact on the environment and increase the sustainability of the economy as a whole.

One of the main features of decoupling in Ukraine is the significant potential for the introduction of energy-efficient technologies and reduction of energy consumption. Ukraine has significant opportunities for the development of renewable energy, in particular wind and solar energy, which will reduce dependence on imported energy resources and reduce emissions.

Ukraine can also increase the efficiency of water resources use and reduce pollutant emissions into water bodies. For example, more efficient technologies for wastewater treatment and water consumption in industry could be used.

Significant potential for decoupling also exists in the area of waste recycling and material reuse.

Ukraine has significant potential for the development of waste recycling, including attracting investment in the creation of new industries that will specialize in waste recycling and material reuse.

However, there are also certain challenges and obstacles to decoupling in Ukraine. One of the main challenges is the lack of necessary investments and funding for the introduction of new energy-efficient technologies and the creation of new waste processing facilities.

In addition, there is a rather low level of awareness among the population and businesses in Ukraine about the importance of transitioning to a circular economy and decoupling. More work needs to be done on conscious consumption and responsible behavior towards the environment.

Ukraine also faces the problem of low resource and energy efficiency in industry and construction. More work needs to be done to create new energy efficiency standards and environmental regulations in construction and industry.

A decoupling analysis should be carried out when assessing the implementation of these measures, which can be generally described as the “green” modernization of Ukraine to accelerate its transition to a circular economy. Target decoupling indicators can be used in the development of strategic plans for sustainable development of the state and regions. The calculation of decoupling indicators will allow us to assess Ukraine’s success or failure on the path to sustainable development and implementation of the circular economy.

The results of the analysis can be used in the development of management decisions in the field of environmental and economic interactions, as well as in the preparation of strategic planning documents. Comparison of the rates of economic development and environmental pollution in the context of the main types of economic activity can be useful when considering investment projects planned for implementation in the country, including initiatives involving foreign investment. In order to achieve the decoupling effect for certain types of negative environmental impacts, a set of measures is needed to improve the environmental protection mechanism (increasing the rates of payments for negative impacts, restoring the targeted nature of their use, etc.

Thus, decoupling is an important condition for the transition to a circular economy in Ukraine. This requires efforts to increase energy efficiency, use renewable energy sources, recycle waste,

and reduce pollutant emissions. However, in order to achieve these goals, it is necessary to develop the investment environment, attract investments, and do more work on conscious consumption and environmental education of the population and businesses.

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IMPACT OF INTELLECTUAL CAPITAL AND RISK ATTITUDE THROUGH FINANCIAL LITERACY ON BUSINESS SUSTAINABILITY IN INDONESIA BATIK SMES

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ABSTRACT

This study aims to create a theoretical model of business sustainability with financial literacy antecedents. The antecedents of financial literacy are intellectual capital and risk attitudes. The research location is in the province of East Java, Indonesia. Batik SMEs are only found in Indonesia because it is a cultural heritage belonging to Indonesia that does not exist in other countries. The sampling technique used was purposive sampling, with 222 respondents from the batik SMEs spread across six cities. The data was taken using a questionnaire on a Likert scale. Data analysis uses SEM (structural equation modeling) with the SmartPLS application. The study results show that risk attitudes toward financial literacy have a positive effect. The effect of financial literacy on the business sustainability of the batik industry has a positive influence. The impact of intellectual capital on the business sustainability of the batik industry has a positive effect. Risk attitudes have no significant positive impact on business sustainability. Financial literacy has yet to be able to mediate intellectual capital's influence on the batik SME's business sustainability. This needs to be explored further with further research. Furthermore, financial literacy can mediate risk attitudes towards the business sustainability of batik SMEs.

Keywords: *Financial literacy, business sustainability, intellectual capital, risk attitudes, batik SMEs*

1. INTRODUCTION

Indonesia is one of the developing countries whose economy is supported by creative SMEs (Raharja & Kostini, 2021). Many creative SMEs have sprung up because they are the newest economic concept that promotes creativity and information (Srikalimah et al., 2020; Boğa & Topcu, 2020). Likewise, Indonesia has creative SMEs, especially batik SMEs (Rahayu et al., 2023); see Table 1. Indonesia is the only place for batik SMEs globally because batik was selected as a cultural heritage of Indonesia on October 2, 2009, by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) and the World Education, Science, and Culture Organization (Citradika et al., 2019a; Nugroho et al., 2022). Indonesia has a batik textile art with a distinctive character that does not exist in other countries. Batik SMEs are heavily influenced by their history and culture (Tanziha et al., 2022).

Business sustainability is an essential factor that SMEs must have (Qianwei Ying et al., 2019). Previous studies tried to examine creativity as a driver of business sustainability in SMEs (Srikalimah et al., 2020). This study provides recommendations for further studying intellectual

capital. Apart from that, financial performance still leaves gaps for SMEs in Indonesia; uncertainty impacts funding sources, which causes SMEs to grow and even go bankrupt (Purba et al., 2021). In 2020 the world experienced the Covid-19 pandemic, which affected the condition of creative SMEs, one of which was batik SMEs (Patma et al., 2021). The development of batik SMEs still needs help with business sustainability, financial literacy, human resources, and the risk of failure (Garba, 2021). For batik SMEs in Indonesia to rise quickly, it is necessary to study the theoretical model of business sustainability in batik SMEs.

Table 1. Number of Batik SMEs in Indonesia

Province	Small & Medium Scale	Large Scale	Total
Central Java	821	108	929
East Java	89	40	129
West Java	65	23	88
Bali	62	3	65
Yogyakarta	49	12	61
Banten	27	16	43
Jambi	16	3	19
Bangka Belitung	3	1	4
West Sumatera	2	2	4
Jakarta	4	-	4
North Sumatera	4	-	4
East Kalimantan	3	-	3
Riau	3	-	3
Bengkulu	2	-	2
South Kalimantan	1	-	1
Lampung	1	-	1
Maluku	1	-	1
North Maluku	1	-	1
West Nusa Tenggara	1	-	1
South Sulawesi	1	-	1

Source: Indonesian Ministry of Trade, 2023

Intangible resources are needed to develop batik SMEs in Indonesia (Isa et al., 2023). Intangible resources like the ability to think, be sensitive to opportunity, communicate, and have other skills to pursue a business are essential to the perpetrators of batik SMEs (Sarjiyanto et al., 2023). The importance of business transaction recording, profitability planning, working capital management, and financial report analysis preparation should be the responsibility of batik SMEs (Ambarriani & Purwanugraha, 2012). Understanding of financial analysis is believed to be very minimal among SME batik managers (Siregar et al., 2020). Financial decision-making tends to be done spontaneously (Rita & Huruta, 2020). From the above explanation, research on financial literacy and business sustainability of creative industry efforts focusing on batik SMEs still needs to be more specific and done better.

The main objective of this study is to investigate how intellectual capital and risk tolerance affect financial literacy and how that affects the sustainability of Batik SMEs in Indonesia. This theoretical framework on managing money with a strong knowledge that making the correct choices would help a company expand is anticipated to become an empirical truth. Intellectual capital is one of the characteristics examined since it influences business performance more than natural resources do. Another issue that has to be studied is risk attitudes, which is seen to

be crucial in enabling Batik SMEs to adjust to the environment's quick and unexpected changes.

This article is organized as follows. First, the research problem is provided (section 1). Second, a brief overview of the literature review (section 2). Third, the methodological strategy applied is described (section 3). Fourth, the results obtained from the data analysis are described (section 4). Fifth, the results of the discussion are explained (section 5). Furthermore, finally, conclusions are presented (section 6).

2. LITERATURE REVIEW

According to Gross-Gołacka et al. (2020), business sustainability integrates social, economic, and environmental principles into a business model. Fulfilling economic, social, and ecological goals will increase the competitiveness of a business. Meanwhile, according to Muslimat et al. (2020)business sustainability is a form of consistency from business conditions, including growth, development, and strategies to maintain business sustainability, which all lead to business sustainability and existence. According to Jayashree et al. (2021)it will be very difficult for SMEs' performance to improve and impossible for them to reach their sustainability goals. Small businesses should therefore be encouraged to embrace the next technological frontier, Industry 4.0 (I4.0, business sustainability in SMEs can be seen from the company's success in innovating, managing employees and customers, and returning their initial capital. Even though business sustainability is closely related to companies, business continuity can also be applied to creative industries. A business will do well when it can create value from a financial perspective, such as profit, and a non-financial perspective, such as the environment and social responsibility.

Business sustainability is the ability of a business to continue running its business (Cagnin et al., 2013;Ciceri et al., 2010). The sustainability businesses of Batik SMEs are influenced by the financial capital they have in order to survive and avoid business closures (Raharjo, 2019). One of the steps to obtaining financial capital is financial inclusion in the form of easy access to funding to help creative industries survive. Financial literacy is defined by Noctor et al. (1992) as the ability to make appropriate judgments and effective decisions regarding the use and management of money. According to Marcolin & Abraham (2006), financial literacy is urgently needed along with financial market regulations and easier access to loans to financial institutions, the rapid growth of financial products, and encouragement from the government. According to Huston (2010), financial literacy is grouped into four, namely: 1) the basics of money (time value of money, purchasing power, personal financial accounting concepts), 2) loans (use of credit cards, consumer loans, or mortgages), 3) investments (savings, stocks, bonds or mutual funds), and 4) protection (insurance).

Then some researchers like Thabet et al. (2019) and Rahim & Balan (2020) simplifies the construct of financial literacy into three, namely: financial knowledge (financial knowledge), financial attitude (attitude financial), and financial behavior (behavior financial). Then according to Eniola & Entebang (2017) financial literacy is divided into knowledge, attitude, and awareness. Financial knowledge is an ability that is obtained from the process of learning to manage income, expenses, and savings. Financial attitudes combine concepts, information, and emotions, resulting in a readiness to respond positively about finances. Meanwhile, financial behavior is the essence of financial literacy.

Financial literacy is an important thing that must be possessed by creative industry players (Alharbi, 2021). Financial literacy helps Batik SMEs to make better financial decisions regarding sources of financing and capital structure for their businesses (Citradika et al., 2019b). Financial literacy is believed to maintain business sustainability. Even more so with financial literacy

for the SMEs. One that supports business sustainability in Batik SMEs is financial literacy. The fact is that Batik SMEs initially developed but, over time, have yet to be able to survive due to not managing their finances properly. This can happen because Batik SMEs tend to use spontaneity when making financial decisions since they don't understand how to record transactions, track income and costs, plan for profitability, and manage working capital.

Besides financial literacy, there is also the intellectual capital needed for SMEs (Ying et al., 2019; Khan et al., 2021). The Resource-Based View (RBV) theory states that unique, rare, and unchanging resources enable businesses to achieve business continuity (Barney, 1991). Intellectual capital is knowledge, information, intellectual property, and experience that can be used to create value for a business (Stewart, 1997). Intellectual capital is one of the keys to business sustainability. Intellectual capital is an intangible resource that can realize business sustainability in Batik SMEs. Intellectual capital that is well-managed can increase business sustainability. It has become a general discussion that creative industries face limited resources, including intellectual ones.

According to Stewart (1997), intellectual capital includes knowledge, information, intellectual property, and experience that can be used to create value for the company. According to Sullivan (2000), intellectual capital is knowledge owned by a company that can provide real benefits for the company. From the definitions above, intellectual capital is a change in the traditional concept of company capital and is an intangible asset that can create value for the company. According to Kaplan & Norton (1996), intellectual capital contributes more than 75% to firm value, while physical capital and money contribute less than 25%.

Researchers from various disciplines, such as accounting, economics, finance, strategy, human resources, and psychology, have different models for measuring intellectual capital. Stewart (1997) introduced intellectual capital consisting of three components: human capital, structured capital, and relational capital. In comparison, Pulic (2000) explained the Value Added Intellectual Coefficient (VAIC) model using data from financial reports, dividing intellectual capital into human, customer, and structure capital. In comparison, Khalique et al. (2015); Stanivuk (2015) and Ying et al. (2019)\"Should one either invest in tangible resources or intangible resources/capabilities?\" is still fragmented. In prior studies, more emphasis is given to tangible resources, while intangible resources have comparatively received minor attention, despite their significant role in the success of small and medium enterprises (SMEs used human capital, customer capital, structural capital, social capital, and technological capital for SMEs in Pakistan. Then Supeno et al. (2015) used human capital, structural capital, and relational capital in the creative industries in Indonesia. Likewise, Dabić (2019) uses human capital, structural capital, and relational capital in SMEs in Croatia. Asyik et al. (2022)such as Indonesia. The number of samples are use 500 respondents. The analysis method uses the Partial Least Square (PLS use curiosity and motivation, experience, innovation and creativity, and competency ability.

Intellectual capital is capital owned by business organizations in the form of skills, intelligence, and mastery of tools for business excellence (Stanivuk, 2015). Research conducted by Ying et al. (2019)\"Should one either invest in tangible resources or intangible resources/capabilities?\" is still fragmented. In prior studies, more emphasis is given to tangible resources, while intangible resources have comparatively received minor attention, despite their significant role in the success of small and medium enterprises (SMEs and Khan et al. (2021) emphasized the influence of intellectual capital on the sustainability of SME businesses. Based on empirical studies conducted on the case of creative industries in Indonesia, the three capitals can be adopted, namely a) Human Capital, b) Organizational Capital, and c) Information Capital. Human capital is company capital in the form of employee ownership with the required level of

mastery of competencies, loyalty, and attitude in developing the company. This human capital is temporary. Its situation is very dependent on the atmosphere and organizational environment of the company, as well as the internal factors of the workers themselves (Supeno et al., 2015).

Organizational capital, not only in the structural realm, is capital for creative industry organizations but also for organizational culture. Both encourage the creation of conditions, inspiration, and opportunities to develop the company's potential in achieving its goals. Internal organizational capital is needed to develop the organization. However, organizational capital can also provide value for external parties to generate trust, involvement, and loyalty to the activities carried out by the organization (C. Jardon, 2014; C M Jardon, 2015; Carlos M. Jardon & Martos, 2012)formed by small to medium-sized enterprises (SMEs.

Information capital is ownership of a collection of data, information, and network systems integrated into the organizational structure to support personnel, optimize work processes, and contribute to the creation of accelerated decision systems. Information capital reaches beyond customers but also customers, work partners, and other members of stakeholders (C. Jardon, 2014; C M Jardon, 2015; Carlos M. Jardon & Martos, 2012)formed by small to medium-sized enterprises (SMEs. Apart from intellectual capital, which is believed to be able to maintain business sustainability, what is no less important is the risk attitude possessed by Batik SMEs (Redha et al., 2021). A weak risk attitude makes it difficult for creative industries to adapt to changes in the environment that are so fast and uncertain.

Risk attitude is a preferred response to the perception of uncertainty (Hillson & Murray-Webster, 2007). However, the attitude of risk requires a long time to be implemented in the creative industry. Often interpreting risk attitudes is only a perception to comply with existing legal or statutory regulations. Even though the attitude of risk is broader than that meaning. Awareness regarding risk attitudes still needs to be increased in Batik SMEs.

According to Mittone et al. (2022) the risk is the result or deviation from the realization of plans that may occur unexpectedly. Even though an activity has been planned as well as possible, it still contains uncertainties. According to Li et al. (2022), risks can happen anywhere, anytime, and to anyone. Riyanto et al. (2021) explains that one of the abilities that batik industry players must possess is being able to face risks. Batik SMEs players need to measure risk so that decisions are taken result from careful thought. Then batik industry players need to know any risks that can cause failure for their business. This knowledge can be obtained from participating in training and being open about the business conditions in which they are involved. Risks can cause losses caused by human error or natural factors. So that the risk does not turn into a loss, the risk needs to be appropriately managed. According to Moeuf et al. (2020), there are four risks faced by the SMEs in the 4.0 industrial revolution, namely 1) the first risk, lack of expertise in the batik industry; 2) the second risk, short-term strategy in the batik industry; 3) the third risk, the speed of technology improvement; and 4) fourth risk, fear of employees who perceive industry 4.0 as a means to increase supervision of their work.

Based on a review of the above literature, business sustainability is a concept in SMEs that can combine economic, social, and environmental objectives. Such a combination is complex and requires the help of intangible resources owned by managers or SME owners, such as financial literacy, intellectual capital, and risk attitudes. Financial literacy means assessing and making effective and efficient financial decisions regarding where SME capital is obtained and how to manage it properly. Intellectual capital is information and intellectual property owned by managers or owners of SMEs that can create added value for SMEs. Risk attitude is how SME managers and owners respond with the best choices regarding the uncertainty and opportunities they face. This research seeks to provide empirical evidence that intellectual capital, risk

attitudes, and financial literacy are necessary for the business sustainability of Batik SMEs in Indonesia. In addition, there is financial literacy, which becomes a variable that mediates intellectual capital and risk attitudes towards the business sustainability of Batik SMEs in Indonesia.

3. METHODS

3. 1. DATA SOURCES

This study uses a quantitative approach based on positivism, namely a research method based on the assumption that a symptom can be classified and the relationship between symptoms is causal. The research strategy used was a survey with a questionnaire to obtain data about opinions, characteristics, behavior, and relationship variables and to test several hypotheses (Saunders et al., 2009). The research was conducted from March 2023 to July 2023 at the Batik SMEs in Indonesia. Population is a generalized area consisting of objects/subjects with specific qualities and characteristics determined by the researcher. The sample is part of the number and characteristics of the population. This study used a population of 522 batik SMEs in East Java province, Indonesia. The sampling technique uses non-probability sampling, meaning it does not provide equal opportunities or opportunities for sample population members. It uses a sampling technique, namely purposive sampling, namely a sampling technique by determining the target of the population that is estimated to be the most suitable for collecting data. Criteria that Batik SMEs must meet have a turnover/gross income of more than 300 million a year and a minimum business length of 5 years (Aryani et al., 2020). Then, the study was conducted on 222 samples of the batik SMEs in East Java province, Indonesia.

The type of data used in this research is primary data. Primary data is data collected by researchers directly from the first source. Data collection in this study used a questionnaire (questionnaire), a data collection technique that is carried out by giving respondents a set of questions or written statements to answer. This study uses a questionnaire because it is suitable for many respondents and is spread over a large area. Data was taken using a questionnaire using a Likert scale. Data analysis uses the SEM (structural equation modelling) with the SmartPLS application. Data analysis in PLS is divided into 2, namely, Structural Model Analysis (Outer Model) which explains the validity and reliability of the relationship between indicators and variables. Analysis of the Equation Model (Inner Model), which explains the correlation between variables (hypothesis) (J. Hair et al., 2014). The PLS technique influences abnormal data in accordance with the central limit theorem; consequently, PLS-SEM is not overly stringent when working with abnormal data (J. F. Hair et al., 2019).

3. 2. DEFINING VARIABLES

Financial literacy uses indicators from Adomako & Danso (2014) and Sohilauw & Nohong (2020), then business sustainability uses needles from Cagnin et al. (2013) and Patma et al. (2021) for intellectual capital using hands from Ying et al. (2019) and Khan et al. (2021). Meanwhile, risk attitude uses indicators from Redha et al. (2021) and Pratono (2018).

Table 2. Variable Operational Definitions

	Indicators	References
Financial Literacy (FL)		
FL1	Separation of assets, liabilities, income and expenses between personal and business.	(Adomako & Danso, 2014; Sohilauw & Nohong, 2020)
FL2	The use of a financial report program, even though it is as simple as Excel.	
FL3	Recording of every Batik SMEs transaction.	
FL4	I am making financial reports periodically.	
FL5	Preparation of true and accurate financial reports.	
FL6	Financial reports are made helpful in decision-making.	
Business Sustainability (BS)		
BS1	I can create new jobs.	(Cagnin et al., 2013; Patma et al., 2021)
BS2	I maintain environmental sustainability.	
BS3	I can develop local culture and wisdom.	
BS4	I can harmonize economic, environmental and social activities.	
BS5	I generate profits and business growth.	
BS6	The business that I make has an institution.	
Intellectual Capital (IC)		
IC1	I have competence according to the field.	(Khan et al., .2021; Ying et al., 2019)
IC2	I have loyalty and attitude.	
IC3	I can communicate and have extensive knowledge.	
IC4	I have good relationships with customers, partners and governments.	
Risk Attitude (RA)		
RA1	I set aside some business income just in case.	(Redha et al., 2021; Pratono, 2018)
RA2	I develop standard safe work procedures.	
RA3	I comply with government regulations and applicable laws.	
RA4	I cooperate with other parties in terms of the availability of raw materials.	
RA5	I have knowledge about insurance.	
RA6	I do not delay paying debts to the bank.	

Source: constructed by authors

3. 3. RESEARCH HYPOTHESIS

Intellectual capital is the knowledge that provides information about a company's intangible value that can affect the company's resilience and competitive advantage to achieve added value to financial performance. Meanwhile, Choo & Bontis (2002) explained that intellectual capital represents existing knowledge in an organization at a particular time. The company's intellectual capital consists of human resources, structure, organizational routines, intellectual property, and the relationship between the company and its customers, suppliers, distributors, and partners.

Meanwhile, financial literacy is an essential issue in the world. Several countries worldwide are even very focused on financial literacy and include it in their strategic programs, such as the United States, United Kingdom, Australia, Canada, Japan, Singapore, and Malaysia. According to Kirsten (2013), financial management skills or abilities are needed for SME owners to manage a business to survive and continue to grow. One form of capacity building is training

in financial management for business. Resource Based View (RBV) Theory is very relevant to explain the effect of intellectual capital on financial literacy. The batik industry hopes to have financial literacy skills because this ability is a resource that is scarce, difficult to imitate, and irreplaceable. This hypothesis is supported by the results of research conducted by Asyik et al. (2022)such as Indonesia. The number of samples are use 500 respondents. The analysis method uses the Partial Least Square (PLS, which showed an influence between intellectual capital and financial literacy.

H1. Intellectual Capital has a positive effect on Financial Literacy.

Currently, SMEs are faced with various uncertain conditions, such as the Covid-19 pandemic which has passed which has resulted in an increased risk of failure or bankruptcy for SMEs (Resmi et al., 2021). The inability to manage risk and the lack of financial skills training make SMEs focus only on short-term goals rather than long-term ones (Buchdadi et al., 2020)the purpose of this study was to examine the determinant variable of the SMEs performance namely financial literacy of the manager. This study utilize acces to financial product and financial risk risk attitude as the mediation variables. This type of research uses a quantitative approach and the structural equation modeling (SEM. For this reason, a risk attitude is needed in every business by identifying and managing risks as early as possible (K. Kulathunga et al., 2019)in the growing literature of SMEs management, inadequate consideration has been devoted on the financial literacy of the SMEs, and the mechanisms through which it impacts on SMEs performances. Drawing upon knowledge-based view and dual process theory, we tested the impact of financial literacy and risk attitude on SMEs performances in an integrated model. The sample included 244 chief financial officers of SMEs in three provinces of Sri Lanka (Central, Western and Southern provinces. Risk attitude will increase the understanding of financial literacy for managers such as bookkeeping, financial statement analysis, investment management, and matters relevant to business finance.

The influence of risk attitudes on financial literacy is based on TRA (Theory of reasoned action) and TPB (Theory of planned behavior) initiated by Ajzen in 1985. TRA emphasizes the critical role of intention as a determinant of behavior. Meanwhile, TPB is an extension of TRA which explains that in addition to the intention that determines the behavior, it is also influenced by the perception (perceived) owned by a person. TPB explains that individuals are pretty rational, use available information, and consider the consequences of their actions before deciding whether to follow a behavior. This theory explains that the theory of planned behavior relates to the relationship between beliefs and behavior. This theory states that attitudes toward behavior, subjective norms, and perceptions of behavior control together form individual behavioral intentions. Based on this theory, the authors assume that the stronger the risk attitude, the greater the financial literacy. This hypothesis is supported by the results of research conducted by Mabula & Ping (2018)Small and Medium Enterprises (SMEs that the risk attitude of SME managers will improve their level of financial literacy. Likewise, the study by Kulathunga et al. (2020)the influence of techno-finance literacy in the development of SMEs is still not adequately researched. Drawing upon KBV, we developed a single-mediator structural model with an aim to explore the effect of techno-finance literacy and enterprise risk management (ERM, Nohong et al. (2019), and Sohilauw et al. (2020) state that a higher-risk attitude will increase financial literacy.

H2. Risk attitude has a positive effect on Financial Literacy.

As the largest mover of the informal sector in Indonesia with the most significant number of workers absorbed, SMEs have an essential role in the economic system. According to Cole et al. (2011), the fastest way to drive the economy in emerging markets is to focus on the devel-

opment of the informal sector (SMEs), which will impact increasing the income level of the middle class. In this case, SMEs with sound financial literacy can achieve their company goals, have a business development orientation, and survive in challenging economic conditions. Business sustainability in SMEs can be seen from the company's success in innovating, managing employees and customers, and returning their initial capital. This shows that the company is oriented to development and continuously sees opportunities for innovation (Hudson et al., 2001). Financial literacy is needed to manage and make effective decisions regarding financial handling, such as budgeting, bookkeeping, paying bills and utilities, acquiring and repaying loans, and other financial decisions (Adomako & Danso, 2014).

With sound financial literacy, entrepreneurs can use their financial skills to make the right decisions for their companies (Muraga & John, 2015). SME owners/managers are closely related to making complex and strategic financial decisions related to the success of achieving goals and business sustainability (Drexler et al., 2014). The RBV (Resource-based-view) explains that financial literacy is a unique, rare, and unchanging resource that enables businesses to achieve business continuity. Several research results show that financial literacy affects the performance of SMEs (Dahmen & Rodríguez, 2014; Chepngetich, 2016; Ngek, 2016). This relationship is logically applied to companies that, with good financial literacy, can strategically identify and respond to changes in the business, economic and financial climate so that the decisions are well directed towards business sustainability.

H3. Financial Literacy has a positive effect on Business Sustainability.

SMEs need more resources. However, these conditions were not an obstacle to the development of his business. The sustainability of SMEs must be oriented toward management skills and human resource strategies to compete in the global market (Styaningrum et al., 2020). One resource that can be maximized is intellectual capital (Ying et al., 2019). Several studies in developed countries such as England, America, and Sweden and developing countries such as Malaysia prove that intellectual capital positively affects business performance (Khalique et al., 2015).

An emphasis on intellectual capital owned by managers will affect the performance of SMEs (Khan et al., 2021). The combination of human capital, structural capital, and relational capital influences the performance of SMEs (Sardo, 2018). Research by Ullah et al. (2021) offers a new concept called Green Intellectual Capital which affects the sustainability of SME businesses in Pakistan. Green Intellectual Capital is the overall intangible assets, relationships, knowledge, and capacities of an organization that are applied to maintain the organizational environment. Based on the Knowledge-Based View (KBV) theory, the batik creative industry is expected to be able to manage and utilize intellectual capital to improve business sustainability properly. This business's sustainability will spur the batik industry's added value in competing and meeting customer needs.

H4. Intellectual Capital has a positive effect on Business Sustainability.

The risk attitude allows SMEs to identify opportunities and risks related to business continuity. Gärling et al. (2009) found risk attitude as a significant factor affecting the business continuity process. Thus the attitude towards risk-taking plays an essential role in the sustainability of SME businesses. Many studies have attempted to provide empirical evidence about the impact of risk attitudes on the sustainability of SME businesses. Empirically, K. Kulathunga et al. (2019)in the growing literature of SMEs management, inadequate consideration has been devoted on the financial literacy of the SMEs, and the mechanisms through which it impacts on SMEs performances. Drawing upon knowledge-based view and dual process theory, we tested the impact of financial literacy and risk attitude on SMEs performances in an integrated model. The sample

included 244 chief financial officers of SMEs in three provinces of Sri Lanka (Central, Western and Southern provinces show that risk attitudes positively affect SME performance. Kortana (2019) examines strategic risk, financial risk, operational risk, and compliance risk that have a positive effect on SME business performance. Agyapong (2020) did the same about market, operational, financial, and technology risks, which positively affect SME performance.

In Knowledge Based-View Theory (KBV), companies can rely on knowledge as a strategic resource to rise in competition among competitors. The basic tenet of KBV is that knowledge is a uniquely valuable asset in that it is not easily lost and difficult for competitors to copy, giving organizations that acquire knowledge assets an advantage over those that do not. Risk Attitude is seen as an intellectual asset that can drive business sustainability. The study's results Jalali et al. (2020) found that risk-taking positively affects SME performance. SME actors must become risk-takers to perform better by allocating resources for risky strategies and actions with precise results.

H5. Risk attitude has a positive effect on Business Sustainability.

Gross-Gołacka et al. (2020) explains that the sustainability of SME businesses in Poland is determined by the intellectual capital of human resources with skills and a high level of knowledge. Then concerning SMEs in Indonesia, it shows that there is a clear relationship between intellectual capital, financial literacy, and SME business sustainability, as was done by Arum (2021) and Nuryakin et al. (2021)Central Java. The analysis unit is conducted with the owners or manager of export based brass industry in Central Java. The collection of data for this research was done by the use of purposive sampling. This study takes 200 respondents as its sample. The structural equation modelling (SEM that when SME business actors have good level of financial literacy, they tend to be able to manage their business finances better and can recognize and access financial resources so that they are expected to be able to maintain the continuity of their business.

Asyik et al. (2022) explained that intellectual capital can affect financial literacy. SME actors with sound financial literacy are determined from the intellectual development of business actors obtained from the learning process or training provided by the government and educational institutions. The same thing was also obtained by Nur Hamidah et al. (2020) and Sudewi & Dewi (2022) that intellectual capital and financial literacy can improve the sustainability of SME businesses in Indonesia with existing resources through optimally empowering intellectual capital and managing finances by increasing understanding of financial literacy.

H6. Financial Literacy mediates the effect of Intellectual Capital on Business Sustainability.

Research conducted by Kortana (2019) suggests that the government should participate in activities to increase understanding of risk management for SME performance. Risk management, such as strategic risk, financial risk, operational risk, and legal compliance risk, accounts for 60% of the performance of SMEs in Thailand. Glowka et al. (2021) explained that SME activities that involve family involvement in them would reduce the performance of these SMEs, so one solution is to implement risk management.

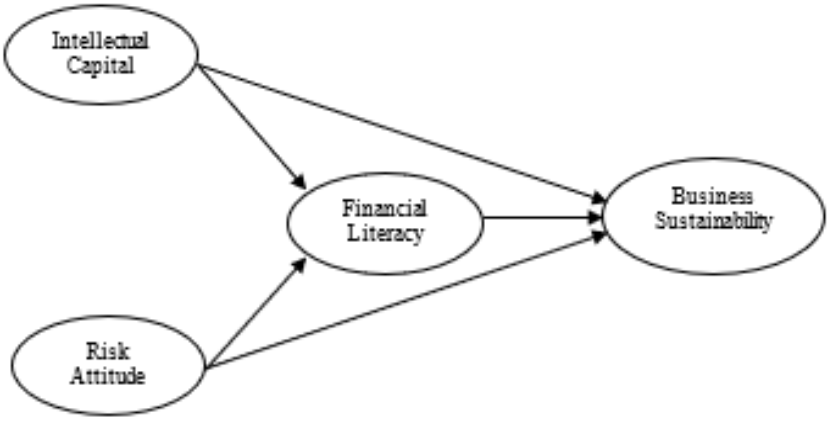
Several studies combining risk attitudes, financial literacy, and SME business continuity were conducted by Buchdadi et al. (2020)the purpose of this study was to examine the determinant variable of the SMEs performance namely financial literacy of the manager. This study utilize acces to financial product and financial risk risk attitude as the mediation variables. This type of research uses a quantitative approach and the structural equation modeling (SEM and Mabula & Ping (2018)Small and Medium Enterprises (SMEs. Research by Buchdadi et al. (2020)the purpose of this study was to examine the determinant variable of the SMEs performance name-

ly financial literacy of the manager. This study utilize acces to financial product and financial risk risk attitude as the mediation variables. This type of research uses a quantitative approach and the structural equation modeling (SEM explain that SMEs with a higher level of financial literacy can manage risk attitudes efficiently so that SMEs can face problems and make the right decisions in running their business. The same thing was also revealed by Mabula & Ping (2018) Small and Medium Enterprises (SMEs that business sustainability is vulnerable to internal and external changes. This research also offers insurance as part of risk management. SME actors who know about financial literacy, especially in risk management, can objectively evaluate their actions. Risk management is considered an integral part of individual and corporate financial literacy.

H7. Financial Literacy mediates the influence of Risk Attitudes on Business Sustainability.

Based on this explanation, a research model was created to be analyzed in Figure 1 and the hypothesis.

Figure 1. Research Model



Source: created by the authors

4. RESULTS

222 samples were acquired based on the dissemination of questionnaires to business actors in the creative batik sector. Table 3 below shows the demographic information for the respondents, which reveals that most of them are female, between the ages of 31 and 40, with a high school diploma, less than five years in business, one to four employees, and annual sales of less than IDR 100,000,000.

Table 3. Description of Respondents

Description		Amount	%
Age	20-30 years	62	27,8
	31-40 years	136	61,1
	> 40 years	24	0,11
Gender	Male	86	38,9
	Female	136	61,1
Education	Senior High School	191	86,1
	College	31	13,9
City	Kediri	18	8,11
	Tulungagung	58	26,13
	Blitar	30	13,51
	Madiun	20	9,00
	Mojokerto	19	8,56
	Malang	77	34,69
Business Age	< 5 years	136	61,1
	5-10 years	24	11,1
	>10 years	62	27,8
Number of employees	1-4 employees	154	69,4
	5-19 employees	61	27,7
	> 20 employees	7	2,9
Sales	< IDR. 100.000.000	154	69,4
	IDR. 100.000.000-IDR. 300.000.000	68	30,6

Source: constructed by authors based on result of model development

The validity and reliability of the indicators are used in structural model analysis to gauge how strongly an indicator reflects its relationship with variables. Two tests—convergent validity and discriminant validity—are used to assess a construct's validity. For the convergent validity test, the loading factor value of each variable used to generate the variable must be more than 0.6 (Fornell & Larcker, 1981; Hair et al., 2014). The benchmark used to analyze the discriminant validity test is the AVE root (AVE). If AVE > 0.6, the instrument is deemed to be genuine. As a result, the model satisfies the requirements and has enough discriminant validity (Fornell & Larcker, 1981; Hair et al., 2014). Table 3 below will summarize the convergent and discriminatory validity.

Table 4. Loading Factor and Average Variance Extracted

Indicators	Loading Factor	√AVE
Financial Literacy (FL)		
FL1	0,814	0,824
FL2	0,748	
FL3	0,886	
FL4	0,795	
FL5	0,843	
FL6	0,851	
Business Sustainability (BS)		
BS1	0,822	0,870
BS3	0,893	
BS4	0,945	
BS5	0,716	
BS6	0,954	
Intellectual Capital (IC)		
IC1	0,975	0,877
IC4	0,767	
Risk Attitude (RA)		
RA1	0,918	0,854
RA2	0,719	
RA3	0,843	
RA4	0,868	
RA6	0,908	

Source: constructed by authors based on result of model development

While two tests—the Composite Reliability test and Cronbach's alpha—can be used to assess a construct's reliability. According to the general rule, if the value of the two tests—whether it is the Composite Reliability value or the Cronbach's alpha value—is greater than 0.7, it satisfies the requirements (Fornell & Larcker, 1981; Hair et al., 2014). Therefore, it can be concluded from table 4 below that the four variables are reliable.

Table 5. Construct Reliability and Validity

Variables	Cronbach's Alpha	Composite Reliability
Financial Literacy (FL)	0,906	0,927
Business Sustainability (BS)	0,917	0,939
Intellectual Capital (IC)	0,755	0,868
Risk Attitude (RA)	0,906	0,931

Source: constructed by authors based on result of model development

The value of R square is a measure of the proportion of variable values that are influenced by the dependent (endogenous) variable and that can be explained by variables that affect the independent (exogenous) variables. The R Square value determines whether the model is good or bad. R Square value has several criteria, namely that a model with a value of 0.75 is said to be substantial (strong), a model with a value of 0.5 is said to be moderate (moderate), and a model with a value of 0.25 is said to be weak. Based on table 6, the R Square value is used to see the

influence of Intellectual Capital, Risk attitude, and Financial Literacy variables on Business sustainability, which is 0.866 or 86.6%, so this relationship is strong. While the influence of Intellectual Capital and Risk Attitudes on Financial Literacy is 0.680, or 68.0%, this relationship is moderate.

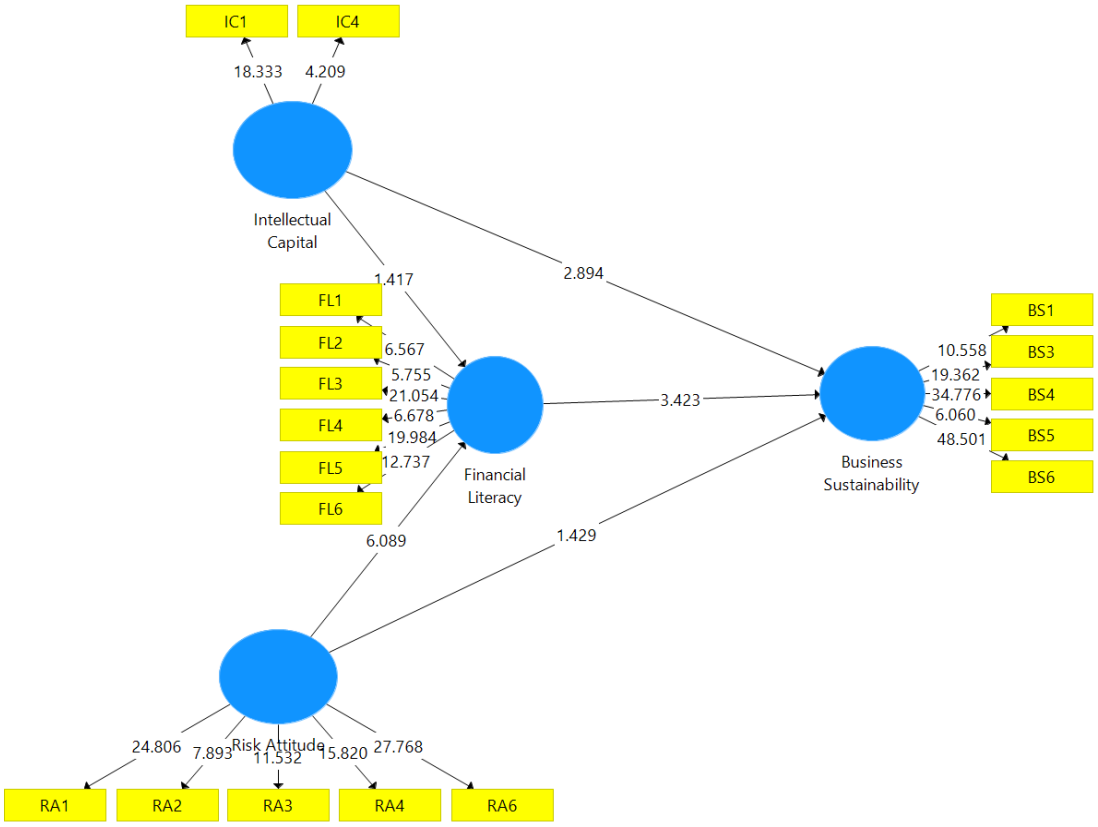
Table 6. R-Square

	R-Square
Business Sustainability	0,866
Financial Literacy	0,680

Source: constructed by authors based on result of model development

Hypothesis testing with SmartPLS 3.2 is used to see the magnitude of the structural path coefficient and the stability of the estimates, which are evaluated using the t test with the bootstrapping method shown in Figure 2 below. Testing with the bootstrapping method aims to minimize the occurrence of abnormal data. The results of the hypothesis testing using bootstrapping from the PLS analysis are presented in Table 7 below.

Figure 2. Bootstrapping



Source: constructed by authors based on result of model development

Table 7. Hypothesis Test Results

Variables corelations	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Result of Hypothesis path
Intellectual Capital (IC) -> Financial Literacy (FL)	0.224	0.256	0.158	1.417	0.173	H1 Rejected
Risk Attitude (RA) -> Financial Literacy (FL)	0.719	0.706	0.118	6.089	0.000	H2 Accepted
Financial Literacy (FL) -> Business Sustainability (BS)	0.535	0.549	0.156	3.423	0.001	H3 Accepted
Intellectual Capital (IC) -> Business Sustainability (BS)	0.396	0.373	0.137	2.894	0.004	H4 Accepted
Risk Attitude (RA) -> Business Sustainability (BS)	0.171	0.165	0.120	1.429	0.153	H5 Rejected

Source: constructed by authors based on result of model development

The results of the H1 test show that the correlation between the Intellectual Capital variable and Financial Literacy for the batik creative industry players gets a path coefficient value of 0.224 with a t value of 1.417 < 1.98, which shows that the direction of the correlation between Intellectual Capital and Financial Literacy is positive and not significant because t value <t table. Indicators IC1 and IC4 are essential to intellectual capital and demonstrate how Batik SMEs are proficient in their particular sectors and have positive working connections with clients, partners, and the government. Regarding financial literacy, namely FL1, FL2, FL3, FL4, FL5, and FL6, which demonstrate how Batik SMEs often utilize FL by research indicators, this condition shows that the higher the intellectual capital of creative industry players, the higher their financial literacy, but it is not significant. This means that efforts are still needed to increase intellectual capital in the form of training and education for batik industry players in managing business finances properly, for example, by teaching them how to separate business finances from personal finances. This does not follow the first hypothesis, so H1 is rejected.

The results of the H2 test show that the correlation between the Risk Attitudes variable and Financial Literacy in the batik creative industry gets a path coefficient value of 0.719 with a t value of 6.089 > 1.98, which shows that the direction of the correlation between Risk Attitudes and Financial Literacy is positive and significant because the statistical t value is greater than the t table. Risk Attitude indicators consist of RA1, RA2, RA3, RA4, and RA6, which explain that Batik SMEs can set aside a portion of their business income just in case; Batik SMEs develop standard safe work procedures; Batik SMEs comply with regulations and laws, Batik SMEs can cooperate with suppliers of raw materials, and Batik SMEs do not delay debt payments. All indicators above become RA constructs that can improve FL for Batik SMEs. The higher the Risk Attitude of the batik creative industry players, the higher their financial literacy. This is in accordance with the second hypothesis, so it can be said that H2 is accepted.

The results of the H3 test show that the correlation between the Financial Literacy variable and the Batik Creative Industry Business Sustainability has a path coefficient value of 0.535 with a t value of 3,423 > 1.98, which shows that the direction of the correlation between Financial Literacy and Business Sustainability is positive and significant because the value t count > t table. FL indicators that explain how Batik SMEs can separate assets, liabilities, personal and business income and expenses (FL1), make simple financial reports (FL2), record every business transaction (FL3), make financial reports periodically (FL4), and prepare financial statements correctly (FL5). Batik SMEs make the right decisions (FL6). While the BS indicators explain that Batik SMEs can create new jobs (BS1), Batik SMEs can develop local culture and wis-

dom (BS3), Batik SMEs can align economic, environmental, and social activities (BS4), Batik SMEs can generate profits and grow businesses (BS5), and finally, Batik SMEs have transparent institutions (BS6). The higher the financial literacy of the batik creative industry players, the higher the chances of business continuity. This is in accordance with the third hypothesis, so it can be said that H3 is accepted.

The results of the H4 test show that the correlation between the Intellectual Capital variable and the Business Sustainability of the batik creative industry has a path coefficient value of 0.396 with a t value of 2.894 > 1.98, which shows that the direction of the correlation between intellectual capital and Business Sustainability is positive and significant because the value t count > t table. Indicators IC1 and IC4 are essential to intellectual capital and demonstrate how Batik SMEs are proficient in their particular sectors and have positive working connections with clients, partners, and the government. While the BS indicators explain that Batik SMEs can create new jobs (BS1), Batik SMEs can develop local culture and wisdom (BS3), Batik SMEs can align economic, environmental, and social activities (BS4), Batik SMEs can generate profits and grow businesses (BS5), and finally, Batik SMEs have transparent institutions (BS6). This is in accordance with the hypothesis, so H4 is declared accepted.

The results of the H5 test show that the correlation between the risk attitude variable and the business sustainability of the batik creative industry has a path coefficient value of 0.171 with a t value of 1.429 < 1.98, which shows that the direction of the correlation between risk attitudes and business continuity is positive and not significant. because the value of t count < t table. Risk Attitude indicators consist of RA1, RA2, RA3, RA4, and RA6, which explain that Batik SMEs can set aside a portion of their business income just in case; Batik SMEs develop standard safe work procedures; Batik SMEs comply with regulations and laws, Batik SMEs can cooperate with suppliers of raw materials, and Batik SMEs do not delay debt payments. All indicators above become RA constructs that can improve FL for Batik SMEs. While the BS indicators explain that Batik SMEs can create new jobs (BS1), Batik SMEs can develop local culture and wisdom (BS3), Batik SMEs can align economic, environmental, and social activities (BS4), Batik SMEs can generate profits and grow businesses (BS5), and finally, Batik SMEs have transparent institutions (BS6). This is not in accordance with the fifth hypothesis, so H5 is rejected.

Table 8. Mediation Test Results

Variables corelations	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Result of Hypothesis path
Intellectual Capital (IC) -> Financial Literacy (FL) -> Business Sustainability (BS)	0.120	0.149	0.105	1.142	0.254	H6 Rejected
Risk Attitude (RA) -> Financial Literacy (FL) -> Business Sustainability (BS)	0.384	0.385	0.121	3.170	0.002	H7 Accepted

Source: constructed by authors based on result of model development

The results of the H6 test show that the correlation between the Intellectual Capital variable and the Business Sustainability of the batik creative industry is mediated by the Financial Literacy variable, obtaining a path coefficient value of 0.120 with a t value of 1.142 <1.98 which shows that the direction of the correlation between Intellectual Capital and Business Sustainability is mediated by Financial Literacy is positive but not significant because the value of t count <t table. This proves that the Financial Literacy variable cannot mediate the influence of Intellectual

Capital on Business Sustainability. This is not in accordance with the sixth hypothesis, so H6 is declared rejected.

The results of the H7 test show that the correlation between the Risk Attitude variable and Business Continuity is mediated by the financial literacy of the batik creative industry business actors, obtaining a path coefficient value of 0.384 with a t value of 3.170 > 1.98, which shows that the direction of the correlation between Risk Attitudes and Business Sustainability is mediated by financial literacy and is positive and significant because the t count > t table. This indicates that the financial literacy variable is successful in mediating the effect of risk attitudes on business sustainability. This is in accordance with the seventh hypothesis, so H7 is declared accepted.

5. DISCUSSION

Intellectual capital in Batik SMEs is a collection of knowledge that describes intangible assets that can affect Business Sustainability. Batik SME owners need financial management skills or competencies to run the business and ensure its survival and expansion. Training in financial management is one approach to increasing the intellectual capital of Batik SME owners. It was found that intellectual capital has little impact on the financial literacy of creative batik businesses in Indonesia, and this still needs to be improved. Stakeholders should pay attention to this matter so that the intellectual capital development of batik SMEs can be taken more seriously.

The COVID-19 epidemic that has now passed and increased the danger of failure or bankruptcy for Batik SMEs is just one of the conditions of uncertainty facing Batik SMEs in Indonesia today. Batik SMEs only concentrate on short-term rather than long-term goals due to their inability to manage risk and lack financial skills training. As a result, every organization needs to adopt a risk-taking attitude by identifying and managing risks as early as possible. Risk attitudes will increase the financial literacy of Batik SMEs in various fields such as bookkeeping, financial statement analysis, investment management, and other business finance-related topics. The risk attitude has a significant impact on financial literacy in batik SMEs.

Batik SMEs with solid financial literacy will be better equipped to meet company goals, focus on business development, and survive difficult economic times. Financial literacy is required to manage and make financial decisions effectively, including bookkeeping, payments, loans, and other financial choices. To achieve the goals of company success and sustainability, owners or managers of Batik SMEs must make difficult financial decisions. The justification above makes perfect sense regarding batik SMEs in Indonesia. Batik SMEs can survive if their financial knowledge is good.

Batik SMEs do, however, usually have few resources. However, this did not hinder the growth of his business. Batik SMEs must focus on human resources and management strategies to compete in the global market. The sustainability of Batik SMEs will be influenced by a focus on the intellectual capital owned by the owners or managers of Batik SMEs. With sufficient intellectual capital, the batik industry can guarantee the long-term sustainability of its sector.

Batik SMEs can recognize opportunities and dangers related to business continuity by taking a risk-taking attitude. The threats Batik SMEs face, including financial, market, operational, and technological risks. If these risks are adequately managed, the sustainability of Batik SMEs will improve. Furthermore, investigated how risk attitudes can enhance the sustainability of Batik SMEs. Before developing a risk attitude and learning more about the different hazards, the batik creative sector must first learn a risk attitude because this attitude will guide future risk management actions. Batik SMEs must still understand the proper risk mindset to maintain

economic viability.

6. CONCLUSION

In general, the results of the research above prove that variable intellectual capital does not affect financial literacy because the batik industry is a family industry, which assumes that industry players simply learn from the skills taught by the family. However, because the batik industry has high prospects, batik industry players should start adding insight into financial literacy by attending training or financial education.

The effect of risk attitudes on financial literacy has a positive influence, meaning that with increasing attention from industry players regarding risks that always occur anytime and anywhere, the level of financial literacy obtained is also higher. The effect of financial literacy on the sustainability of the batik industry business has a positive influence, meaning that the level of financial literacy is one of the factors or abilities needed by batik industry players so that their business continues to run and develop. The effect of intellectual capital on the sustainability of the batik industry business has a positive influence, meaning that the higher the intellectual capital owned by the batik creative industry players, the stronger the business sustainability. Meanwhile, the risk attitude has not had a positive effect on business sustainability.

Financial literacy has yet to mediate intellectual capital's influence on the sustainability of the batik industry. This needs to be explored further with further research. Furthermore, financial literacy can mediate risk attitudes toward the sustainability of the batik industry's business. The implications of these findings are to prove that financial literacy is beneficial for the business sustainability of Batik SMEs. Whether intellectual capital becomes an antecedent of financial literacy. When intellectual capital becomes a value for Batik SMEs, then it provides tangible benefits for Batik SMEs. Whether risk attitude an antecedent of financial literacy. When batik, SMEs have the mindset that risks can occur anytime and anywhere, batik SMEs can face risks. The risk attitude allows Batik SMEs to maintain business sustainability.

As a limitation of this study, there is a possibility of respondent bias which could lead to different results when compared to other regions in Indonesia. Another limiting factor can be observed in the sample size and the fact that it refers to batik SMEs, which may differ from the results obtained in a more significant number of respondents and in large companies. Even considering the methodological rigor used, another limitation concerns the non-generalizability of the results because the variables used may show some trends in the results, as predicted by the authors who investigated the relationship between FL and BS. Therefore, it is advisable to use another sample and replicate this study considering this use and the inclusion of other variables to verify the results.

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ASSESSMENT OF TOURISM-LED GROWTH RISKS IN RESOURCE-RICH COUNTRIES: EVIDENCE FROM AZERBAIJAN

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ABSTRACT

The COVID-19 pandemic has provided important lessons in determining future development strategies for countries whose economies are largely dependent on natural resources. The following study was conducted to analyze the potential for tourism to contribute to economic growth and sustainability of economic development in countries rich in natural resources during the post-resource period. Using data from the Republic of Azerbaijan, a co-integrated regression model was used in the analyses. Findings showed that (1) tourism has a positive effect on economic growth and can play a role in ensuring its sustainability; (2) a decrease in revenues from tourism carries more risk for the economy than revenues from oil (coefficient of variation); (3) if an oil and gas country chooses a tourism-based development path in the post-oil and gas era, it may face very serious challenges (due to the fact that tourism sector is highly vulnerable to direct and indirect events); (4) dominance of the tourism sector in the economy carries more risk than dominance of the oil and gas sector.

However, combining two different approaches showed that choosing tourism as one of the priority sectors in the post-oil and gas era can reduce risks and will contribute more to the diversification of the economy.

Keywords: *Azerbaijan, economic growth, tourism income, regression model, coefficient of variation, non-oil sector*

1. INTRODUCTION

Azerbaijan is a resource-rich country, dependent primarily on oil and gas; in 2022, this sector accounted for 52% of gross domestic product (GDP), 50% of the state budget, and 92% of exports. In the early 2000s, the oil and gas sector accounted for one-quarter of GDP. Since 2005, with the beginning of a new mining boom, revenues from oil sales have become an important source of financing economic and social development in Azerbaijan (Khalilov et al., 2021). It is widely acknowledged that resource dependency confers numerous disadvantages. Heavy dependence on oil revenues exposes the country to risks, which emanate from volatility in oil prices, exhaustibility of resources, and exchange rate risks (World Bank, 2022). Since 2014, for example, as a result of the sharp drop in oil prices and the economic crisis in trading partner countries, the rate of economic growth in Azerbaijan slowed considerably and the country faced new challenges. As a result, in 2015, Azerbaijan was forced to devalue its currency twice. In parallel with this, in order to ensure a successful transition to a new model of economic growth and development in Azerbaijan, the country must focus on implementing economic reforms in

new "leading sectors" that will bring about sustainable development. Accordingly, the government has chosen to support a number of sectors of the economy, including agriculture, and to promote the production of competitive products (Shalbuzov et al., 2020).

Tourism was one of the eight priority sectors targeted for development in the strategic road maps adopted by the government of Azerbaijan in 2016. As a result of measures to develop tourism, rapid growth occurred in this sector between 2015 and 2019. In 2015, 1,922,000 tourists visited Azerbaijan; this figure increased in 2019 by 49% to 2,864,000 people (SSC, 2023a). The development of tourism has been significant for Azerbaijan. However, since the beginning of 2020, the coronavirus (COVID-19) pandemic and the restrictions on socio-economic activity in most countries have created new strategic policy challenges for the economy of Azerbaijan and especially for the non-oil sector (tourism sector).

The government of Azerbaijan is taking measures to strengthen strategic, institutional, and financing mechanisms to ensure the sustainable development of the non-oil sector, especially the tourism sector during post-pandemic period, and this issue is reflected in the country's socio-economic development strategy. The strategy aims to increase tourism receipts by 20% by 2026 compared to 2022 (Azerbaijan – 2026, 2022). Thus, tourism is important not only for the post-pandemic but also for the post-oil era. It should be noted that many international institutions, including the World Bank, have emphasized tourism as a priority sector for the development of Azerbaijan during the post-oil era. Azerbaijan's government also expects this sector to play an important role in realizing its goal of ensuring a two fold growth in the economy. This study examines the opportunities for the development of tourism in oil and gas-rich Azerbaijan, its positive impact on economic growth, and the opportunities and risks created by replacing the economy's dependence on oil and gas with dependence on the tourism sector.

The structure of the paper is as follows: The current section introduces the background of the topic. We discuss our literature review and development of hypotheses in Section 2. In Section 3 we explain our research methodology. In Sections 4 and 5 we provide the results of our analysis and discuss the findings. We summarize our research in section 6.

2. LITERATURE REVIEW

Tourism's contribution to the economy is seen primarily in revenues from transportation, tour operators, accommodations, recreation centers, retail sales establishments (such as restaurants and gift shops), etc. (Aktas, 2005:163; Chan et al., 2005). Tourist purchases of goods and services (such as direct spending on places like hotels and restaurants) also generate more spending and income growth in the economy through a multiplier effect. Tourism is recognized as one of the most important sources of economic growth and development in many developed and developing countries by many tourism scholars worldwide (Diamond, 1977; Britton, 1982; Copeland, 1991; Hao et al., 2002; Eugenio-Martin, 2004; Brida et al., 2008; Sana, 2021).

Services in the tourism sector provide additional foreign exchange flows and national income (Fayed and Fletcher, 2002). In fact, the theoretical basis for tourism's role in economic growth is grounded in the literature on exports and economic growth (Vanegas and Croes, 2003). Including tourism in the international services section of the balance of payments current account positions it at the forefront of traditional service activities in international trade. Therefore, tourism expenditures made by foreign tourists in another country have an export effect, given the foreign currency income they bring to that country, exactly like the export of goods. In other words, tourism is an invisible export product (Theobald, 2005).

A wide range of studies exist that aim to measure the economic impacts of the tourism sector.

Some selected examples follow:

According to results from the Granger Causality Test, tourism income has an effect on economic growth (Yıldırım & Ocal, 2004). There are also studies that claim the opposite, which reject the hypothesis of a relationship between tourism and economic growth (Oh, 2005; Yavuz, 2006). According to the hypotheses of other researchers, there is a relationship between international tourism revenues, the real effective exchange rate, and real growth (Dritsakis, 2004; Balaguer and Lorda, 2002). Meanwhile, Bal et al. (2016) examined the relationship between tourism receipts and long-term economic growth in Turkey. Thus, the the result of the research shows strong evidence of a link between tourism and economic growth (*1% increase in tourism receipts leads to economic growth by 0.314%*). Also, Işık Maden et al. (2019), Cuhadar (2020), Yenişehirlioğlu et al. (2020), and Ozer (2021) describe the tourism sector as a contributor to Turkey's economic growth.

Tang & Tan (2013) try to find an answer question of "How stable is the tourism-led growth hypothesis in Malaysia?" and Vanegas & Croes (2003) impact of tourism development in a small economy.

In Azerbaijan, research focused mainly on effects on the non-oil sector (especially agriculture sector) during a post-oil/gas era (Huseyn, 2011, Shalbuzov et al., 2020), and researchers have concentrated on the development of tourism. According to Azizov's analysis (2022), using an econometric model, the impact of tourism revenues on the non-oil sector will lead to an increase in non-oil GDP.

Since we lack sufficient studies for Azerbaijan, we include other studies that examine the impact of tourism on economic development. Diversifying their economies is the key objective for many resource-rich countries. In the case of Saudi Arabia, diversification has been a part of development plans since the 1970s. (Albassam, 2015). Alodadi and Benhin (2015) show that religious tourism has been recognized as a key non-tradable sector in oil-rich Saudi Arabia, and tourism is therefore potentially important for any future diversification of the economy. A recent study on Saudi Arabia by Naseem (2021) spanning from 2003 to 2019 also confirmed a positive relationship between economic growth and tourism. Karim et al. (2021) conducted a study on oil-producing countries like Algeria, revealing that tourism serves as a critical strategic sector for economic growth and development. Their results underscored the considerable potential of tourism programs in Algeria. Some other researchers have explored the potential for tourism to replace the oil economy in Saudi Arabia or as a more sustainable alternative to oil in Nigeria.

In summarizing the literature, it becomes evident that numerous researchers have examined the relationship between tourism and economic growth, with some focusing on the impact of war (terrorism) and economic crises on tourism. However, there has been insufficient research on the impact of epidemics or pandemics on tourism before 2020. In the realm of the limited examination that have taken place, Yang and Chen (2009) conducted a study on the consequences of the SARS epidemic on the tourism sector. Their findings unveiled detrimental effects on Taiwan's GDP and employment, primarily attributable to a reduction in spending by foreign tourists. Also, Zeng et al. (2008) researched impact of SARS in China's and Rittichainuwat & Chakraborty (2009) studied impact of terrorism, SARS and bird flu on Thailand's tourism sector. As well as Cahyanto et al. (2016) examined impact of Ebola on Americans' domestic travel.

According to Zenker and Kock (2020) it is claimed that the research studies have recently been recognized with the unique nature of the coronavirus pandemic in terms of academic perspective. Authors conclude that some imports of disaster/crises are worth researching. In addition, they noted that former studies related to disaster/crises similar patterns and academic literature are able to provide an explanation to the currently observed phenomena.

Up until 2020, researchers did not anticipate the significant damage that a pandemic could inflict on the global economy and tourism. However, since 2020, the COVID-19 pandemic has severely affected the tourism industry, prompting numerous studies. It is an undeniable notion that the impact of COVID-19 on major service sectors including tourism has been its own kind comparing with other events in the 21st century (Zenker & Kock, 2020). Wickramasinghe & Naranpanawa (2023), Wang et al. (2021), Nikolova & Pavlov (2021), Amin & Taghizadeh-Hesary (2023), Pavlov (2023) and others have analyzed the impact of the COVID-19 epidemic on tourism in Europe, Asia, or individual countries. Wickramasinghe & Naranpanawa (2023) examined the potential of domestic tourism in alleviating economic challenges caused by reduced international tourism following the COVID-19 pandemic, particularly in developing countries. Wang et al. (2021) simulated the impact of COVID-19 on the Chinese economy, revealing that the tourism sector suffered more severe consequences. Pham et al. (2021) studied the short-term economic impacts of the inbound tourism industry on the Australian economy during the pandemic, while Amin & Taghizadeh-Hesary (2023) emphasized the sudden and substantial negative shock to Bangladesh's tourism industry in the early months of 2020. Ljubotina and Raspor's (2022) findings indicated that the COVID-19 pandemic and the Ukraine crisis had a profound impact on the tourism sector, suggesting that Slovenian tourism might not fully recover until 2026. Overall, these studies underscore the sensitivity of tourism development to economic crises, pandemics, and conflicts. They also highlight the volatility of the relationship between tourism and economic growth, which is contingent on economic events like recessions and debt crises. In alignment with Wołowiec et al. (2002), it is essential to address economic crises and conflicts for the tourism services market to operate successfully.

According to the literature review, earlier studies examined the issues of tourism for economic development and the impact of the COVID-19 pandemic on this sector in Azerbaijan (Azizov, 2022; Huseyn & Sadigova, 2021; Demiroglu & Muller, 2021; Huseyn & Museyibov, 2022). This article focuses on the relationship between tourism and economic growth, to identify their causal relationship. By doing this, we take into account the risks of replacing the economy's dependence on oil and gas with dependence on tourism sector. Also, this paper reviews previous research papers while focusing on the importance of tourism for Azerbaijan's economy. At the same time, this study presents new approach and reveals that what will be happen with long-term economic growth if the tourism sector would be only the priority sector to be developed after the post-oil-gas era.

3. RESEARCH METHODS AND MATERIALS

3. 1. REGRESSION ANALYSIS

Analytical generalization, comparison, and quantitative analysis methods were used in the research process. Comparative analysis, regression analysis, and coefficient of variation were used to achieve the research goal.

The parameters in the econometric methodology, which we will use for the application of modeling the research object, were evaluated using the *Eviews 9* software package. A co-integrated regression model was used to analyze the relationship between tourism revenues and gross domestic product.

Between 2001 and 2021, the time series of variables consisting of tourism revenues and GDP and the effects of tourism revenues on GDP were examined. Regression coefficients were estimated using the appropriate econometric method by collecting statistical data on variables included in the model. The initial stage consisted of presenting the hypothesis in the form of a stochastic equation and determining the initial theoretical expectations about the sign of the

parameters included in it.

$$logGDP = \alpha + \beta * logTG \quad (1)$$

Here:

log Change in GDP volume

α - fixed (autonomous) limit;

β,γ- propensity ratios;

logTG- Change in tourism revenues

Here, as the main variable included in the regression model, the following hypothesis was established and tested with regard to the effect of the dependent variable of tourism income on GDP.

H_0 – Changes in tourism revenues determine changes in the GDP. It is possible to determine authenticity by the econometric method.

H_1 - Changes in tourism revenues cannot determine changes in GDP. It is impossible to determine authenticity by the econometric method.

Co-efficient of variation. The co-efficient of variation (CV) is a statistical measure of the dispersion of data points in a data series around the mean(Hayes, 2023). The concept of CV indicates the ratio of the standard deviation to the mean, and it is powerful information for comparing the degree of variation from one data series to another, even if the means are drastically varies from one another (Hayes, 2023). The co-efficient of variation shows the extent of variability of data in a sample in relation to the mean of the population. The co-efficient of variation can be useful when comparing data sets with different units or widely different means.

Data. The data was collected from the statistical data of the State Statistics Committee of Azerbaijan, the Central Bank of Azerbaijan, and reports of the State Tourism Agency of Azerbaijan. Also, two focus group discussions (organized by the Faculty of the Management of the Azerbaijan Tourism and Management University in December 2022 and April 2023 and consisting of twelve tourism experts each) took place to focus on the problems in the development of tourism.

4. RESULTS

4. 1. ANALYSIS OF THE CURRENT SITUATION

The World Bank's (2022) Long-Term Growth Model (LTGM) forecasts that Azerbaijan's GDP growth will slow from 1.5% in 2024 to zero by 2050, with an average growth of only 0.5% over 2024-2050. This projection is even less encouraging in per capita terms. GDP per capita growth is projected to start just below one percent and approach zero in the mid-2030s. As a result, GDP per capita would increase from USD $5,900 in 2020 to USD $6,500 in 2050, a cumulative growth of only 11% over 30 years.

Furthermore, the tourism sector is a leading field of activity in many countries around the world, and its development enables the active use of the most popular and valuable natural resources and the creation of jobs. (Wołowiec et al., 2022). Tourism is a stimulating and sustainable industry, which includes activities such as marketing services, accommodation and transportation services, food and beverage activities, retail stores, and various amusement/entertainment attractions. Factors such as technological development, urbanization, population growth, increasing life expectancy, vacations, social security, and freedom to travel play a dynamic role in the development of the tourism industry. In addition, the tourism economy has direct or indirect spillover effects on the transport, trade, construction, accommodation, food and beverage sec-

tors, as well as other service sectors in many countries (Proença & Soukiazi, 2008).

Indeed, the tourism sector plays an important role in world development and it is positively and negatively correlated with global economic growth (Khan et al., 2020). According to the report WTTC, prepared by the World Tourism and Travel Council and Oxford Economics, and which covers the impact of the pandemic on tourism in 185 countries and 25 geographic or economic regions of the world, the tourism industry was responsible for 10.3% of world GDP in 2019 (USD $9.6 trillion); in 2020 this indicator decreased to 5.5% (USD $4.5 trillion) due to the COVID-19 pandemic (WTTC, 2021a).

According to this report, before the pandemic, international tourism accounted for one in four new jobs worldwide and 10.3% of all jobs (333 million). In 2020, there were approximately 62 million or 18.5% job cuts in the tourism sector. In 2021, the number of people in this field was 272 million (WTTC, 2021a).

In 2019, tourists spent USD $1.7 trillion during their travels, which accounted for approximately 7% of international exports and 27.4% of service exports (Earth-changers, 2022). According to WTTC, the summer of 2020 saw a 70% drop in tourist arrivals in Europe, despite a small and short-lived revival. This region suffered the largest decline in absolute terms, with more than 500 million fewer international tourists in 2020 (WTTC, 2021b). In 2019, 3.17 million people visited Azerbaijan. This number had been increasing by 9.16% on average annually, from 681,000 people in 2000 to 3.17 million people in 2019. The direct contribution of travel and tourism to Azerbaijan's GDP increased from USD $0.1 billion in 2000 to USD $1.8 billion in 2019, with an average increase of 19.88% (Knoema, 2019).

Table 1. Tourism and Travel Statistics for Azerbaijan

Years	Tourism service export (thousand USD)	Number of tourists (thousand people)	Expenditure ($)	Tourism as % of GDP	International Tourism, Receipts, % of Exports of Goods and Services*	Balance of International Tourism, % of GDP**
2010	620,652	1279.8	485	1.0	2.76	-0.12
2015	2,309,485	1921.9	1201	2.4	12.64	-0.39
2016	2,713,789	2044.7	1327	2.4	16.24	0.69
2017	3,011,781	2454.0	1227	2.4	16.20	1.01
2018	2,634,163	2605.3	1011	2.3	11.10	0.80
2019	1,791,514	2863.5	626	2.4	8.48	0.34
2020	304,185	519.4	586	1.1	2.24	-0.23
2021	312,746	461.7	677	1.3	1.44	-0.53
2022	823,264	1058.1	778	1.6	-	-

Source: (SESRIC, 2022; SSC, 2022; SSC, 2023a; CBAR, 2022)

**Level of international tourism receipts expressed as a percentage of exports of goods and services (SESRIC, 2022).*

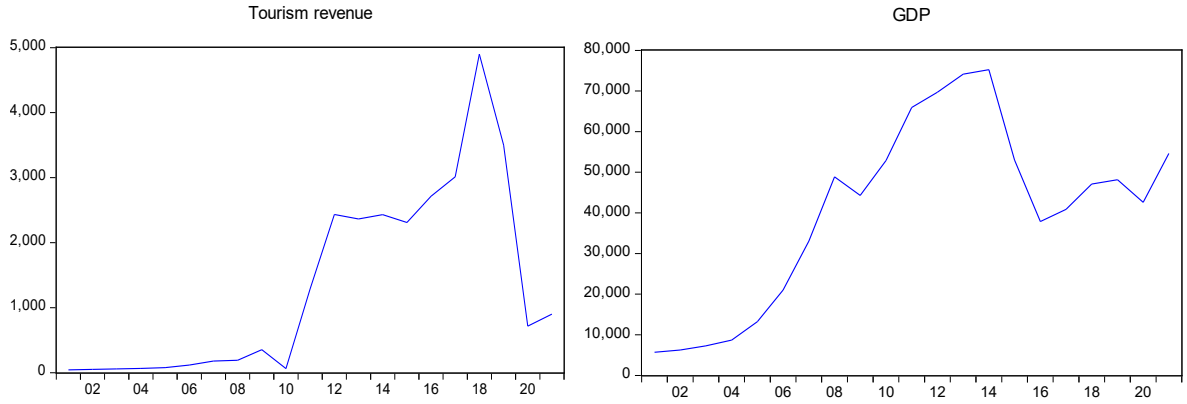
*** Level of international tourism balance expressed as a percentage of GDP (SESRIC, 2022).*The table shows an overall increase in the number of tourists, tourism income, and expenditures from 2010 to 2019, until the Covid-19 pandemic, which seriously affected the tourism sector, beginning in 2020. The coronavirus has also resulted in the closing of borders, restrictions on citizens' travel in Azerbaijan, and has seriously reduced the number of arrivals in the country. According to information from the State Border Service, in 2020, 795,700 foreigners from 155 countries visited Azerbaijan, which was four times less than in 2019. In 2019, 3,170,000 foreign

visitors came to Azerbaijan (SSC, 2022), and in 2020 five million foreigners were expected.

4. 2. CHECKING THE CORRECTNESS OF DATA DISTRIBUTION

Figure 1 shows the time dependence graphs in the specified time interval of the parameters in our model.

Figure 1. Change in variables over time, Azerbaijan, 2001-2021



Source: Prepared by the author based on the results of calculations made using the *Eviews 9* software package

The coefficients obtained from the regression model were assessed according to economic, statistical, and econometric criteria. The question was whether the initial theoretical expectations placed on the parameters of the model were confirmed or not. By testing whether the parameters of the model are statistically significant at an acceptable level of significance, it was possible to determine whether the important econometric assumptions of the regression equation were met. The study details whether the changes in the main variables satisfactorily explain the changes in the dependent variables.

Since each of the main and dependent variables is a time series, it is important to test their stationarity. If the indicators of the variables included in the model in the current period depend on the indicators in the previous period, this indicates a violation of their stationarity.

Table 2. Checking the Stationarity of the Tourism Income Parameter

Null Hypothesis: D(LOGTG) has a unit root				
Exogenous: None				
Lag Length: 0 (Automatic - based on SIC, maxlag=4)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-5.433403	0.0000
Test critical values:	1% level		-2.692358	
	5% level		-1.960171	
	10% level		-1.607051	
*MacKinnon (1996) one-sided p-values.				
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 19				

Source: Results of calculations made using the *Eviews 9* software package

In the table above, the stationarity of the logtg variable was tested using the ADF Unit Root test. The probability value of the logtg parameter is less than 5% and the t statistic value is modulo

1 difference greater than that parameter.

Table 3. Checking the Stationarity of the GDP Parameter

Null Hypothesis: D(LogGDP,2) has a unit root				
Exogenous: Constant				
Lag Length: 1 (Automatic - based on SIC, maxlag=4)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-4.043356	0.0073
Test critical values:	1% level		-3.886751	
	5% level		-3.052169	
	10% level		-2.666593	
*MacKinnon one-sided p-values.				
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 17				

Source: Results of calculations made using the *Eviews 9* software package

As can be seen from Table 4, the p value is less than 10% at the 10% significance level in the logudm parameter, and the t statistic value is larger than the first difference modulo in that parameter. A significance level of 10% in the GDP parameter indicates that there is no single root problem in the variable. Thus the variable was stationary.

Based on the result of our stationarity test, there is no single root problem in the first difference between the two variables. The presence of a cointegration relationship between the two variables was tested by Eager-Granger approach. The residuals of the model were found to be stationary at the (ETGUDM) level. This means that the two variables are in equilibrium over time. That is, there is a cointegration relationship between the logtg and logudm variables.

Table 4. Checking the Stationarity of the Residuals of the Model

Null Hypothesis: ETGGDP has a unit root				
Exogenous: None				
Lag Length: 0 (Automatic - based on SIC, maxlag=4)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-2.986243	0.0050
Test critical values:	1% level		-2.692358	
	5% level		-1.960171	
	10% level		-1.607051	
*MacKinnon (1996) one-sided p-values.				
Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 19				

Source: Results of calculations made using the *Eviews 9* software package

4. 3. RESULTS OF REGRESSION ANALYSIS

A co-integrated regression model was used to analyze the relationship between tourism revenues and GDP.

Table 5. Results of Regression Analysis (DOLS)

Dependent Variable: LOGGDP				
Method: Dynamic Least Squares (DOLS)				
Date: 01/26/23 Time: 18:48				
Sample (adjusted): 2005 2018				
Included observations: 14 after adjustments				
Cointegrating equation deterministics: C				
Automatic leads and lags specification (lead=3 and lag=3 based on AIC criterion, max=3)				
Long-run variance estimate (Bartlett kernel, Newey-West fixed bandwidth =3.0000)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGTG	0.285222	0.108676	2.624522	0.0468
C	8.424091	0.755492	11.15048	0.0001
R-squared	0.756935	Mean dependent var		10.69347
Adjusted R-squared	0.368030	S.D. dependent var		0.489937
S.E. of regression	0.389483	Sum squared resid		0.758486
Long-run variance	0.193725			

Source: Results of calculations made using the *Eviews 9* software package

Based on the results of the preliminary analysis, the T-statistic value (2.624522) of the main variable tourism income (logtg) is greater than the Tcritical value and, accordingly, the P value (0.0468) is less than 5%, which indicates the significance of the coefficient of the variable and makes our model acceptable. Also, the fact that the adjusted R^2 coefficient (0.756935) is close enough to 1 indicates that the forecast numbers we received will sufficiently reflect reality.

Now let's analyze the results obtained from our equation Log(GDP) = α + β* log(TG). In models with log-nan, the percentage change of parameters is checked. According to the result obtained from the model, a 1% increase in tourism revenues increases the GDP by 0.285%. The general equation is as follows:

$$LOGGDP = 0.285222272158*LOGTG + 8.42409122964 \quad (2)$$

Therefore, we can conclude that it is important to increase the effectiveness of the measures utilized to stimulate the development of the tourism sector, taking into account the impact of tourism income on GDP over the long term.

4. 4. RESULTS OF THE CO-EFFICIENT OF VARIATION

The co-efficient of variation calculated for oil and tourism revenues yield the following results.

Table 6. Calculation Coefficient of Variation for Tourism and Oil Revenues

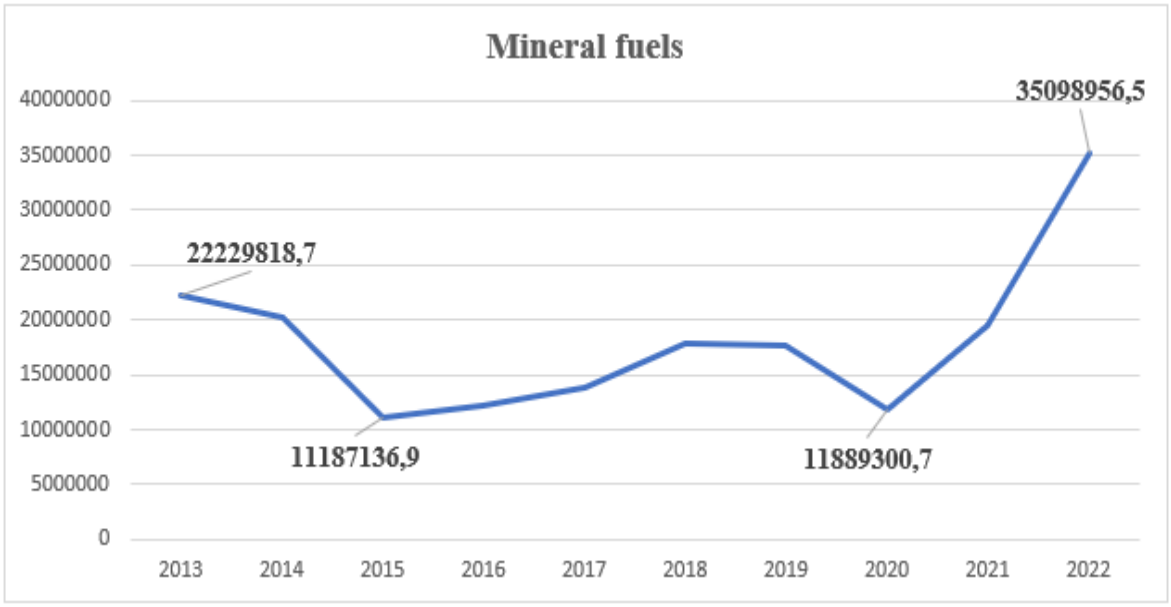
	Standard deviation	Mean	Coefficient of variation, %	Skewness	Kurtosis
Tourism revenues	910769,8999	2030757,6	44,85	-1,34368948	0,52918215
Oil revenues	4056491,537	16928192,38	23,96	-0,149131587	-1,722689686

Source: Calculation by authors

As we know the co-efficient of determination is considered a general measure of variability of statistical data. If we calculate this co-efficient for tourism and oil revenues, we will see that the revenues from tourism show more volatility. The table shows that the co-efficient of variation of tourism is 44.85%; for the oil sector it is 23.96%. Thus the risk in the tourism sector is higher

than in the oil sector.

Figure 2. Export of mineral fuels, minerals oils and bituminous substance products, thousand US dollars



Source: (SSC, 2023b)

The analysis of the data presented in Figures 2 and 3 confirms the validity of our hypothesis, and the results of the coefficient of variation once again demonstrate the uniqueness of this study. We agree that the most visible economic impact of tourism is the significant cash flow it generates, and in some economies, tourism is an important source of income. For example, in the Maldives, the share of tourism in the GDP was almost 60%, and in Palau, it was about 40% (in 2018). Considering the examination of Figure 3, we can envision the scenario that might unfold if Azerbaijan's economy was to rely on tourism, as tourism industry is among the sectors experiencing the most significant impact.

Figure. 3. Tourism - service export, thousand US dollars

Source: (CBAR, 2023; SSC, 2022; SSC, 2023a)

Summing up, the impact of the contribution of tourism on long-term economic growth still needs to be fully understood. As an emerging economy, the tourism sector in the Republic of Azerbaijan has been substantially improving, especially in an international perspective. As an essential instance, the year 2011 was declared the "Year of Tourism", and it shows that not only the economic interests of the government but also political commitment to the development of the tourism sector has taken a new pace as the supply and demand in the sector illustrated upward trend until COVID-19 (Demiroglu & Muller, 2021). The reality is that when formulating Azerbaijan's tourism development strategy in the 2000s, and later in 2016 in the Strategic Roadmap of Tourism the possibility of such a situation arising with significant risks to the tourism industry was not anticipated. The points mentioned in this paper can be useful for countries that consider tourism as the only alternative to the oil sector in their future development strategies.

5. DISCUSSIONS

Taking into account all aforementioned facts and points, it is more likely that the oil reserves in Azerbaijan have been reducing over the past years, and the strategy of the government is more inclined toward the diversification of the energy resources in which it cannot continue relying on this source anymore. It is important to look at some of the alternative economic activities (including tourism) that the country is promoting currently. Therefore Azerbaijan is moving ahead with efforts to diversify its economy and invest in non-oil sectors. However, it will need to offer better quality services in order to turn the tourism sector into a major source of employment (World Bank, 2009). The resurgence seen in Azerbaijan's tourism sector has been based mainly on local tourism in 2022.

A priority is to invest in education and training to meet future labour demand and the higher skill needs expected in agriculture, agro-processing, oil production, oil-related industries, tourism, communication, and financial services (World Bank, 2009).

Tourism, which is a service sector, is developing very rapidly all over the world. In 2019, tourism accounted for 10.3% of global GDP ($9.6 trillion) and 10.3% of global jobs (333 million). Tourists spent $1.7 trillion on travel in 2019, accounting for nearly 7% of international exports and 27.4% of service exports (WTTC, 2023).

Tourism occupies an important place in the non-oil sector of Azerbaijan's economy, which is why the most important element of the analysis is the impact of tourism on the development of the non-oil sector. The impact of tourism activity on other sectors of the economy (agriculture, transport, information technology) was also analyzed using several econometric models. The logarithmic regression in the model shows that a one percent increase in tourism income leads to a 0.76% increase in GDP from the non-oil sector (Azizov, 2022).

In 2019, the added value created in the non-oil sector of the country's economy increased by 3.5% compared to the same period the previous year. The specific weight of the added value created in the non-oil sector of the GDP was 61.7%. According to the State Statistics Committee of Azerbaijan, in 2019, the added value created in the field of tourist accommodation and public catering increased by 6.4% compared to the corresponding period the previous year and reached 1976.7 million manats; its share in the non-oil GDP was 3.9% (SSC, 2023a).

The COVID-19 pandemic caused a serious decline in the tourism sector. In 2020, 5.5 times fewer tourists came to Azerbaijan compared with 2019, and the export of tourism services decreased by 5.9 times(SSC, 2023a). Due to the drop in oil prices, in 2015 oil exports of Azerbaijan decreased by 2.1 times compared to 2014, which caused a problem in the country's economy; this problem would have been considerably more severe if the economy had depended on tourism revenues. The co-efficient of variation calculation confirms this, and it is also the final

result of two focus group discussions, which were organized in 2022. The analysis conducted during the focus group discussions and the results of the established model were presented. The participants agreed that there is a long-term causal relationship between the development of the tourism sector and economic growth. According to the result obtained from our model, a one percent increase in tourism revenues raises the GDP by 0.29%. According to the model established by Azizov (2020) in 2020, a one percent increase in tourism revenues leads to a 0.76% increase in non-oil GDP. Based on results from the focus group discussions, it will be necessary to support the development of several sectors (green energy, ICT, agriculture, etc.) in addition to the tourism sector in countries whose economies depend on oil and gas revenues.

Rapid growth in the economy of Azerbaijan took place mainly in the period of 2005-2010: during this period, the country's economy grew twice. In the following years, the growth rates decreased sharply and an economic growth of only 20% was recorded in the period 2011-2022. Government of Azerbaijan is predicting that total GDP and non-oil GDP will grow on average by 3 and 5%, respectively, in each year from 2022 to 2027, and the tourism sector will grow by an average of 28%. Moreover, Azerbaijan expects to increase the share of tourism in non-oil/gas GDP to 20% by 2027 (Azerbaijan – 2026, 2022).

Note that foreign tourists can play a greater role in the development of the tourism sector in Azerbaijan compared to that of domestic tourists. The country has a population of ten million, but 46% of income is spent on food consumption. Other expenses include education, healthcare, etc.; thus the level of tourism generated by the local population is not high. Despite this, it is necessary to fully realize the existing potential for both domestic and foreign tourism. A main challenge is that two countries (Russia and Georgia) account for more than half of the tourists coming to Azerbaijan. Attracting tourists from high-income countries must be part of the marketing strategy.

6. CONCLUSIONS

Azerbaijan has great potential as a tourist destination, but the country still faces many challenges in the development of its tourism industry. Empirical results show that tourism has a positive effect on economic growth and can play a role in ensuring the sustainability of economic growth. According to the results of causality test made, availability of unilateral causality relation between the tourism revenues and GDP has been confirmed. This outcome indicates that tourism is affected positively by the economic growth. Due to findings, it was defined that 1 % increase in GDP results with 0.285% increase in tourism revenues during the period studied. Thus, this study conducted for Azerbaijan defines that economic growth and development in long period affect tourism sector. Also, our analysis shows that increasing tourism in the economy will have a positive effect in reducing dependence on oil and gas. However, as an oil/gas country, Azerbaijan may face serious challenges if it chooses a development path based solely on tourism in the post-oil/gas era. The COVID-19 pandemic, as in other countries, has not left the tourism sector of Azerbaijan unaffected and has been a negative but important experience for determining the country's future post-oil development strategies. The co-efficient of variation also shows that the risks are higher in dependence on the tourism sector; thus dominance of the tourism sector in the economy carries more risk than dominance of the oil/gas industry (due to the fact that tourism sector is highly vulnerable to direct and indirect unexpected events, crises, incidents). In addition to tourism, Azerbaijan has chosen several other sectors (green energy, ICT, agriculture, etc.) as priority sectors in the post-oil/gas era, a strategy which reduces these risks and contributes more to diversification of the economy.

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DETERMINANTS OF BANKING OPERATIONAL EFFICIENCY AND THE RELATIONSHIP BETWEEN THE FACTORS TO MARKET PRICE: EVIDENCE FROM INDONESIA

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ABSTRACT

Banks play an essential role in the economy, therefore, their performance must be maintained. Compared to other business sectors, the banking sector has continually achieved the greatest market shares over several periods. When a bank becomes more efficient, it can raise its income and market prices as well as investor confidence. This study examines various factors that influence operational efficiency and the implication for market prices. In 2016 – 2021 years, 28 banking companies were sampled from all banking companies listed on the Indonesia Stock Exchange. Purposive sampling was used for data collection, and linear multiple regression was used for data processing by running tests such as descriptive statistics, determination, regression equations, hypotheses, and implications. The findings reveal a statistically significant relationship between a firm's size, capital adequacy, loan-to-deposit ratio, net interest, and inflation with operational efficiency, while non-performing loans and exchange rates have no a substantial impact. Additionally, capital adequacy, loan-to-deposit ratio, inflation, and exchange rates had statistically significant effects on market prices, although operational efficiency, non-performing loans, and net interest did not. The mediating analysis reveals that there is no interaction between non-performing loans and net interest with market prices, but it is a mediator for other variables. The research is important for a variety of stakeholders, including managers, investors, and policymakers, who are interested in resolving banking business operations, increasing financial performance, and preserving market prices by establishing mitigation strategies related to specific-internal and external factors.

Keywords: *size, shares, capital. deposit, performing, interest, inflation, currency*

1. INTRODUCTION

The banking sector has become essential to supporting and fostering the nation's economic growth (Hussein et al., 2022). There is no difference in the fact tht the banking sectors represent the most important financial institutions that play an important role in the development of the economic sector (Vunjak et al. 2020). Given that fact, the banking sector has a multidimnsional impact on the development of the national economy (Topić-Pavković et al., 2022). An efficient banking business will contribute the most to the capital market (Northcott, C. N. 2004). Recently, the capital market in Indonesia has grown significantly with an increasing number of consumers from diverse social groups and income levels. In 2017, there were approximately

500,000 investors, with close to 3.88 million expected by the end of 2021. Banks have the highest capitalization value of any sector listed on the Indonesian Stock Exchange (IDX). This suggests that investors are interested in investing because majority of stock market prices and returns are expected to rise-capital gain.

When a bank becomes more efficient, it can raise competitiveness, profits, market prices and investor reliance. It is thought that both specific-internal and external factors cause had a contributed in the proclivity. Banking companies use a standard metric to assess their operational efficiency, or their ability to control expenses, generate operational income, and maintain market prices (Hughes et al., 2012). The specific-factors are often use to highlight the company performance, including company size, capital adequacy, loan-to-deposit ratio, non-performing loans, and net interest that are suspected to have an impact on efficiency, and market prices. Likewise, two macroeconomic issues-inflation and currency rate are also fathomed can be determined operational efficiency and market prices.

As mention, this study covers various specific factors: Firm-size expansion has always been sustainable and consistent with operating performance, although productive assets cannot generate interest income properly. The asset-based liquidity is significant for banking activities and prices (Bhati et al., 2019); Capital adequacy is a measure of how much capital a bank has available, reported as a percentage of a bank's risk-weighted credit exposures. It is an essential measure of a bank's financial health, indicating its ability to absorb potential losses and meet its financial obligations including to boost efficiency and market shares (Naoaj, M. S., 2023) including the Fixed Effect model, Random Effect model, and Pooled Ordinary Least Square (POLS; One of the most important forms of risk that banks face uncertainty-risk operation; Loan to deposit as a syndicated loan involves two or more lenders issuing a loan to a common borrower under the same contract. (Enkhtaivan & Bolortuya, 2019). Loan defaulters among commercial banks remain high leading to financial distress of the banks.

The lender must absorb all the credit risk alone, receiving all income while at the same time, it must bear all the losses; Non-performing loans are financial pollution that can affect efficiency and economic growth as well as social welfare (Shihong, Z. 2012). The importance of non-performing financing on overall financial performance and not only focus on credit growth for profitability but also on controlled and supervised loan allocation (Altinay et al., 2022); Then, net interest affects the measurement of efficiency and leaves an impression on investors. Earnings from fees and commissions provide the main source of income used by credit institutions to offset the decrease in the interest margin (Dadang, L., 2021). However, related to the share price a percentage unit increase in net margin will decrease the price (Rafaqat et al. 2021). The other sides like inflation can affect operational efficiency as well as market perception. When inflation rises, it will impact on banking lending and the stock market (Boyd et al. 2001); The exchange rate is the standard instrument of analysis in economic and financial environments (Murshed, M., & Rashid, S. 2020). An increase in the foreign exchange rate against the local currency will impact the decline in stock indexes (Tjandrasa et al., 2020). The establishment of efficiency could raise market prices. It can be determined by the ability to minimize risk, maximize profit, and meet market prices (Gabriel, O. et al., 2019).

Given the recent events banking in Indonesia, this study aims to conduct the effect of various bank-specific and macroeconomic factors on efficiency, including the implication to market prices, covering a 6 period from 2016. This study's expected novelty is a longitudinal analysis that could be used as an approach to explain the influence of bank-specific, and macroeconomic factors on banking operational efficiency and the relationship between the factors to market prices. It is, therefore, essential to examine those fundamental factors when it comes to assess-

ing the specific performance and market prices of banking companies.

This paper is organized as follows: the next section is preparing some kinds of literature that have been reviewed, highlights the research design-method, followed by analysis and results, and a conclusion in the home stretch.

2. LITERATURE REVIEW AND HYPOTHESES

The majority of banks that list on the Indonesia Exchange have attained appropriate financial performance that can influence investors' perceptions. (Ulansari et al., 2020). Compared to other sectors, Indonesia's stock market for banking has the highest capitalization. To assess performance, using the essential metric for overall efficiency and market prices. Stock price volatility is generally related with long term debt ratio, earning volatility, asset growth, and size (Nazir et al., 2010). Forecasting accounting earnings and stock returns have long histories in accounting and finance. Commercial banks should also uphold their responsibility in a way that is excessive and proportionate to their actual costs to boost profits and market prices (Obeid R., & Adeinat, M. 2017). Despite the recent or continuing returns, forecasting market prices the forecaster with significant challenges (Green, J., & Zhao, W. 2022). Managers know that if they produce returns that exceed the firm's efficiency, they are creating value for their shareholders (Walker et al., 2021). A bank's disclosure of financial information can affect the willingness of investors to invest (Zogning, F. 2022).

Banking efficiency is a metric that indicates how to increase a firm's value and the scale efficiency measures implying that investors pay much attention to the improvement in bank profitability and future dividends (Alsharif, M., 2021). It must be considerable for a corporation when it faces the uncertainty market (Gabriel, O et al., 2019). Companies with significant efficiency and productivity will increase market prices, and explain why firms exist, how market borders are formed, and why there are disparities in their organizational performance (Pervan, M., & Višić, J. 2012).

Capital adequacy as a bank's risk of assets includes investments, credit, claims on other banks, and financial securities. The term efficiency, particularly in the banking sector, means the best utilization of limited resources with minimum cost and maximum output. (Ullah et al., 2023).

It affects efficiency, profitability, and liquidity (Arseto, D. D., 2022)meaning that profitability is influenced by the Capital Adequacy Ratio (CAR. Bank Indonesia stipulates a capital adequacy ratio of 8% as a minimum capital requirement that must be maintained as a particular proportion of the total risk-weighted assets. This is crucial in light of various variables.

Deposit activity is not as low as credit activity (Bošnjak et al., 2017). Loan-to-deposit is one of the essential factors for achieving profit and can affect both profitability and share prices. On the one hand, as it is based on outstanding volumes, thereby implying that past activities are included in the weights. The quantity of credit and public deposits might impact the market shares. Occasionally, investors make decisions using this proxy. Credit creation is linked to the growth of loan portfolio and loan deposit ratio. A bank creates deposits when cred its borrowers both insiders and outsiders' current accounts with loan proceeds.

Banks have a comparative advantage in providing credit. the main responsibility of financial institutions that is to allocate and multiply the savings of society which they intermediate capital has substantive resonations on the performance.

Net interest represents revenue that generated from banking productive assets. For both domestic and foreign banks, net interest has a variety of implications (Hamadi, H. & Awdeh, A., 2012). The net interest margins referred to in this box relate only to loans to and deposits from the nonfinancial private sectors. In terms of operational efficiency and market prices, low in-

terest rates do indeed significantly increase bank risk-taking (Saksonova, S. 2014). Structural changes in a bank's net interest income–or, conversely, in its net interest margin–have a significant impact on its efficiency and profit and are likely to lead the bank's investors and has a considerable effect on market prices (Busch et al., 2017).

Rising prices and a slow decline in purchasing power are two characteristics of the phenomenon known as inflation. Inflation targeting policy needs to be maintained. (Alkhaliq B., & Cili, M. R. 2022). In general, inflation became one of the serious matters over a period of time (Islam & Rabiul, 2017). The profit margin will increase when the inflation rate rises and investors become more interested in investing in the stock market. Substantially, it can affect the market share prices. A swapped exchange rate is used to determine how much a certain nation's currency is worth. An exchange rate is the price of one currency expressed in terms of another currency or group of currencies. (Hamilton, A. 2018). The exchange rate risk which occurs every time cause the company to have to face payment obligations in the future in foreign currency. (Anindhita, A. Y., 2017). It could have an impact on market supply and demand as well as be tied to the value of a certain nation. If the currency strengthens, the operational cost will decrease and market prices move up. Although the market stock price will decrease and operational costs will rise, investors' perceptions are going to decline.

As known, this study addresses assessing how certain specific-internal and external factors affect operational efficiency and the implications for market share prices. The bank's performance is a component that is heavily taken into account; hence, it is quite necessary to conduct a study and look for a relationship between these aspects. The purpose of this study is to examine how firm size, capital adequacy, loan-to-deposit, no-performing loans, net interest, inflation, and currency affect operational efficiency and how those factors to have an implication on market share prices, as formulated in the following hypothesis:

H1: Firm size influences on operational efficiency
H2: Capital adequacy influences on operational efficiency
H3: Loan to deposit influences on operational efficiency
H4: Non-performing loan influences on operational efficiency
H5: Net margin influences on operational efficiency
H6: Inflation influences on operational efficiency
H7: Exchange rate influences on efficiency
H8: Independent variables influence on operational simultaneously
H9: Firm size influences on operational market price
H10: Capital adequacy influences on market price
H11: Loan to deposit influences on market price
H12: Non-performing loan influences on market price
H13: Net margin influences on market price
H14: Inflation influences on market price
H15: Exchange rate influences on market price
H16: Independent variables influence on market price simultaneously

3. METHODOLOGY

3. 1. DATA AND SAMPLE

This study employs a quantitative approach to investigate the effect of specific-internal and external factors on operational efficiency and the implications for market shares in commercial banks in Indonesia. Secondary data was obtained from the websites of 28 companies sampled for the 2016–2021 period, yielding a total of 168 data observations. All of the data used is cross-sectional and time-series from those banking companies. Purposive sampling is used to select companies that meet the following criteria: (1) They were listed on the Indonesia Stock Exchange during the study; (2) They had annual reports published during the research; (3) There had been no mergers or initial public offerings during the study.

3. 2. VARIABLE MEASUREMENT

As previously stated, independent variables are firm size (FS), capital adequacy ratio (CAR), loan-to-deposit ratio (LDR), non-performing loan (NPL), net interest margin (NIM), inflation, and exchange rate, while operating efficiency is the dependent variable for research model 1. The factors utilized in research model 1 that are also used in research model 2 including operational efficiency-also as an intervening variable, and market price as dependent variables. Table 1 indicates that every variable utilized in this study were measured by using a variety of indicators.

Table 1. Operational parameters

No	Variables	Concepts	Measurements	Scales
1	Market price-Share return	A stock return is an indicator that assesses the exchange of stock prices and explains the return obtained of market value shifted.	Percentage of share prices value distinction	Ratio
2	Operation efficiency	The level of a bank's efficiency and capability in conducting operations activities can be gauged by comparing total operating costs to total operating income.	OCOI = Operating Costs to Operating Income	Ratio
3	Firm-size	The size scale that can be measured by the total assets with the aim of producing goods and services.	Firm size = Total Assets	Nominal
4	Capital adequacy ratio	A Capital Adequacy Ratio is a minimum capital provision based on assets and risk weight	CAR = Total Capital to risk weighted assets.	Ratio
5	Loan to Deposit Ratio	That shows a bank's ability to cover loan losses and withdrawals by customers	LDR = Total Loans to Total Deposits	Ratio
6	Non-performing loan	As a bank's loan that are to late repayment or unlikely to be repaid by the borrower.	NPL = Total NPL to Total Credit	Ratio
7	Net interest margin	Net Interest Margin is a measure of net interest income by using the productive assets.	NIM = Interest income to Productive assets	Ratio
8	Inflation rate	The indicator describes the tendency of the general price level of goods and services to increase in the market	Inflation = Price Index – Price index/ Price Index x 100%	Ratio
9	Exchange rate	The exchange rate of the rupiah against the United States dollar	Exchange Rate = ER2 – ER1 / ER1	Ratio

Source: Prepare by Author

3. 3. DATA ANALYSIS METHOD

In this inquiry, the regression analysis method is applied. The Chow, Hausman, and Langrage tests were used to determine which model as the best among the Common Effect Model, Fixed Effect Model, and Random Effect Model. For traditional presumptions; tests for normality, autocorrelation, heteroscedasticity, and multicollinearity were performed. The purpose of the hypothesis examinations is to look for those components' influences. The regression models are built as follows:

Research model 1:

$$OCOI_{it} = \alpha + \beta 1FS_{it} + \beta 2CAR_{it} + \beta 3LDR_{it} + \beta 4NPL_{it} + \beta 5NIM_{it} + \beta 6INFi_{t} + \beta 7ER_{it} + \varepsilon$$

Research model 2:

$$SR_{it} = \alpha + \beta 1OCOI_{it} + \beta 2FS_{it} + \beta 3CAR_{it} + \beta 4LDR_{it} + \beta 5NPL_{it} + \beta 6NIM_{it} + \beta 7INFi_{t} + \beta 8ER_{it} + \varepsilon$$

Where:

OCOI = Operational efficiency
SR = Share Return
α = Beta coefficient of constant -intercept.
β = Beta coefficient of independent variables.
FS = Firm Size
CAR = Capital Adequacy Ratio
LDR = Loan to Deposit Ratio
NPL = Non-Performing Loan
NIM = Net Interest Margin
INF = Inflation
ER = Exchange rate

4. RESULTS

4. 1. STATISTICAL DESCRIPTION

With a total of 168 data observations, this study used multiple techniques to represent the overall data, including mean, median, maximum, minimum, and standard deviation (Table 2).

Table 2. Statistical description of the research variables for the period 2016 – 2021

	SR	FS	OCIO	CAR	LDR	NPL	NIM	INF	ER
Mean	0.065025	0.08107	0.810738	0.250506	0.824175	0.04589	0.050638	0.029169	0.022438
Median	0.041000	0.83350	0.833500	0.211000	0.862000	0.03581	0.049000	0.031000	0.011500
Maximum	1.114000	1.19400	1.194000	1.171000	1.135000	0.05461	0.095000	0.036000	0.109000
Minimum	-0.441000	0.10100	0.189000	1.131000	0.042000	0.01256	0.011000	0.017000	-0.041000
Std. Dev.	0.240538	0.16359	0.163594	0.179105	0.161761	0.07810	0.017432	0.006120	0.052232
Skewness	0.068295	-1.7576	-1.757648	1.364123	-1.503070	-0.09321	-0.092633	-1.058955	0.457754
Kurtosis	5.163968	8.12414	9.804680	22.26984	6.919961	4.20932	3.232328	2.968562	1.878415
Jarque- Bera	31.34276	21.25897	25.74275	298.3394	62.16865	13.4892	10.58865	29.91021	13.97405
Probability	0.000000	0.00000	0.000000	0.000000	0.000000	0.00239	0.005029	0.000000	0.000924
Sum	10.40400	12.9718	12.97180	40.08100	131.8680	7.09281	8.102000	4.667000	3.590000
Sum Sq. Dev.	19.19954	42.5533	4.255305	5.100492	41.60473	0.03857	0.048317	0.005954	6.433783
Observation	168	168	168	168	168	168	168	168	168

Source: eviews output

The above statistical description will clarify as follows:

In 2016, BC had the greatest share return of 1.1140, while QNBI had the lowest share return of 0.4410, with an average value of 0.0650 and a median of 0.0410. The OCOI variable had a minimum value in 2018 of 0.189 at Bank CIMB and a maximum of 1.194 at Bank SM in 2020, with an average value of 0.8107, a median of 0.8335, and a standard deviation of 0.1635. When referring to the regulation of the Central Bank, the OCOI is around 92%, and all of the banks reviewed are within a regulated range. The maximum value of CAR is 1.1173 was obtained by Bank SM in 2019 year, while the minimum value of 0.1310 was obtained by Bank Maya in 2016, with an average value of 0.2505, and a median of 0.2110. According to the minimum capital adequacy requirement, banks must have capital that is at least 8% of their risk-weighted assets (RWA). It is reasonable to conclude that the overall CAR performance of the 28 banks under review met the Central Bank regulation's minimum standard of 8%. In 2022, the savings bank reached the LDR's maximum value of 1,135. The minimum value was obtained by BTPN of 0.0420, with an average of 0.8241, a median of 0.8620, and a standard deviation of 0.1617. In line with the Central Bank's regulations. Demand deposits are made by commercial banks and must be approximated into designated categories. The NIM variable had a maximum value of 0.0950 obtained by Masp. Bank in 2017 and a minimum value of 0.0110 obtained by the BTPN in 2016, with an average value of 0.0506, a median of 0.0490, and a standard deviation of 0.1617. The regulation states that the maximum ratio must be greater than 6%. So, it might be possible to prevent a bank from getting into trouble. The inflation rate had a minimum value of 0.0170 (1.70%) and a maximum of 0.0360 (3.60%), with a median of 0.0310 and an average rate of 0.0291. According to the Authority, during the years 2016–2021, the inflation rate was below the 5% statutory limit during 2016 – 2021. The minimum rate for the USD exchange rate is 0.1090, the average is 0.0224, the median is 0.0115, and the standard deviation is 0.0522.

4. 2. STATISTICAL ANALYSIS OF DETERMINANTS ON OPERATIONAL EFFICIENCY (RESEARCH MODEL 1)

The appropriate regression model was selected as revealed in Table 3, and using Random Effect Model shown in Table 4. This was done before the regression test would be conducted.

Table 3. The results of selecting the best regression model-for research model 1

Type of tests	Results	Selected
Uji Chow (FEM vs CEM)	Cross Section Chi Square 0,0000 < 0,05	Fixed Effect Model
Uji Hausman (FEM vs REM)	*Cross Section Chi-random* 0,7295 > 0,05	Random Effect Model
Uji Langrage Multiplier (REM vs CEM)	Cross Section Breusch Pagan 0,0000 < 0,05	Random Effect Model
Conclusion		Random Effect Model

Source: eviews output

Table 4. REM for research model 1

Dependent Variable: OCOI
Method: Panel EGLS (Cross-section random effects)
Sample: 2016 – 2021
Periods included: 6
Cross-sections included: 28
Total panel (unbalanced) observations: 168
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.886039	0.213765	0.870300	0.3855
FS	1.585791	4.401513	2.360283	0.0191
CAR	3.199068	0.248698	-3.100441	0.0007
LDR	1.697281	2.606269	0.268231	0.7889
NPL	-0.712805	8.751705	0.424402	0.6719
NIM	1.644773	0.758847	2.849674	0.0018
ER	0.050864	0.047621	1.068091	0.2871
INF	2.982048	0.282897	-2.996999	0.0203
R-squared	0.780417	Mean dependent var		2.130789
Adjusted R-squared	0.775521	S.D. dependent var		0.535332
S.E. of regression	0.542120	Akaike info criterion		1.671691
Sum squared resid	45.84746	Schwarz criterion		1.859160
Log likelihood	-128.7503	Hannan-Quinn criter.		1.747786
F-statistic	8.543765	Durbin-Watson stat		2.969006
Prob(F-statistic)	0.000719			

Sources: eviews output

4. 3. STATISTICAL ANALYSIS OF DETERMINANTS ON SHARE RETURN (RESEARCH MODEL 2)

To select the compatible model of determinants on share return, the best model was obtained in Table 5, namely Common Effect Model, in Table 6.

Table 5. The results of selecting the best regression model-for research model 2

Type of tests	**Results**	**Selected**
Uji Chow (FEM vs CEM)	Cross Section Chi Square 0.4159 > 0,05	Common Effect Model
Uji Hausman (FEM vs REM)	*Cross Section Chi-random* 0.0003 < 0,05	Fixed Effect Model
Uji Langrage Multiplier (REM vs CEM)	Cross Section Breusch Pagan 0.3596 > 0,05	Common Effect Model
Conclusion		**Common Effect Model**

Sources: eviews output

Table 6. CEM for research model 2

Dependent Variable: SR
Method: Panel Least Squares
Sample: 2016 – 2021
Periods included: 6
Cross-sections included: 28
Total panel (unbalanced) observations: 168

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.851371	0.302140	4.211799	0.0000
OCOI	0.307242	0.055095	2.576548	0.0040
FS	2.291330	1.228181	8.865630	0.0000
CAR	4.044683	0.070070	-3.637692	0.0046
LDR	1.602486	0.705314	-4.689827	0.0003
NPL	0.350905	2.467605	0.953316	0.3419
NIM	0.092672	1.092008	-0.038917	0,8972
ER	-3.002081	0.005128	-2.405859	0.0054
INF	1.020167	0.013338	5.512034	0.0005
R-squared	0.839886	*Mean dependent var*		1.825084
Adjusted R-squared	0.826250	*S.D. dependent var*		0.183618
S.E. of regression	0.152939	*Akaike info criterion*		-0.864869
Sum squared resid	3.672262	*Schwarz criterion*		-0.696147
Log likelihood	80.78413	*Hannan-Quinn criter.*		-0.796384
F-statistic	10.10471	*Durbin-Watson stat*		3.002474
Prob(F-statistic)	0.000000			

Source: eviews output

Table 7. The results of selecting the best regression models for research model 1 and 2

Hip	Descriptions	Coeffi-cients	T - F counts	Prob.	Conclusions
H1	FS → OCOI	1.5857	2.3602	0.0191	Significant positive
H2	CAR → OCOI	3.1990	-3.1004	0.0007	Significant positive
H3	LDR → OCOI	1.6972	0.2682	0.7889	Not significant
H4	NPL → OCOI	-0.7128	0.4244	0.6719	Not significant
H5	NIM → OCOI	1.6447	2.8496	0.0018	Significant positive
H6	ER → OCOI	0.0508	0.0680	0.2871	Not significant
H7	INF → OCOI	2.9820	-2.9969	0.0203	Significant negative
H8	FS, CAR, LDR, NPL, NIM, IT, ER, INF → OCOI	R^2 = 78.04%	8.5437	0.0007	Significant
H9	OCOI → SR	0.3072	2.5765	0.0040	Significant positive
H10	FS → SR	2.2913	8.8656	0.0000	Significant positive
H11	CAR → SR	4.0446	-3.6376	0.0046	Significant positive
H12	LDR → SR	1.6028	-4.6898	0.0003	Significant positive
H13	NPL → SR	0.3509	-0.9533	0.3419	Not Significant
H14	NIM → SR	0.0926	-0.0389	0.8972	Not significant
H15	ER → SR	-3.0020	-2.4058	0.0054	Significant negative
H16	INF → SR	1.0201	5.5120	0.0005	Significant positive
H17	OCOI, FS, CAR, LDR, NPL, NIM, IT, ER, INF → FS	R^2 = 83.98 %	10.1047	0.0000	Significant

Source: eviews output

4. 4. LINIER REGRESSION EQUATIONS

A linear regression equation was employed to find the coefficient values of each independent variable. This equation is applied to determine how independent variables effect on efficiency -or share returns. The regression equation in Table 5 is as follows:

$$OCOI = 0.8860 + 1.5857FS + 3.1990CAR + 1.6792LDR - 0.7128NPL + 1.6447NIM - 2.9820INF + 0.0508ER$$

$$RS = 2.8513 + 0.3072OCOI + 2.2913FS + 4.0446CAR + 1.6028LDR + 0.3519NPL + 0.0926NIM + 1.020INF - 3.0020ER$$

Interpretation:

The OCOI remains at 0.8860 if the other variables are zero, conforming to the constant value of research model 1 of 0.8860. The coefficient value of FS is 1.5857. Hence, if the other factors remain constant, a 1% change in FS will result in a 1.5857% decrease in the OCOI. The constant value for research model 2 is 2.8513, the OCOI coefficient is 0.3072, and it is predicted that the other variables will remain constant. As a consequence, every 1% change in this variable will increase SR by 0.3072%. For the other variables, it can be conducted for the same reason.

4. 5. HYPOTHESIS TESTS

The regression panel data was estimated using a random effects model for research model 1. Table 4 shows that variables FS, CAR, NIM and INF have a significantly positive effect on OCOI,

whereas factors LDR, NPL, and ER have no a considerably effect on OCOI. The simultaneous results (F-test) indicate that all independent factors have an impact on OCOI with a probability value of 0.000. The goodness of the fit test demonstrates that overall independent variables can be determined with an SR of 78.04% based on the coefficient of determination R2. While other factors not considered in this study account for or determine 31.96% of the variance.

According to research model 2 with the Common Effect Model (Table 6), some factors have a statistically significant impact on RS. There are OCOI, FS, CAR, LDR, ER, and INF. While other variables such as NPL and NIM have no impact on RS. Owing to the adjusted coefficient of determination R2, these variables may explain RS to a value of 83.98%, while other factors do not account for 16.08%.

4. 6. THE ROBUSTNESS IMPLICATION TEST

The Sobel test was utilized to determine whether there was an established connection between endogenous (internal and/or external) factors and market prices through operational efficiency. By multiplying each beta coefficient of the independent variable (M-1) with the coefficient value of the intervening variable OCOI, it was possible to determine whether there were any direct or indirect influences on the relationship between the two sides. The coefficient of indirect impact is expressed as OCOI x M-1. The two results are compared to determine the direct influence. (M-2). It can be argued that independent factors have an indirect effect on stock returns through the intermediary variable if the indirect coefficient exceeds the direct coefficient and vice versa. The robustness implications are shown in Table 8 when OCOI is used as an intervening variable.

Table 8. The intervening robustness test

Variables	Coefficient of beta M-1	Indirect impact (OCOI x M-1)	Coefficient of direct impact M-2	.
FS	1.5857	0.4871	1.3709	OCOI as an intervening
CAR	3.1990	0.9827	0.6342	OCOI is an intervening
LDR	1.6972	0.5217	0.3008	OCOI is an intervening
NPL	-0.7128	-0.2726	-0.2189	OCOI is not an intervening
NIM	1.6447	0.5052	0.9565	OCOI is not an intervening
ER	0.0508	0,0156	-0.3992	OCOI is an intervening
INF	2.9820	-0.8160	-0.8458	OCOI is an intervening
OCOI	0.3072			

Source: eviews output

Research model 2 reveals that NPL and NIM are unrelated to share price or stock return. This is confirmed by the robustness test in Table 8, which also serves as more evidence that OCOI is not mediating between each side. OCOI, however, is a mediator between FS, CAR, LDR, ER, and INF and the market price. These results verify the findings of the second investigation model.

5. DISCUSSION

According to the aforementioned findings and justifications, it is established that an assortment of variables has a substantial impact on operational efficiency. Firm size has a significant impact which implies that obtaining efficiency is considerably influenced by the size of assets. By reducing operating costs, it is essential to expand firm operations and generate business income.

Investors might also evaluate a firm based on its assets in making investing decision.

Capital adequacy and operational efficiency are significantly related. Risk-weighted assets and total capital are used to determine whether a bank's capital is sufficient. If this adequacy declines, banks will become less efficient. In Indonesia, adequacy was set at 8%. Overall banks studied reached that target. Banking managers must conform and consistently preserve that level above the provision. This indicator is useful for investors when making investments.

To determine a bank's liquidity throughout a certain period, the loan-to-deposit ratio is used to compare the total loan to customers' deposits. This study disproves the association between loan-to-deposit and operational efficiency. Providing loans will generate interest income, but receiving savings or deposits will incur interest expenses. However, this study states that there is a significant influence between loan deposits and market share. Investors must be aware of this circumstance and how it may impact their decision to invest. This is to ensure they can evaluate the quality of liquidity and effectiveness of banking intermediation by utilizing this measurement.

As is known, a non-performing loan refers to the amount of bank loans. In the financial crisis, borrowers will face difficulties making their instalment payments on time. Even though many banks are concerned about increasing that performance, it has had no impact on operational efficiency. Additionally, since this factor indicates no discernible relationship to market prices, investors consider it can't be affected.

Even though currency fluctuations have an impact on banking operations, this study revealed that the exchange rate had no statistically significant effect on banking operational efficiency. Due to the unpredictability of the indigenous currency, growing import costs may result in increased costs for goods and services. Foreign market competition will reduce demand for banking services, but it is unlikely to have a significant effect on the way they'll be run. However, this study reveals a negative substantial relationship between the exchange rate and market prices. This invention can be helpful because as the price of the currency declines, investors are more likely to invest in stocks, which raises the price of market share, and vice versa.

Indonesia's inflation rates were stable during this study. When prices are rising, people will stop producing, purchasing, and spending money. This might have an impact on the bank's operational income and escalate to increased expenses. When inflation rates exceed a certain threshold, financial performance will be impacted. In all likelihood, this study suggests that economies with high inflation rates will increase market share price movements.

Operational efficiency is examined to find out if it can act as a mediator between independent and dependent variables. The robustness test determines and validates research model 2's conclusion that non-performing loans and net margin are unrelated to share returns. As a result, operational efficiency is not a mediator between these two variables and share returns. Operational efficiency is used as an intermediary variable for other factors like firm size, capital adequacy, loan-to-deposit ratio, currency, and inflation.

6. CONCLUSIONS

A banking system is closely related to managing those specific-internal and external factors. Managing and controlling the operating business processes, including financial performance, is very substantial. The results of research model 1 revealed that firm size, capital adequacy, net interest, and inflation have a substantial effect on operational efficiency. Whereas loan-to-deposit, non-performing loans, and currency have no statistical effect. In managing operational efficiency, both internal and external factors should be identified and anticipated. Yet, due to the market price, non-performing loans and net interest as internal factors have no a statistically

significant impact, while the other variables, including two external factors, have a considerable influence.

Based on the findings, the following recommendations are proposed: Those results can be used to create business plans for enhancing banking financial performance, such as the implementation of business rules into banking activities to achieve efficiency and business competition. The regulator must carry out the necessary policies in controlling banking operations, keep track of and comprehend the actions, and contribute as development agents and financial intermediary institutions. In addition, investors need to monitor their financial performance to reduce unnecessary risks. Making an investment selection is essential for minimizing risks and increasing returns related to both internal and external factors.

To the best of our knowledge, it is the only accessible proxy for assessing the financial performance of the sample companies. There are some limitations, including the use of the conventional operational cost-to-operating income approach to quantify operating efficiency. It is suggested that non-parametric data envelopment analysis be employed, which could result in more precise outcomes. Additionally, the results might not fully represent Indonesian banking as a whole, the research periods are short, and they might also not be flawless models. For the future, studies should improve methodologies, add research variables and periods, and include proactive mitigation, which also entails paying closer attention to banking performance.

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DETERMINANTS OF THE INFLATION RATE: EVIDENCE FROM PANEL DATA

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ABSTRACT

This study analyzes the relationship between macroeconomic factors that affect the inflation rate. Through our research, we will analyze the impact of money supply growth, economic growth, import level and export level on the inflation rate for 40 countries that we have taken. There are: 6 Latin American countries, 2 Western Balkan countries, 19 European countries, 10 countries of Asia, 2 countries of Africa and Australia, within 12 years, from 2012 to 2023. The data for the execution of the work were obtained from the World Bank as a credible institution for the publication of statistics and Trading Economics, Another important institution in terms of statistics where 320 observations which are included in the analysis, so the data of this study are second-hand data. Since we have a group of study countries, then the data type of the study is Panel. The econometric model that we used for analysis is the model with the method of small squares. The findings of this paper show that countries that increase the money supply will also face an increase in the inflation rate, so the impact of the money supply on the inflation rate is positive. In the research countries, the results show us that we have a very small difference in the average import and export, which results in a very small average economic growth.

Keywords: *Inflation rate, Money supply, Import, Export*

1. INTRODUCTION

Inflation has consistently posed significant challenges to both developed and developing economies. The pervasive and evolving nature of inflation not only impacts economies but also affects the daily lives of consumers and the strategic decisions of businesses. According to Dornbusch and Fischer (1994), inflation indicates that "your money will not be able to buy today as much as it could buy yesterday". Such periods of inflation often lead to discontent among the public, especially when incomes do not adjust at the same pace as rising prices.

Research on inflation's causes and effects has spanned several decades, but the specific factors contributing to it in different regions remain a subject of debate. This ambiguity becomes even more pronounced when analyzing countries with diverse economic characteristics, such as those in Latin America, Europe, Asia, and Africa.

The fact that esteemed international financial bodies such as the World Bank and the IMF are forecasting that global economic growth for this year will hit its lowest point in the past three decades is a source of significant concern. It should serve as a clear warning for the entire global community. Alongside the nearly unbridled surge in inflation and the upward trajectory of interest rates, unexpected developments like the declaration of a banking and financial crisis in the United States, the ongoing conflict in Ukraine, and the deepening geopolitical tensions involving the USA, Russia, and China are all contributing factors to long-term risks that were challenging to foresee (Đukić, 2023).

The core challenge this study seeks to address is understanding the influence of various driving variables on the inflation rate, with a special focus on regions that have not been extensively studied. To this end, this research aims to evaluate the impact of factors like money supply, economic growth, and trade balances (import and export) on inflation rates in a selection of 40 countries. These countries, chosen for their diverse economic landscapes, span across six regions and over an 11-year period (2012-2023).

This paper addresses a range of significant issues related to inflation, offering valuable contributions to the field of economics. Firstly, it delves into the complex problem of inflation's impact on both developed and developing economies. Inflation is a pervasive economic phenomenon that affects the lives of everyday individuals and shapes the strategic decisions of businesses. By examining the evolution of inflation and its consequences, the paper contributes to a better understanding of this multifaceted issue. Secondly, the paper recognizes the problem of regional variations in inflation. It acknowledges that the causes and effects of inflation can differ significantly across diverse economic regions, such as Latin America, Europe, Asia, and Africa. This variation is a critical problem in economics that requires careful analysis to inform effective policy-making. By selecting 40 countries from these regions for study, the paper aims to shed light on the unique dynamics of inflation in less-explored areas, making a valuable contribution to the literature. Lastly, the paper addresses the problem of the role of central bank policies in influencing inflation rates. It acknowledges that central banks have a crucial role to play in managing inflation through adjustments in money supply.

By delving into these particular regions and timeframe, this study contributes to the literature in two significant ways:

(i) Providing insights on inflation trends in countries that have not been at the center of most inflation studies.
(ii) Analyzing the role of central bank policies in influencing inflation through money supply adjustments across these nations.

The research is divided into the following sections and subsections: an introduction, a review of the literature from a theoretical perspective, a description of the methodology and an elaboration of the econometric model, and finally a statistical analysis of the inflation rate. The econometric results of the STATA program will be reported in the following paragraphs, and conclusions and suggestions will be given at the end.

2. LITERATURE REVIEW

Research has repeatedly underlined the role of money supply and exchange rate adjustments in influencing inflation, especially in developing countries. Swagel et al. (2001) analyzed data from 53 developing nations spanning 1964 to 1998 and concluded that these factors predominantly steer the inflationary processes in emerging economies. A common thread in empirical studies has been the examination of the relationship between inflation and the exchange rate

regime. In a comprehensive study covering 59 countries, Al Sabaey (2012) differentiated between the primary variables affecting inflation in affluent versus developing nations. The research indicated that for industrialized countries, inflation was majorly influenced by factors like government spending, money supply augmentation, oil prices, interest rates, and population growth. In contrast, for developing countries, the main culprits were the growth in money supply, fluctuations in global oil prices, and nominal effective exchange rates.

Bilgrami and Maryam (2022) and Beckmann et al. (2022) both focus on elucidating the determinants of inflation, albeit in differing geographies and through varying lenses. Bilgrami and Maryam's study centers on South Asian economies, particularly Pakistan, India, Bangladesh, and Sri Lanka. Utilizing World Bank panel data from 1980–2020 and deploying the Robust System GMM model, their research reveals that trade factors, notably the current account balance and exchange rates, are crucial drivers of inflation in these nations. Moreover, the Real Interest Rate (RIR) is identified as another determinant influencing inflation in this regional context. Their findings underscore the need for these countries to factor in these determinants when formulating inflation-controlling policies. On the other hand, Beckmann et al. embark on an exploration of inflation expectations within the G7 economies. They recognize the paramount importance of these expectations in influencing monetary policy transmission, especially in the age of unconventional monetary policies. The Bayesian VAR analysis of survey data from Consensus Economics unveils that professional inflation expectations in the G7 are significantly swayed by international spillovers, primarily originating from the United States. This influence of the US, especially its monetary policy, further echoes in the impulse-response functions and forecast error decompositions. Additionally, determinants like oil price shocks, changes in the trajectory of monetary policy, and fluctuations in uncertainty measures have notable impacts on inflation expectation updates. Connecting the two works, it's evident that both studies underscore the multifaceted determinants of inflation and its expectations. While Bilgrami and Maryam highlight the profound role of trade-related factors and interest rates in South Asia, Beckmann and colleagues shed light on the pronounced influence of international spillovers, especially from a hegemonic economy like the US, on the G7 nations. This juxtaposition offers a comprehensive insight, emphasizing both regional-specific and global factors impacting inflationary trajectories. Moreover, both studies accentuate the importance of understanding these determinants to craft effective monetary and fiscal policies tailored to specific economic contexts.

A strong connection between economic growth and factors influencing exports is evident from the works of Gylfason (1997). The study underscored that high inflation often coexisted with subdued economic growth and a surplus of natural resources. Gylfason's research leveraged various statistical tools to discern the correlation between export propensity and a myriad of factors like population, per capita income, and primary exports. Delving into a country-specific scenario, Okpe (2021) studied Nigeria's economy, particularly examining the interplay between inflation and its food import-export dynamic. Utilizing data from 1981 to 2017 and employing the vector error correction model, Okpe found that inflation was beneficial for food imports but had an inverse relationship with the country's exports. In summary, the literature broadly suggests a multifaceted relationship between inflation, money supply, and various economic variables, which differ across developed and developing nations. These insights guide our approach to the current research, framing our analysis of the factors driving inflation across diverse regions.Using monthly time series data for Bangladesh's economy from 1994 to 2011, Muki (2014) examines the relationship between inflation and export and import. The notion of cointegration, an error correction model, and variance decomposition analysis were used in this study to ascertain the long-run and short-run correlations between the variables. To investigate

causal connections, the Granger causality test was applied. Research using the cointegration technique shows that over the long run, a 1% increase in imports and exports causes a 3.21% increase and a 1.91% decrease in inflation, respectively. The annual deviation of the inflation rate from the long-term equilibrium level of 0.09% is corrected based on the estimated error correction coefficient. Export had the biggest impact on inflation among the elements of the inflation system, according to the variance decomposition data. Granger causality research indicates that there is unidirectional causality between inflation and import as well as between inflation and export.

Understanding the relationship between inflation and economic growth has been a focal point of several studies. Xiao (2009) explored this relationship in China from 1978 to 2007 using a variety of statistical methods, concluding that inflation and economic growth are inextricably linked over the long term. Similarly, Behera's 2014 study on South Asian countries found a significant correlation between the two variables, though the long-term relationship varied across countries. One consistent takeaway from these studies is that rapid economic development can sometimes lead to temporary inflationary pressures, and nations often consider price levels in their economic growth strategies. The causes of inflation and their macroeconomic implications have also received significant attention in the literature. Van (2019) stressed that inflation, as a currency phenomenon, often results from the monetary policies of countries, echoing views of renowned economists like Marx, Fisher, and Friedman. The consistent narrative here is that inflation often emanates from an unchecked increase in the money supply.

Further widening the lens, research has evaluated how trade dynamics influence inflation. Ulfa's 2018 study on Indonesia between 1990 and 2016 discovered a pronounced positive impact of imports on inflation, whereas exports exerted a more subdued influence. Such findings are paramount for policymakers aiming to strike a balance between fostering trade and maintaining inflationary stability. Moreover, Korkmaz (2017) analyzed nine Mediterranean countries, emphasizing the crucial role of monetary authorities in controlling money supply to achieve macroeconomic goals. While there was a one-way causality between money supply and inflation, the same was not true for economic growth, underscoring the nuanced relationship between these variables.

Lastly, Yilmazkuday (2013) provided a distinctive perspective by identifying specific inflation thresholds, beyond which various economic determinants affect growth differently. The study detailed optimal inflation ranges for maximizing benefits from factors such as the catch-up effect, human capital, financial development, government size, and trade. In essence, the literature consistently demonstrates a multifaceted relationship between inflation, economic growth, and various determinants across different regions and timeframes. These insights provide a solid foundation for further exploration in this domain.

The intricate relationship between inflation and economic growth has been the subject of numerous academic pursuits. For instance, Xiao's (2009) evaluation of China's economic dynamics from 1978 to 2007 revealed a long-term beneficial relationship between inflation and growth, hinting at China's consideration of price levels during economic expansion. A parallel can be drawn with Behera's 2014 examination of South Asian countries, where a significant correlation was identified between these two variables. However, the nuances of these relationships differ across nations, highlighting the complexity of the inflation-growth dynamic.

Contributing to the discourse on inflation's origins, Van (2019) noted that inflation often arises from certain monetary policies, a sentiment shared by notable economists like Marx, Fisher, and Friedman. This shared viewpoint elucidates inflation as a product of unchecked increases in the money supply. Exploring the intersection of trade and inflation, Ulfa (2018) discovered a nuanced influence of imports and exports on Indonesia's inflation. This research accentuates the importance of understanding trade dynamics in inflation considerations, as imports, in this case, had a more pronounced effect than exports.

Both Iqbal et al. (2022) and Ridwan (2022) delve deeply into the determinants of inflation from differing yet intersecting perspectives. While Iqbal and colleagues emphasize the Pakistani context, assessing the influence of variables such as GDP, money supply (M2), oil prices, and exchange rates on inflation, Ridwan adopts a more generalized approach, investigating the broader monetary and macroeconomic factors that impact inflation. A common thread between these studies lies in their recognition of the monetary sector's pivotal role in influencing inflation. Iqbal et al. notably point out the significance of the money supply (M2) and its positive impact on the Consumer Price Index in the long run, aligning with Ridwan's assertion that adept management of economic instruments, particularly within the monetary sector, can help mitigate inflation's repercussions. Ridwan's emphasis on the circulation of money, both in trade activities and savings, offers a complementary lens to Iqbal et al.'s focus on Pakistan-specific monetary factors. Furthermore, the methodologies of both works lean heavily on econometric analyses – with Iqbal et al. using the ARDL approach and the ADF test for stationarity, and Ridwan employing regression analysis on secondary data. These analytical methods allow both studies to produce evidence-based insights, illuminating the intricate connections between monetary dynamics and inflationary outcomes. Lastly, the studies underscore the intricate and gradual nature of inflation. While Iqbal et al. spotlight the complexities and interplays of inflationary factors within Pakistan, Ridwan emphasizes the prolonged and slow emergence of inflation influenced by financial and economic changes. These shared insights suggest that regardless of the geographical or economic context, inflation is a multifaceted phenomenon that requires a deep understanding of both macroeconomic and monetary determinants.

Korkmaz (2017) analysis of Mediterranean countries unveiled another layer of this multifaceted relationship. While there was a discernible causality between money supply and inflation, the linkage between money supply and economic growth remained elusive, underscoring the complexities of these macroeconomic variables. Building upon this, Yilmazkuday (2013) offered an innovative angle by delineating specific inflation thresholds that influence economic growth determinants in varied manners. This exploration brings to the forefront the significance of maintaining inflation within optimal bounds to harness its potential benefits. Collectively, these studies weave a narrative that underscores the multifarious relationship between inflation, economic growth, and other pivotal determinants.

In recent years, the significance of monetary policy has grown considerably due to a range of economic challenges affecting both developing and developed nations. According to a recent article authored by Ahmić and Isović (2023), which examines shifts in the European Union's monetary policy conducted by the European Central Bank, it is underscored that there has been a rise in interest rates aimed at curbing the upward movement of inflation's core rates. Specifically, the European Central Bank increased the refinancing rate from 0.5% to 2.5% in 2022 and terminated asset purchase initiatives, such as the Pandemic Emergency Purchase Program, which had previously acted to boost liquidity levels.

3. METHODOLOGY

In this work, we are based on empirical research methodology where we aim to measure the impact of independent variables on the inflation rate. These independent variables are: Market Money Supply, Economic Growth, Export, Import, Dummy GDP and Dummy Country. This study was carried out for 40 countries which are: 6 Latin American countries, 2 Western Balkan countries, 19 European countries, 10 countries of Asia, 2 countries of Africa and Australia, within 12 years, from 2012 to 2023. The data will be imported from the database of the World Bank, trading economics, as more serious and credible institutions for the publication of statistics.

3. 1. ECONOMETRIC MODEL

To measure the impact of independent factors on the inflation rate, we used this econometric model:

$$\textit{Inflation rate} = \alpha + \beta 1\ \textit{(Money supply in the market)} + \beta 2\ \textit{(Economic growth)} + \beta 3\ \textit{(Import)} + \beta 4\textit{(Export)} + \textit{Ui} \quad (1)$$

The inflation rate is the dependent variable of the study, while the variables in parentheses are the independent variables of the study. At the very bottom, the standard error term (μ) is presented. a and β are parameters estimated by running the model, while the data will be processed with the STATA program.

The choice of our model's specific independent variables is deeply rooted in existing literature. The role of the money supply in the market, for instance, has been highlighted by Van (2019) and Korkmaz (2017), who noted that unchecked increases in money supply can frequently lead to inflation. In fact, Korkmaz's study on Mediterranean countries documented the direct causal relationship between money supply and inflation. Additionally, the interplay between economic growth and inflation has been a focal point in studies by Xiao (2009) and Behera (2014). Both emphasized the enduring relationship between these two factors, accentuating the importance of incorporating economic growth into our model. Shifting the lens to trade components, Ulfa's 2018 research on Indonesia drew attention to the notable influence of imports on inflation, contrasting with a more muted impact from exports. This research lends credence to our decision to include both imports and exports as determinants in the model. Anchoring our approach in such a comprehensive backdrop of prior studies allows us to build on the groundwork laid by past researchers, offering deeper insights into the intricate mechanisms driving inflation dynamics.

A set of data in which the behavior of people is followed over time is known as panel data, sometimes referred to as longitudinal or cross-sectional time series data. These organizations may be countries, corporations, states, or people. Panel data models shed light on how individuals interact with one another and within their own groups. Cross-sectional and time-series dimensions are included in both the data and the models. When all individuals are taken into account throughout all time periods, panel data can be balanced; otherwise, they may be imbalanced (Hsiao, 2022). Examples include assessing the effects of income on savings utilizing data spanning years and countries, as well as calculating the effects of education on income using time and person data. The pooled model (OLS), the fixed effects model, and the random effects model are examples of panel data models. The fixed-effects model examines connections between predictors and results within an economic unit (a nation, an individual, a business, etc.) (McNeish and Kelley, 2019). Each unit has distinctive qualities that may or may not have an effect on the predictor variables (for example, a person's gender may influence their opinion on a particular issue, a country's political situation may have an effect on trade or GDP, or a compa-

ny's business practices may have an effect on its share price). To properly use FE, we must consider the possibility that an individual's attributes may skew or change the predictor or outcome variables. For this reason, it is presumpted that the unit error term and the predictor variables are associated. By utilizing FE to lessen the impact of such time-invariant characteristics, we can assess the total impact of the predictors on the outcome variable (Clark and Linzer, 2015).

The results that we will present in this chapter include these 40 countries, which are: 6 Latin American countries, 2 Western Balkan countries, 19 European countries, 10 Asian countries, 2 African countries and Australia, in a period of 12 years , respectively from 2012 to 2023. The Stata program's econometric results that were produced were previously provided. The World Bank database, which is the trade economy and one of the most popular sources for statistics.The characteristics of the variables, the relationships between the variables and finally the econometric models are described in the empirical results. First, we will provide univariate and bivariate descriptive statistics. The method of least squares (OLS), the method of fixed effects (FE) and the method of random effects (RE) were the three techniques used for the econometric models. In this study, we employed three distinct econometric methods (OLS, FE, and RE) to analyze the relationships between our independent and dependent variables. The choice of econometric technique had significant implications for our findings and the inferences we could draw. Our use of OLS allowed us to identify an average linear relationship between the variables, providing insights into the overall trends in our dataset. However, as our data included panel data with repeated observations for each unit, we recognized the potential presence of unobserved time-invariant individual-specific effects. To address this concern, we turned to fixed effects estimation, which controlled for such effects. The results from the FE model highlighted the importance of accounting for these individual-specific factors, offering a more nuanced understanding of our variables' relationships. Importantly, we observed variations in the coefficients for some variables, suggesting that the effects of these factors differed significantly across individuals. Additionally, we explored the random effects model as an alternative approach. Our findings using RE indicated that while individual-specific effects exist, they were better characterized as random and uncorrelated with the independent variables (Gomes, 2010). This choice allowed us to obtain more efficient estimates compared to FE, under the assumption that these random effects were not systematically related to our variables of interest. Thus, our decision between FE and RE hinged on the underlying assumptions regarding the nature of individual-specific effects in our dataset. Our discussion highlights the importance of carefully considering these assumptions when selecting the appropriate econometric technique for panel data analysis (Gurka et al., 2012).

The hypotheses of this research are:

- H1: Money supply has a positive impact on the inflation rate
- H2: Economic growth has a positive impact on the inflation rate
- H3: Imports have a positive impact on the inflation rate
- H4: Export has a positive impact on the inflation rate

Table 1. Description of research variables

Variable	Abbreviations	Unit	Source	Expected impact
INF	INF	%	World Bank	
OP	OP	Milions	World Bank	+
GDP	GDP	%	World Bank	+
IMP	IMP	% of GDP	World Bank	-
EXP	EXP	% of GDP	World Bank	-

Source: Authors Calculation

The variables of the study are described in the table above. There are five variables in total, and all of them were obtained from the World Bank.

3. 2. DESCRIPTIVE STATISTICS

In this part, the descriptive statistics of the variables are presented in different forms, first the variables with all the observations are presented, then the descriptive statistics for developed countries and developing countries are presented, and finally a comparison of the inflation rate before and during is presented pandemic

Table 2. Descriptive statistics

Variable	Obs	Mean	Std.dev	Min	Max
INF	440	4.21	5.54	-1.7	48.7
OP	440	7.51E+08	1.29E+09	26935	6.63E+09
GDP	440	2.56	2.53	-9.6	13.9
IMP	440	44.16	26.85	10.6	174.6
EXP	440	46.86	31.56	9.2	205.4

Source: Authors Calculation

The study was conducted in 40 states over an 11-year period, totaling 440 study observations, as shown in the table above, which provides descriptive data for all study variables. The states of the study model have an average inflation rate of 4.21%, these states have a money supply level of around 751 million euros. These countries have a positive economic performance on average of 2.56%. The import level of the states is 44.16% of the value of gross domestic production, while the level of export is 45.86% of the value of gross domestic production.

From the 40 countries of the study model, the highest level of inflation was recorded in the state of Ukraine in 2015 with a rate of 48.7%. The country with the highest positive economic performance is Iraq in 2012 with 13.9% economic growth, while the country with the biggest economic decline is Ukraine in 2015 with a rate of 9.6%.

Table 3. Comparison between developed countries and developing countries

Variable	Developed Countries	Countries still developing
	Mean	**Mean**
INF	3.34	3.39
OP	1.28E+09	9040494
GDP	2.25	2.85
IMP	46.06	41.05
EXP	50.28	40.55

Source: Authors Calculation

The table above presents a comparison of the averages in developed countries and countries still developing, based on the results presented, the average inflation is approximately similar, where in developed countries this average is 3.34% while in countries still developing it is 3.39% . So, we do not have high differences in this indicator based on the comparison of countries.

Table 4. Comparison of the inflation rate before and during the pandemic

Variable	**Before Pandemic**			**During Pandemic**		
	Obs	**Mean**	**Std. Dev**	**Obs**	**Mean**	**Std. Dev**
Inflation	280	3.42	4.711	160	5.61	7.761

Source: Authors Calculation

Based on the results presented above, where a comparison of the inflation rate is presented during the period before the pandemic and during the pandemic, then in the period before the

pandemic occurred, we have 280 observations and the average rate of inflation in the research countries is 3.42%, while during the period of the pandemic (from 2019 until now) where we have 160 observations, the average inflation rate is 5.61%. So, we have a difference of 2.22% of the highest inflation rate in Peru from 2019 onwards.

4. EMPIRICAL RESULTS

In this chapter the empirical results of the research are presented, first the correlation analysis is presented to identify the relationship of the variables among themselves, then in a tabular summary the results of the econometric models are presented and finally, based on the presented results, the hypotheses of raised.

Table 5. Correlation analysis

Variable	INF	OP	GDP	IMP	EXP
INF	1.00				
OP	0.11	1.00			
GDP	-0.13	-0.01	1.00		
IMP	-0.12	0.11	-0.03	1.00	
EXP	-0.12	0.18	-0.02	0.97	1.00

Source: Authors Calculation

The table above displays the correlation coefficient between the independent and dependent variables. The inflation rate is positively correlated with the availability of money and economic growth, which suggests that each of these factors' respective growths is positively correlated with inflation rate growth. The increase of these two variables has a negative effect on inflation since the other two variables (import and export) have a negative relationship with the inflation rate. The growth of gross local production also has a negative relationship with the rate of inflation with a coefficient of r=-0.13.

Table 6. Results of econometric models

Variable	OLS	OLS R	FE	RE
	INF	**INF**	**INF**	**INF**
OP (log)	-0.09	-0.09	0.23**	0.04
	(-0.91)	(-0.79)	(-0.59)	(-0.20)
GDP	-0.32**	-0.32	-0.62***	-0.55***
	(-2.86)	(-1.25)	(-6.25)	(-5.63)
IMP	0.01	0.01	0.14*	0.04
	(0.24)	(0.22)	(2.00)	(0.81)
EXP	-0.04	-0.04	0.01	-0.06
	(-1.23)	(-1.13)	(0.25)	(-1.24)

*Note: t statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01*

Source: Authors Calculation

Four econometric models' results are shown in the table above, but the model with fixed effects was chosen for interpretation since it was thought to be the most appropriate model for analyzing the outcomes of this research.. The choice of this model is based on the Hausman test, which shows that the difference in the coefficient is systematic when the P value is greater than 0.05 (P=0.0.01 > 0.05). This is why we favor applying the random effects model. According to the results, export (0.14) and import (0.01) also have a positive impact on the rise in inflation, with the import variable showing a statistically significant impact at the 10% significance level. The money supply also has a positive impact on the inflation rate with a coefficient of 0.23; this coefficient is statistically significant at the 5% significance level.. On the other hand, the impact of economic growth has a negative impact on inflation with a coefficient of 0.62, which is statistically significant at the 1% significance level.

Table 7. Hypothesis testing

H	Hypothesis	Testing
H1	Money supply has a positive impact on the inflation rate	Accepted
H2	Economic growth has a positive impact on the inflation rate	Rejected
H3	Imports have a positive impact on the inflation rate	Accepted
H4	Export has a positive impact on the inflation rate	Accepted

Source: Authors Calculation

5. DISCUSSION

The persistent discourse in literature surrounding the factors that influence inflation-namely money supply, exchange rates, and economic growth-finds resonance in the empirical findings of our study spanning 40 states over an 11-year period. Reiterating Swagel et al.'s (2001) conclusions regarding the influence of money supply in steering inflationary processes, our results indeed revealed a positive correlation between the availability of money and inflation. This observation is echoed by Van (2019) who identified unchecked increases in the money supply as the precursor to inflation.

The dynamic interplay between inflation and economic growth was further exemplified in our findings. The negative relationship between economic growth and inflation aligns with Xiao's (2009) and Behera's (2014) observations, suggesting that while economic growth can sometimes lead to inflationary pressures, rapid growth can conversely be a counteracting force to rising inflation in certain circumstances. This intricate balance has been a consistent theme in research and our study provides further empirical evidence to support this.

The trade dynamics of a country, particularly imports and exports, have long been suggested as significant influencers of inflation. Our results indicated that both exports and imports had a positive impact on inflation. This finding complements Ulfa's (2018) study on Indonesia, wherein imports exerted a positive impact on inflation. However, while imports in our study were statistically significant, the magnitude of the impact of exports was comparatively higher.

One of the most striking revelations from our research was the stark difference in inflation rates during the pandemic era versus the pre-pandemic phase. A heightened average inflation rate of 5.61% during the pandemic, in comparison to 3.42% prior, points towards the significant macroeconomic disruptions caused by the global health crisis. This disparity underlines the eco-

nomic volatility of such unprecedented events, wherein conventional determinants of inflation might be outweighed by larger global forces.

Contrasting the inflation rates of developed and developing nations, our results indicate a near parallel in averages. This observation challenges conventional belief and certain empirical findings, such as Al Sabaey's (2012) research, which indicated divergent inflationary factors for affluent and developing nations. It suggests that, in the grand tapestry of globalized economies, the boundaries between developing and developed nations blur in certain macroeconomic contexts.

Conclusively, our findings cement the understanding that inflation is not the result of a singular factor but a nexus of interrelated economic variables. The relationships and correlations identified in our study, corroborated by the vast body of literature on the topic, underscore the importance of a holistic approach when formulating monetary and fiscal policies. As nations navigate the complexities of global economic landscapes, the insights from our research, juxtaposed against the wider academic discourse, will be invaluable in guiding policy decisions.

From the four research hypotheses raised, we find sufficient empirical statistical evidence to accept three of them (H1, H3 and H4). The testing of the hypotheses is done taking into account the results of the analysis of the econometric models, regarding the results of the random effects model, where based on the results of this money supply model, import and export have a positive impact on the increase in the inflation rate, therefore, we have sufficient statistical evidence to accept these hypotheses, while according to the results, economic growth has a negative impact on the increase in the inflation rate, so the second hypothesis is rejected.

6. CONCLUSION

The headline inflation rate is important because it reveals changes in a country's average prices, as well as changes in the amount of goods and services that each consumer has access to. These changes in the consumption basket are distinct because they occur when the inflation rate increases and indicate that the consumer will have a poorer consumption basket and vice versa. A stable inflation rate indicates a country with excellent economic well-being, because the inflation rate has a significant impact on it. The various economic crises have caused us to face an unstable rate of inflation over the years, since a small economic change caused the rate of inflation to increase and it is very difficult to stabilize, in this instability the countries that depend the most are affected from import, countries that have a negative economic growth, that is, in general, countries that are still developing. This paper aims to analyze the main determinants of the inflation rate in order to create certain policies in the future that will help to mitigate the inflation rate, since the latter is present in a large percentage in every economic crisis and very difficult to manage, especially for countries that are still developing. The impact of the money supply, economic growth, imports, and exports on the inflation rate has been examined empirically for each of the 40 countries we chose to cover in this research. Over an eight-year period, we conducted the analysis.

The recommendations for developing countries are as follows:

- Trade Deficit Management: Given the prevalence of trade deficits leading to imported inflation, it's crucial for governments to implement policies that bolster local producers. This can be achieved through protective measures and subsidies, ensuring domestic needs are met through local production, and eventually propelling the nation towards becoming a net exporter.
- Impose Taxes: To combat imported inflation and promote local industries, it's recommended to introduce taxes on the import of specific products, particularly

those that the country has the capacity to produce locally. This not only nurtures domestic producers but also makes imported goods less attractive, thus reducing the outflow of money. Additionally, the revenue generated from these taxes can be reinvested into sectors that further boost domestic production and self-reliance. Care, however, should be taken to ensure that these taxes don't inadvertently harm consumers, especially in the case of essential goods or where domestic alternatives are not immediately available. Regular reviews and adjustments of the taxation policy based on its outcomes and changing economic conditions are also advisable.

While the recommendations for developed countries are:

- Monetary Policy: Consider heightening interest rates. This move can curtail borrowing, subsequently reducing consumption, which in turn can lead to a slowdown in both inflation and overall economic growth.
- Fiscal Adjustments: Adopt measures like increased income taxation and trimmed government expenditure. Such strategies can diminish aggregate demand, leading to moderated growth and curtailed demand-driven inflation.
- Supply-side Initiatives: Implementing policies like privatization and deregulation can foster long-term competition, potentially reducing corporate expenditures and, by extension, inflation.

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STUDY OF BEST PRACTICES OF GREEN ENERGY DEVELOPMENT IN THE EU COUNTRIES BASED ON CORRELATION AND BAGATOFACTOR AUTOREGRESSIVE FORECASTING

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ABSTRACT

Russia's military aggression against Ukraine has undermined the global energy system, leading to high energy prices and increased concerns about the EU's energy security EU leaders have adopted a number of laws and developed the REPowerEU plan to reduce dependence on Russian energy imports by accelerating the transition to clean energy and creating a more sustainable energy system in Europe. The plan includes measures to save energy, diversify supplies and rapidly replace fossil fuels with clean energy sources, as well as prioritizes equity and solidarity, taking into account the energy balances of each EU member state. It builds on the Fit for 55 proposals and supports the ambitious goal of achieving at least -55% net greenhouse gas emissions by 2030 and climate neutrality by 2050. The aim of the article is to study the use of renewable energy in the European Union, the application of autoregressive models to predict the development of renewable energy.The results and conclusions. As a result of the study, based on the methodology of transients, a model of change in the volume of investment in wind energy was developed in the form of a differential equation. It was proved that the transition process is stable, even with time constraints or reduction of investment in the development of wind energy over time it will return to a stable growing trend (which was obtained by means of bagatofactor autoregressive models).

Keywords: *renewable energy sources, wind energy, autoregressive models, investment, transition process*

1. INTRODUCTION

Over the past few years, renewable energy has continued to show rapid growth and successful development in the energy sector. The introduction of a record number of new renewable capacities demonstrates that many countries around the world are recognizing the importance of transitioning to a more sustainable and environmentally friendly energy sector. Solar and wind power continue to be the two most successful sources of renewable energy. Together, they account for nearly 90% of all new renewable capacity additions, indicating that these technologies still have enormous potential for further growth and development.

This is due to the growing demand for clean energy from consumers and corporations. Many companies in various industries are beginning to switch to renewable energy sources as part of their corporate responsibility and sustainability strategy.

Thus, renewable energy continued to show growth in the energy sector in 2021, showing that the transition to greener energy is becoming increasingly real and necessary to address global environmental issues.

This is indeed a positive trend, but there is still much work to be done to increase the share of renewable energy in global energy production and reduce greenhouse gas emissions. There is a need to accelerate the adoption of renewable energy sources and reduce dependence on fossil fuels.

One of the keys to accelerating the transition to renewable energy is to increase investment in this area, including in developing countries. It was also important to develop effective support and incentive mechanisms for renewable energy, including removal of fossil fuel subsidies and carbon pricing.

Technological advances and the development of efficient energy storage systems that will ensure the reliability and flexibility of renewable energy are also essential.

Finally, it is important to promote public awareness and awareness of the benefits of renewable energy and its impact on the environment. This can be achieved through education and awareness campaigns that help people better understand why switching to renewable energy is an important step in combating climate change and creating a more sustainable future.

As noted, increasing installed renewable energy capacity is a positive trend, but there is a need for a more ambitious effort to achieve net zero emissions by 2050. This requires not only an increase in installed renewable energy capacity, but also improvements in energy efficiency, energy conservation and the use of new technologies.

In addition, it is important to note that the installed capacity of SPPP and wind power represents only a fraction of the world's total power generation capacity. Other sources, such as hydropower, nuclear power, and the use of fossil fuels, also play an important role in energy security and sustainability.

Finally, it should be noted that the development of renewable energy sources should not block access to energy for those countries that still face energy constraints. Therefore, it is important to develop and implement energy technologies and solutions that can be affordable and economically beneficial for all countries and regions.

2. LITERATURE REVIEW

The analysis of processes in the energy sector includes components of the development and implementation of renewable energy sources. The statistical information published by the International Monetary Fund and the International Energy Agency is an important source of data on many countries, as well as on the state of global commodity markets, including the energy market. The available forecasts of energy indicators of countries provided by the International Monetary Fund can be used in the future to extrapolate the dynamics of the energy sector development in Ukraine. The developed methods and models relate to both the calculation of indicators and the development of recommendations for energy sector development policy at the international, European, national and local levels, determination of supply and demand in the energy market, assessment of the impact of energy on the environment and human health, interaction of energy and environment. Olena Trofymenko, (Olha Ilyash, Serhii Voitko, Tetiana Dluhopolska, Serhii Kozlovskyi, Svitlana Hrynkevych. (2022))

Considerable attention is paid to methods of analyzing the introduction of renewable energy sources, as energy policy involves long-term strategic planning at all levels of government. The development of energy development strategies and planning for the introduction of renewable

energy sources, increasing the share of joint energy production should include important principles of environmental acceptability, development of competitive and affordable energy markets under conditions of energy security and independence of countries, development of energy efficiency and creation of energy reserves. Determining the optimal directions of energy development at the macro level requires the development and implementation of effective methods for determining the dependencies and links between different elements of the energy system of the country's economy, links with other countries, the impact of external factors, and forecasting the development of such a system (Laitner J.A., DeCanio S.J., Coomey J.G., Sanstand A.H. (2003), Helm D. (2002)).

Today, capital-intensive and long-term energy projects have become more affordable. Understanding the importance of climate change requires long-term planning of the consequences of energy use in general and the introduction of renewable energy sources. This has led to the development of long-term analysis covering periods from 20 to 100 years (Huntington H.G., Weyant J., Sweeney J.L. (1982), Worrel E., Ramesohl S., Boyd G. (2004)).

Particularly noteworthy is the work by Jonn Kilstam and Christer Thornqvist, which examines the problems of sustainable development of society, the conflict between ecology and the economy, the role of corporate social responsibility of businesses and large corporations in addressing the global climate crisis (Thörnqvist,C. & Kilstam,J.(2021)).

Management decision on the development of green energy in Ukraine can be developed on the basis of the model of marginal utility in decision-making presented by the authors Ilhom Abdulloev Gil S. Epstein Ira N. Gang in (Abdulloev, I., Epstein, G. & Gang, I.(2020)).

Statistical information published by the International Monetary Fund and the International Energy Agency is an important source of data on the macroeconomic situation in Ukraine and many other countries, as well as on the state of global commodity markets, including the energy market. The available forecasts of the energy situation of countries provided by the International Monetary Fund can be used in the future to extrapolate the dynamics of the development of the energy sector in Ukraine. The statistical study of energy independence of countries involves the use of the following statistical methods (Yelisieieva O.K., Khazan P.V. (2017)).

- The method of generalized indicators (allows to assess the efficiency of FER use in the Ukrainian economy and to identify weaknesses of enterprises and organizations that hinder further development of the energy situation in the country and to develop necessary measures to eliminate them).

Growth curves describing the regularities of the phenomenon are obtained by analytical smoothing of time series. In most cases, smoothing the series with the help of certain functions proves to be a convenient means of describing empirical data characterizing the development of the phenomenon under study over time. The obtained models, subject to a number of conditions, can be used to forecast the smoothing of series using certain functions in most cases proves to be a convenient means of describing empirical data characterizing the development of the phenomenon under study over time. The resulting models can also be used for forecasting if a number of conditions are met.

The process of smoothing time series consists of two main stages:

- selecting the type of curve whose shape corresponds to the nature of the change in the time series or the type of growth process;

- determining the numerical values (estimation) of the curve parameters.

The found function allows you to get the leveled or, as they are sometimes called, theoretical values of the time series levels. The same function is also used for extrapolation. The question

of choosing the type of curve is the main one when leveling a series. All other things being equal, an error in choosing the shape of the growth curve when solving this issue is more significant in its consequences (especially for forecasting) than an error associated with statistical parameter estimation.

Adaptive methods of modeling and forecasting are based on preserving the inertia of development, but taking into account the factor of "aging" of data, i.e., the model adapts with the help of special parameters to the conditions prevailing at each moment of time, allow building self-correcting models that, taking into account the result of the forecast (or alignment) made in the previous step and the different information value of the members of the dynamic series, are able to respond quickly to changing conditions and, on this basis, give more accurate forecasts for the near future. (Olena Trofymenko, Olha Ilyash, Serhii Voitko, Tetiana Dluhopolska, Serhii Kozlovskyi, Svitlana Hrynkevych. (2022)).

3. RESEARCH OBJECTIVES

On the basis of statistical data on the development of renewable energy, the main components and dynamics of investments in the development of renewable energy sources in the world, in particular wind power, are considered and analyzed.

Through the study of autocorrelation functions, the expediency of using autoregressive forecasting models and the choice of the number of periods of shift of the initial data to form an array of input variables for the application of multifactorial multiplicative autoregressive forecasting is substantiated.

The expediency of applying the mathematical apparatus of transient analysis (in particular, the construction of a differential model, transfer, impulse transient and transition functions) to study the process of changing the use of wind power and the volume of investment in this type of renewable energy sources in the world is substantiated.

By constructing the amplitude-phase frequency response (APFR) of the modeled transient process of Wind power change and constructing the Nyquist frequency hodograph, the stability of the studied process is assessed and the dependence between the dynamic states of Wind power is determined to be resistant to external disturbances and force majeure.

4. METHODS

To model dynamic economic systems, one approach is to use a complex transfer function obtained through applying the Laplace transform to the differential equation that describes the relationship between influencing and studied variables (Worrel E., Ramesohl S., Boyd G. (2004)).

A structural diagram with typical links and operator forms of differential equations is used to depict the system. The transfer function W(s) represents the relationship between the input (influencing variable) and output (studied variable).The impulse and transient functions of the system are related by the relation:

$$h(t) = \int_0^t w(\tau)d\tau \quad (1)$$

Due to its widespread use in the study of the stability of dynamic economic systems and the development of control actions, frequency response characteristics (FRC) have become widespread. If a harmonic signal is applied to the input of a system with a transfer function W(s), then the following theorem is true: if the system under study is stable, then the response of the

output variable to the harmonic effect is a function of the same frequency with amplitude and relative phase shift.

The frequency response W(i) of a stationary dynamic system is the Fourier transform of the transition function

The relationship between the complex transfer function and the frequency response is defined by the following relation:

$$W(S)|_{s\,i\omega} = W(i\omega) \tag{2}$$

At a fixed value of w, the frequency response is a complex number, and thus can be represented in terms of the following components:

A(w) - Amplitude-frequency response (frequency response);

U(w) - Phase-frequency response (PFR);

P(w) - Real frequency response (RFR);

Q(w) - Imaginary frequency response (IF).

The geometric location of the points W(i) on the complex plane when changing from 0 to 1 is called the amplitude-phase response (APR) or Nyquist frequency response.

The autocorrelation function of an economic indicator is given by the formula:

$$\rho_{xx}(\tau) = \frac{\sum_{i=1}^{n}(x_{i-\tau}-\bar{x})*(x_i-\bar{x})}{\delta_x{}^2*(n-\tau)} \tag{3}$$

The autocorrelation function reflects the degree of influence of the previous values of the studied indicator on its current value. A slowly decreasing autocorrelation function indicates that the indicator has significant inertia in time, and its current values are highly dependent on its previous values. autocorrelation is one of the most important elements of time series analysis. Autocorrelation is a phenomenon where the current level of a time series is correlated. In particular, a well-studied and identified autocorrelation can be used for short-term forecasting of certain indicators (Pina A., Silva C., Ferrao P. (2011), Yelisieieva O.K., Khazan P.V. (2017)).

To do this, in the autoregression equation, the value of the studied indicator for previous years is substituted, and thus the predicted value of the indicator for the near future, usually for the next year, is obtained.

The intercorrelation function is as follows:

$$\rho_{xy}(\tau) = \frac{\sum_{i=1}^{n}(x_{i-\tau}-\bar{x})*(y_i-\bar{y})}{\delta_x*\delta_y*(n-\tau)} \tag{4}$$

Where, τ is the time shift under study.

The construction of intercorrelation functions allows us to determine which of the previous periods of the influential indicator has the greatest impact on the one under study. That is, according to the above example, the current amount of wind energy produced (used) may be most influenced by investments in the development of relevant sources in the previous or the year before last, which is determined in numerical form based on the analysis of the obtained values of the correlation function.

5. RESULTS

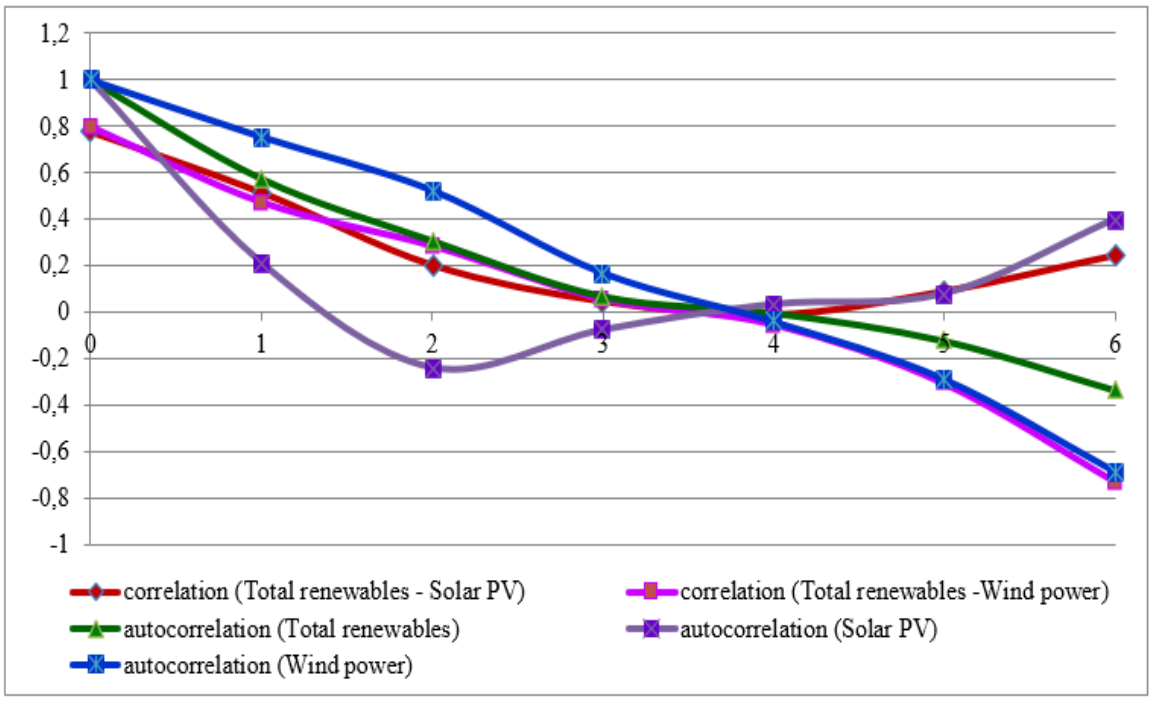
The correlation and autocorrelation functions are defined by the following formulas:

$$\rho_{xy}(\tau) = \frac{\sum_{i=1}^{n}(x_{i-\tau}-\bar{x})*(y_i-\bar{y})}{\delta_x*\delta_y*(n-\tau)} \quad (5)$$

$$\rho_{xx}(\tau) = \frac{\sum_{i=1}^{n}(x_{i-\tau}-\bar{x})*(x_i-\bar{x})}{\delta_x{}^2*(n-\tau)} \quad (6)$$

where τ is the lag (shift period of the studied data); X is the influencing variable; Y is the studied variable; n is the number of periods of the studied data; δ_x is the standard deviation of X, δ_y is the standard deviation of Y.

Figure 1. Correlation and autocorrelation functions for Total renewables, Solar power and Wind power



Source: Author's calculation based on Helm D. (2002), Huntington H.G., Weyant J., Sweeney J.L. (1982)

The autocorrelation functions for Total renewables and Wind power are slowly decreasing, which indicates the high inertia of these indicators and a significant level of dependence of current values of Total renewables and Wind power on their values in previous years, which allows the use of autoregressive multivariate models for their forecasting.

As for the Solar PV indicator, its autocorrelation function is more rapidly decreasing (it goes to a negative value from the 2nd shift period, unlike the previous two functions, which acquire a negative value only at the 4th shift period). Thus, it can be preliminarily noted that the expediency of autoregressive multifactor forecasting of Solar PV is less appropriate, since the resulting models will provide a lower level of adequacy of the built model.

Based on the data in Fig. 3, it is advisable to choose three-factor models for building autoregressive forecasts, where:

Y_i - data of the indicator without a shift (i.e., for the current year);

Y_(i-1) - data of the indicator with the 1st shift period (i.e. for the previous year);

Y_(i-2) - data of the indicator with the 2nd shift period (i.e., for the year two periods earlier than the current one);

Y_(i-3) - data of the indicator with the 3rd shift period (i.e., for the year that is three periods earlier than the current one).

Two approaches have been used to build the autoregressive models: the multi-factor forecast and the multiplicative forecast. For total renewables, the three-factor autoregressive model has the following form:

$$Y_i^* = \sqrt[3]{(131.2 + 0.721 \cdot Y_{i-1}) \cdot (142.66 + 0.598 \cdot Y_{i-2}) \cdot (158.12 + 0.555 \cdot Y_{i-3})} \quad (7)$$

The accuracy of the model 92.98%

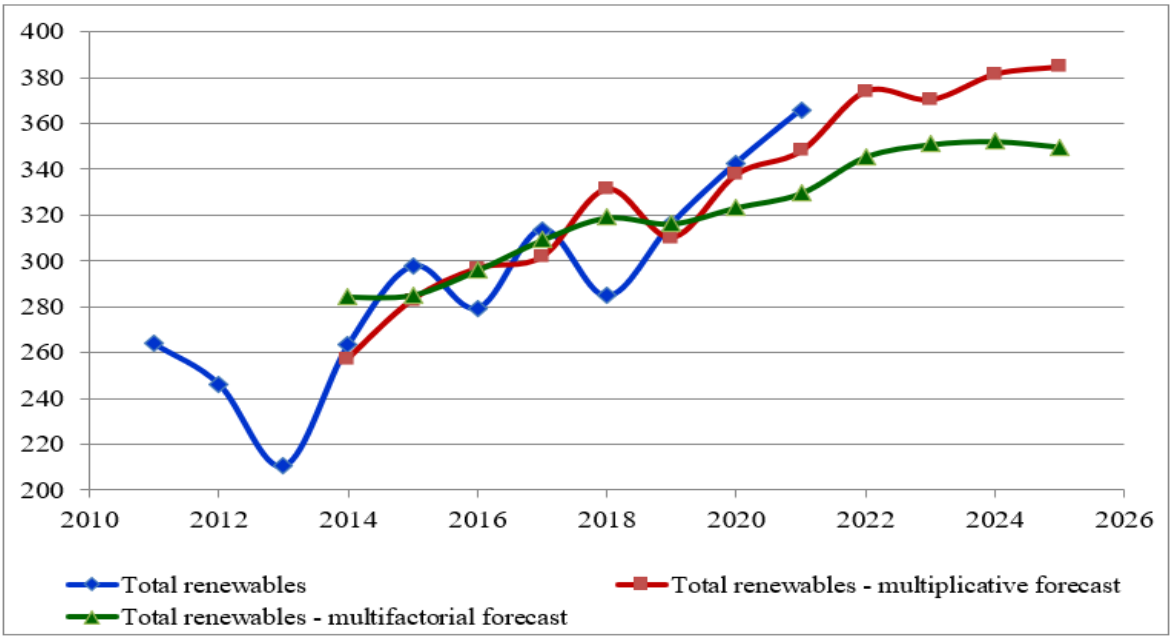
For Total renewables, the three-factor multiplicative autoregressive model has the following form:

$$Y_i^* = (131.2 + 0.721 \cdot Y_{i-1}) \cdot (0{,}948 + 0{,}000186 \cdot Y_{i-2}) \cdot (0{,}766 + 0{,}000865 \cdot Y_{i-3}) \quad (8)$$

The accuracy of the obtained model is 93.45%

The high accuracy of the resulting autoregressive forecasting models for total renewable energy allows them to be used for practical forecasting of global renewable energy investment values up to and including 2025 (Fig. 2 and Table 1).

Figure 2. Results of multivariate autoregressive forecasting Total renewables, billion USD



Source: Author's calculation

For wind power, the three-factor autoregressive model has the following form:

$$Y_i^* = \sqrt[3]{(51.44 + 0.651 \cdot Y_{i-1}) \cdot (60.92 + 0.624 \cdot Y_{i-2}) \cdot (48.36 + 0.812 \cdot Y_{i-3})}$$

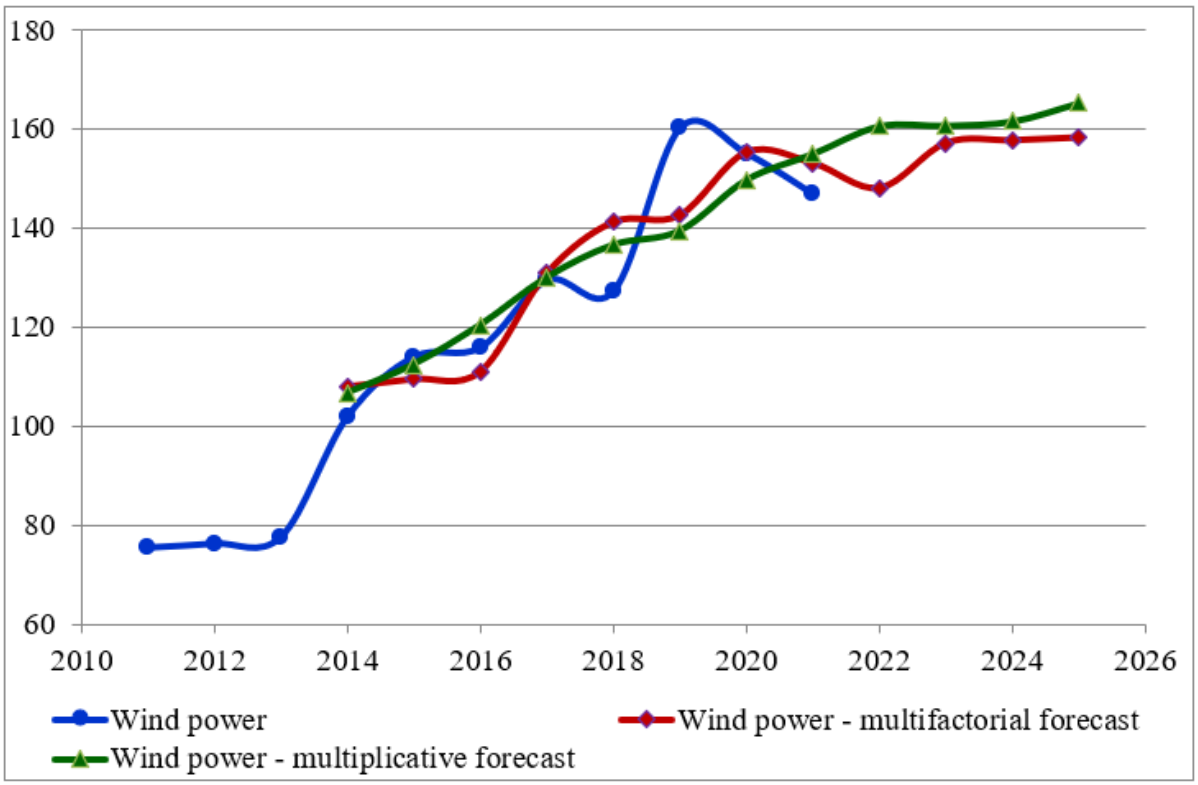
The accuracy of the obtained model is $R^2 = 93.09\%$

For wind power, the three-factor multiplicative autoregressive model has the following form:

$$Y_i^* = (0.967 + 0.000327 \cdot Y_{i-1}) \cdot (0{,}997 - 0{,}0000306 \cdot Y_{i-2}) \cdot (48.36 + 0.812 \cdot Y_{i-3})$$

$(R^2 = 93.26\%)$

Figure 3. Results of multivariate autoregressive forecasting Wind power, billion USD



Source: Author's calculation

The high accuracy of the obtained autoregressive forecast models for wind power allows them to be used for practical forecasting of Global Investment in Wind power up to 2025 inclusive - Fig. 3 and Table1.

Table 1. Forecast of global investments in renewable energy sources, 2022-2025, billion USD

	Total renewables - multiplicative forecast	Total renewables - multifactorial forecast	Wind power - multifactorial forecast	Wind power - multifactorial forecast
2022	374,2032	345,4489	148,0936	160,6159
2023	370,5088	350,8131	157,1871	160,7246
2024	381,7005	352,152	157,7138	161,5889
2025	384,8814	349,7626	158,2649	165,3121

Source: Author's calculation

According to Table 1, all the studied indicators have a fairly stable upward trend in the overall trend dynamics, which is confirmed by the high levels of approximation obtained (more than 90% for wind power and total renewables).

The differential modeling of the studied indicators is carried out using the methodology of transient analysis (Chermack T.J., Lynham S.A. & Ruona W.E.A. A (2001)).

Based on the constructed correlation functions, a system of equations is written to obtain the values of the impulse transient functions for each indicator, which has the form:

$$\{\rho_{xy}(t-k) = \sum_{i=0}^{n} w_i * \rho_{xx}(\tau - i)\} \quad (9)$$

In other words, it is necessary to create two such systems of equations, each with 5 equations and 5 variables, solve all these equations and obtain the values of the impulse transition functions for each indicator. The number of 5 variables is chosen based on the data in Fig. 1, where we can see from the correlation functions that it is better not to use the 6th shift point in further modeling. To model transient processes, the amount of data remaining in the calculation after the shift, the value (n-τ), should be greater than or equal to τ; at the boundary values, the choice is made based on the correlation functions.

Since the statistics of the indicators for 11 years (2011-2021) were used as input data, for a shift of 6 periods, only 5 periods remain for calculation, and at this point the correlation functions rapidly decrease and approach the minimum value:

For Wind power = -0,308 д.о., а = -0,731 д.о

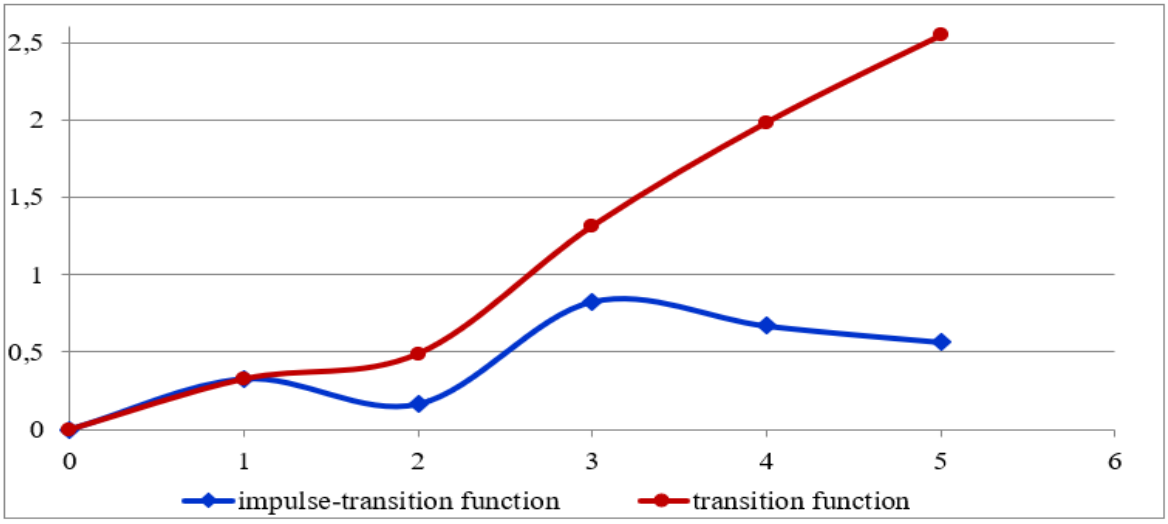
Based on the constructed correlation and autocorrelation functions (Fig. 1), we write a system of equations for Wind power to find the values of the impulse-transient function.

Having solved the system of equations, we obtain the value of the impulse-transient function

$$\left\{\begin{array}{l} 0{,}795 = 1 * \omega_0 + 0{,}755 * \omega_1 + 0{,}525 * \omega_2 + 0{,}169 * \omega_3 - 0{,}040 * \omega_4 - 0{,}288 * \omega_5 \\ 0{,}471 = 0{,}755 * \omega_0 + 1 * \omega_1 + 0{,}755 * \omega_2 + 0{,}525 * \omega_3 + 0{,}169 * \omega_4 - 0{,}040 * \omega_5 \\ 0{,}284 = 0{,}525 * \omega_0 + 0{,}755 * \omega_1 + 1 * \omega_2 + 0{,}755 * \omega_3 + 0{,}525 * \omega_4 + 0{,}169 * \omega_5 \\ 0{,}055 = 0{,}169 * \omega_0 + 0{,}665 * \omega_1 + 0{,}755 * \omega_2 + 1 * \omega_3 + 0{,}755 * \omega_4 + 0{,}525 * \omega_5 \\ -0{,}054 = -0{,}040 * \omega_0 + 0{,}169 * \omega_1 + 0{,}525 * \omega_2 + 0{,}755 * \omega_3 + 1 * \omega_4 + 0{,}755 * \omega_5 \end{array}\right\}$$

for the process of wind power change and calculate the transient function as the sum of the previous values of the impulse transient at each point - Fig. 4.

Figure 4. Impulse response and transient functions for wind power



Source: Author's calculation

To find the coefficients of the differential equation, three auxiliary quantities , re used, which are related to the coefficients of the differential equation by the following dependencies (Maryuta A.N., Ekimov S.V. (2005)).

$$\begin{Bmatrix} a_1 = b_1 + F_1 \\ a_2 = b_2 + F_2 + F_1 * b_1 \\ a_3 = b_3 + F_3 + b_2 * F_1 + F_2 * b_1 \end{Bmatrix} \quad (10)$$

In this case, there are the following rules that define the form of the differential equation depending on the values of F_1; F_2; F_3 (Global Energy Assessment. Toward a Sustainable Future. Key Findings Summary for Policymakers Technical Summary. (2012))

1. If $F_3 < 0$ the process is described by a second-order differential equation with the first transformation coefficient and the first-order output:

$$a_2 \frac{d^2y}{dt^2} + a_1 \frac{dy}{dt} + y = b_1 \frac{dx}{dt} + b_0 x \quad (11)$$

2. If $F_2 > F_3$ then the process is described by a second-order differential equation with the first transformation and a simple step:

$$a_2 \frac{d^2y}{dt^2} + a_1 \frac{dy}{dt} + y = b_0 x \quad (12)$$

3. If $F_1 < F_2 < F_3$ then the process is described by a third-order differential equation with the first transformation and a simple step:

$$a_3 \frac{d^3y}{dt^3} + a_2 \frac{d^2y}{dt^2} + a_1 \frac{dy}{dt} + y = b_0 x \quad (13)$$

For all three cases: $a_0 = 1;\ b_0 = \frac{\Delta y}{\Delta x};\ \Delta y = y_{max} - y_{min};\ \Delta x = x_{max} - x_{min}$

To find the conditions of F, we use the formulas:

$$F_1 = \Delta t * (\sum_{i=1}^{n}(1 - x_i') - 0.5 \cdot (1 - x_1')) \quad (14)$$

where χ_i' – dimensionless value of the transition function.

Δt – the initial transformation step in the calculation of correlation coefficients.

$$F_2 = {F_1}^2 * \Delta Q(\sum_{i=1}^{n}(1 - x_i') * (1 - Q_i) - 0.5 \cdot (1 - x_1')) \quad (15)$$

where $Q_i = \frac{t}{F_{1-n}}$

$$F_3 = {F_1}^3 * \Delta Q(\sum_{i=1}^{n}(1 - x_i') * \left(1 - 2Q + \frac{Q^2}{2}\right) - 0.5 \cdot (1 - x_1')) \quad (16)$$

Table 2. Results of determining the type of differential equation and calculating its coefficients for Wind power

Wind power			
Parameter F		Condition	Coefficients
F1=	2,451	F2 > F3	a1 = 2,45
F2=	1,732		a2 = 1,73
F3=	0,675		в0 = 0,55

Source: Author's calculation

For wind power, the differential equation for modeling the transient process of changes in wind energy investments depending on global investments in renewable energy sources is as follows:

$$1{,}73 \cdot \frac{d^2y}{dt^2} + 2{,}45 \cdot \frac{dy}{dt} + y = 0{,}55 \cdot x \qquad (17)$$

Transfer function for Wind power:

$$\omega_{(p)} = \frac{0{,}55}{1{,}73p^2+2{,}45p+1}$$

The real part for the model indicator AFR for Wind power has the form of:

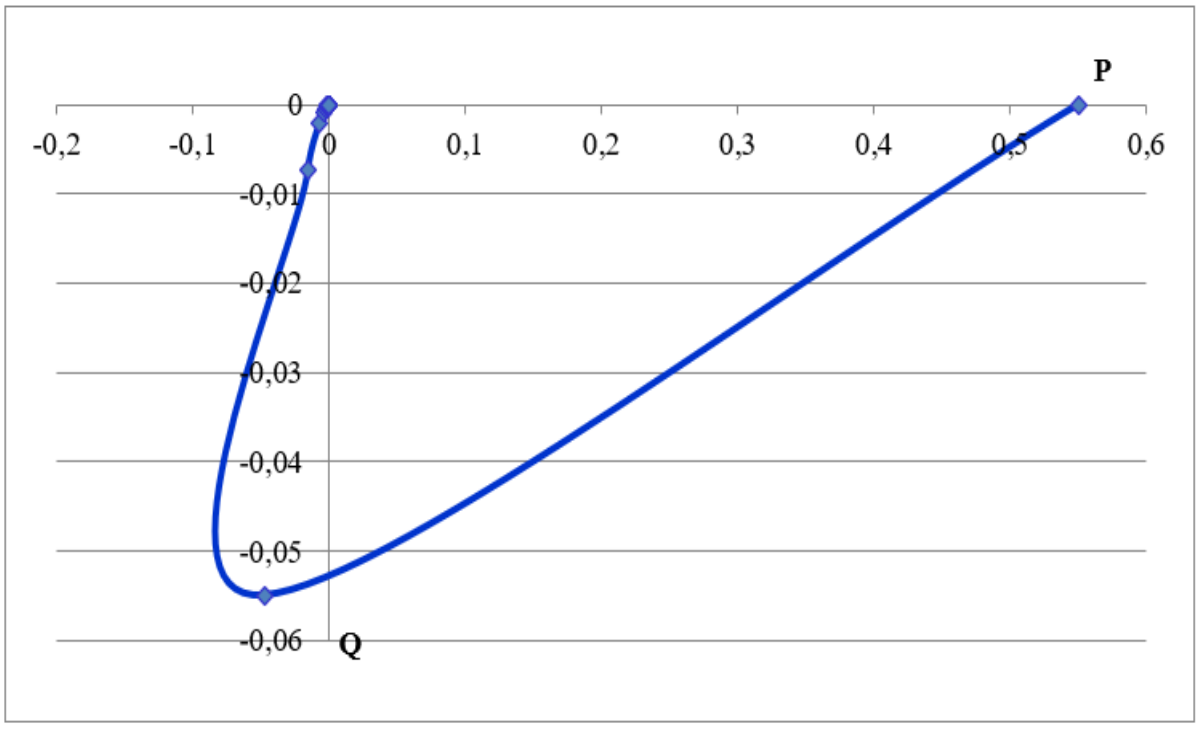
$$P = \frac{0{,}55-0{,}95w^2}{2{,}99w^4+2{,}54w^2+1} \qquad (18)$$

The imaginary part for the model's AFR for Wind power has the form of:

$$Q = \frac{-1{,}35w}{2{,}99w^4+2{,}54w^2+1} \qquad (19)$$

Figure AFR for Wind power is presented in Figure 5.

Figure 5. Amplitude-frequency response of the differential model for wind power



Source: Author's calculation

Since the frequency response line does not cover the point (-1;0), this indicates the stability of the studied process and its ability to self-leveling in the event of random disturbances and force majeure.

Thus, from the modeling carried out using the methodology of transient analysis, a model of changes in the volume of investment in the development of wind energy in the form of a differential equation was obtained and it was found that this process is sustainable, that is, even with temporary restrictions or reductions in such investment, over time it will return to a stable upward trend (which was obtained using multivariate autoregressive models).

6. DISCUSSION

Discussion points: in the economic and mathematical forecasting of economic phenomena and processes, in order to improve the accuracy of the forecast, the quality of the model and expand the prospects for its application in practice, it is important to select influential factors when building a model. In this case, there is a need to exclude mutually influencing factors; to search for indirect influence on the indicator through third uncertain factors and the problem of obtaining forecast values for future periods - if statistics on influencing factors are known only for the past and current periods.

However, the use of autoregressive forecasting models allows simultaneously solving all three of these problems, since it is based on the study of previous values of the main indicator and, depending on the results of autocorrelation analysis, its breakdown into several conditional variables to obtain multifactor forecasting models.

In previous periods, the targeted indicator (Wind power) was affected by all the same identified and unidentified factors that will continue to operate in the future. Therefore, the values of the indicator are already formed under the influence of all the influencing factors, thus taking them into account. In addition, since autoregressive models consider an array of previous values of the indicator as influential variables, it is always possible to calculate the next value on their basis, then add it to the array of statistical data and recursively apply the resulting mathematical model for forecasting for the following periods.

Representation of Wind power development in the form of a dynamic transient process and modeling of its future states by obtaining a second-order differential equation with a simple input, a complex transfer function, and by determining the amplitude-phase frequency response (APFR) and constructing a Nyquist frequency hodograph, which showed the stability of the studied process to external disturbances.

For the first time, the development of wind power was considered as a dynamic transient process, which was represented as a complex transfer function $\omega_{(p)} = 0,55 / (1,73p^2 + 2,45p + 1)$, its real frequency response and its imaginary frequency response

$Q = \frac{-1,35w}{2,99w^4+2,54w^2+1}$, which were used to construct a Nyquist frequency hodograph, which showed the stability of the studied process (changes in the development of wind power) to external disturbances (investment restrictions).

The possibility of applying autoregressive forecasting models to Wind power was substantiated, three-factor autoregressive and multiplicative models were obtained and compared; forecast values of Wind power until 2025 were calculated.

7. CONCLUSION

In 2021, 314.5 GW of new renewable energy capacity was commissioned. Solar and wind power provided more than 10% of the world's electricity.

About 102 GW of new capacity was installed, bringing the total installed capacity of wind farms to 845 GW.

However, the introduction of new renewable energy sources lagged behind the growth in energy demand. Therefore, over the past 10 years, the share of renewable energy in global energy

production has increased from 10.6% to 11.7%, while the share of fossil fuels has only decreased from 80.1% to 79.6%.

Growth in economic activity in 2021 led to a 6% increase in CO2 emissions compared to 2019-2020.

While $366 billion was invested in renewable energy sources, fossil fuel subsidies alone reached $5.9 trillion, equivalent to $11 million per minute. Direct and indirect fossil fuel subsidies account for 7% of global gross domestic product (GDP).

Slow progress in the transition away from fossil fuels and reducing greenhouse gas emissions is a cause for concern, especially as global energy demand continues to grow. The deployment of renewable energy is growing, but not fast enough to meet the goals of limiting global warming to below 2 degrees Celsius, as required by the Paris Agreement. To reach the average of the main zero-emissions scenarios, annual renewable energy growth needs to triple (adding about 825 GW annually by 2050).

High fossil fuel subsidies are the main obstacle to the development of renewable energy. These subsidies create market distortions in favor of fossil fuels, making them economically more competitive than renewables. Eliminating these subsidies and investing in renewable energy infrastructure can accelerate the transition to a low-carbon economy.

Improving energy conservation and efficiency can also help reduce energy demand and emissions. This includes measures such as building codes requiring more energy-efficient buildings, increasing the use of public transportation, and encouraging the use of energy-efficient appliances.

Overall, the progress in renewable energy deployment in 2021 is encouraging, but more needs to be done to achieve zero emissions by 2050. This requires the adoption of laws to abolish fossil fuel subsidies, increase investment in renewable energy infrastructure, and improve energy conservation and efficiency.

Based on the results of the modeling conducted using the methodology of transitional processes, a model of changes in the volume of investment in wind energy in the form of a differential equation was obtained and it was found that this process is stable, that is, even with temporary restrictions or reductions in investment in wind energy development, it will eventually return to a stable upward trend (which was obtained using multivariate autoregressive models).

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IMPACT OF TRADE OPENNESS, HUMAN CAPITAL THROUGH INNOVATIONS ON ECONOMIC GROWTH: CASE OF THE BALKAN COUNTRIES

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ABSTRACT

The importance of trade openness and human capital for the economic growth of countries is the subject of many studies today. The role of innovations and the innovativeness of economies in modern economic development is extremely important. With greater accumulation of human capital, knowledge, skills and innovation are accumulated. All these variables are crucial for achieving higher economic growth. Special attention in the studies of relevant authors is directed towards researching this relationship on the example of small open economies, as well as developing countries. The purpose of this paper is to examine the relationship between trade openness and human capital as explanatory variables and GDP as a dependent variable in a sample of eight Balkan countries. The goal of the research is to quantify the relationship between two independent variables and GDP as a dependent variable. The period in which we observe this relationship covers the period from 2000 to 2019. Achieving the research objective is done on the basis of a panel model with fixed and random effects. The results of the panel research testify to the existence of a positive relationship between trade openness and human capital as independent variables and GDP as a dependent variable. Calculated coefficients with independent variables were obtained with a high level of statistical significance. The conclusion of the research implies that there is a positive impact of trade openness and human capital on GDP.

Keywords: *trade openness, human capital, innovations, economic growth, GDP*

1. INTRODUCTION

The example of the development of East Asian economies from the 80s of the last century is taken in the literature today as an example of economic development based on export orientation, increased openness of the economy and investment in human capital. Stiglitz (1996) states that the success of the development of East Asian economies is partly attributed to their openness. In addition to the openness of these economies, the process of accumulation of human capital and industrialization took place in parallel. The experiences of East Asian countries undoubtedly highlight that industrialization can be achieved without relying on the domestic market (Krueger, 1997). More recent, endogenous theories of economic growth include free trade and human capital as significant determinants of economic growth. At the beginning of the nineties of the last century, a large number of important works and studies appeared that

included trade openness as a significant determinant of economic growth (Grossman & Helpman, 1991; Romer, 1990; Young, 1991; Mankiw et al., 1992; Aghion & Howitt, 1992). Trade openness promotes economic growth by achieving efficiency in resource allocation, improving productivity through technology diffusion and knowledge spillovers, and providing access to a variety of goods and services (Barro & Sala-i-Martin, 1997). Trade openness and trade liberalization, which is reflected in the increase in trade, as well as the abolition of trade barriers, characterize today's globalization processes. This not only enabled the free movement of goods and services, but also of people, information, ideas and new concepts. Trade openness can have multiple benefits through knowledge spillovers from developed countries to less developed and developing countries (Krugman, 1985; Romer, 1990; Edwards, 1997; Winters, 2004).

In addition to openness and a free market, human capital plays a very important role in creating economic development. The accumulation of human capital, which implies a more trained workforce, the development of workers' skills, investments in research and development, implies the creation of a stock of human capital, which today is one of the key factors of economic development. The economy can improve human capital through specialization and division of labor, improving basic education, vocational training, encouraging self-employment and creating business opportunities (Santos de Oliveira et al., 2000). Human capital is positively correlated with economic growth, because investments in human capital tend to increase productivity. The process of educating the workforce is a type of investment, but instead of a capital investment such as equipment, it is an investment in human capital. There are a large number of significant studies that look at human capital through workforce education (Azariadis & Drazen, 1992; Mankiw et al., 1992; Papageorgiu, 2003) but also the health of individuals (Knowles & Owen, 1997; Barro, 1991; Bhargava et al., 2001).

Starting from the subject of the research, i.e. the study of the impact of trade openness and human capital on the economic growth of the Balkan countries, in this paper we will apply the panel model for eight countries, namely Albania, Bosnia and Herzegovina, Bulgaria, Montenegro, Croatia, Romania, Serbia and Slovenia. The aim of the research is to quantify the impact of human capital and trade openness on the economic growth of the countries in the sample. The selected countries used to be socialist economies with a command economic system. Going through the transition process, these countries achieved more or less success in adapting to the market way of doing business.

2. LITERATURE REVIEW

By reviewing empirical research, one can find a large number of studies that target the relationship between foreign trade openness and economic growth, as well as between the relationship between human capital and economic growth. With the increase in the openness of the economy through trade openness, economies gain significantly more through specialization in the production of certain products (Alesina et al., 2000). Among many studies, many panel studies are popular, so Gries & Riedlin (2012) conducted panel research on a sample of 158 countries of the world in the period from 1970 to 2009, and they investigated the long-term and short-term dynamics between trade openness and economic growth. This study showed that the coefficients with the variables testifying to the existence of a long-term relationship between foreign trade openness and growth are positive. In his research, Iyke (2017) observes the relationship between foreign trade openness and economic growth of the countries of Central and Eastern Europe (CEE). Using panel data for 17 countries in the period from 1994 to 2014, he concluded that foreign trade openness is important for growth in the observed countries. Kim et al. (2011) investigated the impact of foreign trade openness on economic growth based on panel data for

61 countries in the period from 1960 to 2000. Their research confirms that trade openness has a positive effect on economic prosperity in more technically advanced countries, while this effect is unfavorable in low-income countries. Abendin & Duan (2021) investigated the impact of foreign trade on economic growth in African countries using panel analysis. The research was conducted on a sample of 53 countries in the period from 2000 to 2018. Research has shown that trade has positive effects on economic growth only if there is an interaction with the digital economy.

Fatima et al. (2020) observed the relationship between trade openness, human capital accumulation and economic growth on the example of Asian countries. Their research concluded that the impact of trade openness on economic growth is positive. However, research has shown that if countries have a low level of human capital accumulation, then there is a negative impact of openness to foreign trade on economic growth. Luqman & Soytas (2023) investigated the impact of trade liberalization and human capital on the economic growth of Pakistan. Their results show that there are positive and negative asymmetric effects of trade liberalization and human capital on growth, and that they vary significantly in the short and long term. In the long run, increased trade liberalization harms economic growth, while increased human capital has a minimal positive impact on economic growth in the short and long term. Winters et al. (2004) state that trade liberalization, together with productivity growth, is the best policy in the fight against poverty.

Huchet-Bourdon et al. (2018) point out that trade can have a negative impact on economic growth if countries specialize in the production of low-quality products, while trade has a positive impact on economic growth if countries specialize in the production of high-quality products. Dauti & Elezi (2022) show that trade openness, inflation, investments and the output gap are important factors in shaping the economic performance of the countries of Central and Eastern Europe, as well as the countries of the Western Balkans. Bojat et al. (2021) analyzed the interdependence of the movement of the real growth rate as a dependent variable, and the movement of the share of exports and imports in GDP as explanatory variables on the example of Serbia. The research was conducted for the period from 2000 to 2019 with the help of VAR methodology. The results showed that economic openness, primarily through export-oriented policies, contributes to real GDP growth in the long term, while the impact of the share of imports in the domestic product is negatively correlated with GDP. Krajišnik et al. (2020) investigated the impact of export structure on the economic growth of Bosnia and Herzegovina. This research showed that there is a bad structure of foreign trade production, and that it is necessary to improve the export performance of the economy of Bosnia and Herzegovina in order to reduce the foreign trade deficit. Also, the research confirmed the importance of exports for the economic growth of Bosnia and Herzegovina. Popović et al. (2020) observed a set of explanatory variables as determinants of economic growth based on a panel model of the Balkan countries. Their research came to the conclusion that only the impact of trade openness is statistically significant, and that it has a positive direction. Popović et al. (2019) showed positive connection between total trade and GDP growth in the Republic of Srpska. They also showed negative correlation between trade deficit and GDP.

3. MATERIALS AND METHODS

The research we aim to carry out in this paper should show the relationship between trade openness, human capital and GDP for the countries we have sampled. We took 8 Balkan countries as a sample, namely: Albania, Bosnia and Herzegovina, Bulgaria, Montenegro, Croatia, Romania, Serbia and Slovenia. The research we are conducting in our work is defined for the time period

from 2000 to 2019, and for this purpose we have collected panel data from relevant databases. The specification of the variables we use in the model is given in the following table:

Table 1. Specification of variables

Variable	Label	**Source**	**Note**
Gross domestic product	*GDP*	International Monetary Fund	Gross domestic product in levels
Trade openness	*OPEN*	World Development Indicators	OPEN = (Export + Import)/ GDP
Human capital	*HC*	Penn World Table version 10.01	Human capital index is based on average years of schooling and returns to education
Gross fixed capital formation	*GFCF*	International Monetary Fund	GFCF = Gross investments/ GDP
Public debt	*GOV*	International Monetary Fund	GOV = Gross public debt/ GDP
Unemployment	*UNEM*	World Development Indicators	Unemployment in percentage of total labor force
Population	*POP*	World Development Indicators	Number of inhabitants

Source: Calculations by authors

Based on the previously described variables that we use in the research, we form a basic research model that is given by the relation:

$$GDP = f(OPEN, HC, GFCF, GOV, UNEM, POP) \quad (1)$$

We estimate this basic model based on a panel model with fixed and a model with random effects. The explanatory variables from the previous relationship are OPEN and HC, while the other variables are control.

A fixed effects (FE) model considers the individual effects of unobserved, independent variables. This model determines the effects as constants over time. These constants are fixed for all objects in the panel model throughout the observation period. We can write the panel model with fixed effects as:

$$y_{it} = \alpha_i + \beta x_{it}` + \varepsilon_{it};\ i = 1,\ldots,N,\ t = 1,\ldots,T \quad (2)$$

where N is the total number of individuals, T is the time period of observation and individuals, is a vector of independent variables, β is a vector of parameters with independent variables, is a constant that is different for each observed individual, is a random error. FE takes to be a constant specific to the individual in the model.

The random effects (RE) model considers the individual effects of unobserved, independent variables as random variables over time. These effects switch between OLS and FE and can focus on both, depending on within-individual differences as well as between-individual differences in the model. We can formulate the random effects model in the following form:

$$y^{it} = \mu + \beta x_{it}` + \alpha_i + \varepsilon_{it};\ i = 1,\ldots,N,\ t = 1,\ldots,T \quad (3)$$

where is a common constant and is a random effect for each individual. RE assumes that in this model are independently and identically distributed random variables per observed observation units with mean 0 and covariance. The choice between these two models on the basis of which

we will make further inferences is made using the test proposed by Hausman (1978), which is most often used when choosing between different panel models.

4. RESULTS AND DISCUSSION

In the continuation of the work, we will present the results on the basis of which we will draw conclusions about the influence of foreign trade openness and the role of human capital on the economic growth of selected Balkan countries. Before that, we will look at the descriptive statistics of the variables included in the model. Descriptive indicators of the variables are given in the following table:

Table 2. Descriptive statistics

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Obs.
lnGDP	3.207271	3.510924	5.520981	-0.034591	1.178692	160
lnOPEN	4.322637	4.284221	5.167934	3.610918	0.333518	160
lnGFCF	3.171672	3.154017	3.71788	2.355936	0.214139	160
lnHC	1.128337	1.114604	1.286171	1.015679	0.068929	160
lnGOV	3.7388	3.715015	5.414993	2.520193	0.502052	160
lnUNEM	2.544729	2.616665	3.437529	1.363537	0.541178	160
lnPOP	15.20464	15.24507	16.92649	13.3129	0.970534	160

Source: Calculations by authors

Based on the observed correlation coefficients between the variables, we detect the potential existence of multicollinearity between the explanatory variables of the model. We discover this by calculating the correlation matrix between all the variables included in the model. The following table shows the calculated correlation coefficients for the variables from the model:

Table 3. Correlation matrix

	lnGDP	lnOPEN	lnGFCF	lnHC	lnGOV	lnUNEM	lnPOP
lnGDP	1						
lnOPEN	0.2741	1					
lnGFCF	-0.0778	-0.2155	1				
lnHC	0.4839	0.3666	-0.1686	1			
lnGOV	-0.3602	-0.3043	-0.2830	0.1374	1		
lnUNEM	-0.7084	-0.3386	-0.1957	-0.4849	0.3293	1	
lnPOP	0.7688	-0.0885	-0.0551	-0.0660	-0.3640	-0.4077	1

Source: Calculation by authors

Based on the previous table, we can see that there is no multicollinearity on the basis of which the results obtained using the panel model could be biased. We see that only two calculated coefficients between the explanatory variables are close to the limit. From the table we see that the value of the correlation coefficient between foreign trade openness and GDP is positive and is 0.2741, as well as the value of the correlation coefficient between GDP and the human capital variable. From the obtained results in the correlation matrix, we can conclude that we can form a model based on the selected variables, and make conclusions based on it.

In this paper, we will estimate panel models with fixed and random effects, and we will test these models based on the Hausman test. The following table presents the results obtained using the fixed-effects model:

Table 4. Results of the panel model with fixed effects

Variable	Coefficient	Std. Error	t-statistics	p-value
lnOPEN	0.5148	0.1417	3.63	0.0000
lnHC	5.5827	0.5378	10.38	0.0000
lnGFCF	-0.0089	0.1375	-0.06	0.9480
lnGOV	-0.3564	0.0663	-5.38	0.0000
lnUNEM	-0.0894	0.1030	-0.87	0.3870
lnPOP	-3.5632	0.6382	-5.58	0.0000
C	50.4485	9.7638	5.17	0.0000
R-squared	0.4526			
F-statistic	66.77			
Prob. (F-statistic)	0.0000			

Source: Calculation by authors

From the previous table, we can see that the value of the coefficient with the OPEN variable is positive, which indicates the positive impact that the participation of foreign trade has on economic growth. The calculated value of the coefficient tells us that a 1% increase in the share of foreign trade in GDP affects an increase in GDP by 0.52% with other variables held constant. The value of the calculated coefficient was obtained at the level of statistical significance of 1%. The value of the coefficient with the human capital variable is also positive and was obtained with a statistical significance level of 1%. The coefficient with the variable GFCF is negative, however, this coefficient was not calculated with statistical significance. The coefficient with the variables GOV, UNEM and POP are negative, which indicates a negative impact on the movement of GDP. The coefficient of determination in the fixed effects model states that 45.26% of all variation in the independent variable is explained based on the set of independent variables included in the model.

The estimation of the panel model with fixed effects is followed by the estimation of the panel model with random effects. Therefore, in the following table we present the results calculated using a panel model with random effects:

Table 5. Results of the panel model with random effects

Variable	Coefficient	Std. Error	t-statistics	p-value
lnOPEN	0.1569	0.1207	1.3	0.0940
lnHC	7.7722	0.6222	12.49	0.0000
lnGFCF	-0.0534	0.1679	-0.32	0.7500
lnGOV	-0.2604	0.0789	-3.3	0.0010
lnUNEM	-0.2862	0.0851	-3.36	0.0010
lnPOP	-0.8601	0.0398	21.61	0.0000
C	-17.4467	1.7412	-10.02	0.0000
R-squared	0.9103			
F-statistic	99.29			
Prob. (F-statistic)	0.0000			

Source: Calculation by authors

The results we obtained using the random effects model deviate to a certain extent from the results obtained in the fixed effects model. If we look at the sign between the obtained coefficients, we see that there is no deviation. However, if we look at the significance of the coefficients as well as the differences between the calculated coefficients, we see that there is a certain deviation. From the table we see that the value of the coefficient with the OPEN variable was calculated without statistical significance, which is the biggest difference compared to the previous model.

Therefore, we test which model is suitable for use based on the methodology proposed by Hausman (1978) and which has the widest application when choosing between two panel models. The Hausman test tries to confirm the null hypothesis, which reads: the differences in the coefficients are not systematic. With this null hypothesis of the Hausman test, we are trying to confirm that the random effects model is suitable because this model is more efficient than the fixed effects model. The following table shows the results of the Hausman test:

Table 6. Results of the Hausman test

Test Summary	Chi Sq. Statistic	Chi Sq. d.f.	Prob.
Cross-section random	82.22	6	0.000

Source: Calculation by authors

The Hausman test uses a chi-square distribution with degrees of freedom equal to the number of time-varying regressors. If the probability of this test is insignificant, then the model with random effects is used, and then we cannot reject the null hypothesis. If the probability is significant, then at the level of statistical significance we reject the null hypothesis and use a model with fixed effects. As shown in the previous table, based on the p-value, we reject the null hypothesis, and conclude that it is necessary to use a model with fixed effects.

5. CONCLUSION

The development of knowledge-based economies and the openness of the economy is yet to be seen in transition economies. Only for some of the transition countries we are able to conclude that there is a correlation between trade openness and economic growth. From the perspective of the impact of human capital on economic growth in transition economies, it can be seen that its importance in relative relation to other determinants of economic growth is significantly lower. The mismatch of workers' skills in these economies remains a consequence of the weak adaptation of the labor market to structural changes and the education system, although we cannot make an absolutely identical conclusion for all transition economies. On the other hand, the exposure of these economies to imported goods is also an obstacle to the long-term development of these countries.

In this paper, we tested the relationship between trade openness and human capital as independent variables and economic growth as a dependent variable. The research was conducted on a sample of 8 Balkan countries, namely Albania, Bosnia and Herzegovina, Bulgaria, Montenegro, Croatia, Romania, Serbia and Slovenia. In the paper, we collected panel data where a panel model with fixed and a panel model with random effects were tested. The results of both models show that, at the level of statistical significance of 1%, openness to foreign trade and an increase in human capital increase economic growth in the example of the observed countries. As models with random and fixed effects were tested in the paper, the results of the Hausman test confirmed that models with fixed effects give better results. These results and analysis are

based on the pre-crisis period. The economy changed a lot after that Covid-19 period. Based on the coefficient of determination, we can conclude that over 45% of the variations in the dependent variable are explained by the variations in the independent variables.

The conclusion that can be drawn from this is that it is extremely important for developing countries, especially small transition economies, to get involved in the process of free trade, and to reorient themselves to the concept of export orientation and human capital accumulation.

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ENHANCING ECONOMIC MANAGEMENT WITH INFORMATION TECHNOLOGY: INSIGHTS FROM COVID-19 IN BOSNIA AND HERZEGOVINA THROUGH THE LENS OF MACHINE LEARNING METHODS

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ABSTRACT

This paper explores the role of information technology in enhancing the efficiency of economic management during the COVID-19 pandemic. The research aim was to investigate how the integration of information technology, data usage, and analytics, digital transformation of the financial sector, ensuring digital inclusion and cyber security can contribute to improving economic management in times of crisis. The research methodology involved data collection through a questionnaire that asked participants a series of questions about their attitudes and perceptions regarding the integration of information technology and its impact on the efficiency of economic management during the pandemic. The data were analyzed using the chi-square statistical method to determine the existence of significant relationships between variables. The results indicate that information technology is a key factor in strengthening economic management during the COVID-19 pandemic. The integration of information technology, data usage, and analytics, digital transformation of the financial sector, and ensuring digital inclusion and cyber security can enhance efficiency, transparency, and stability during crisis times. The research emphasizes the need for investment in information technology, the development of implementation strategies, strengthening cyber security, and ensuring digital inclusion as key steps towards building a more resilient economic environment during the pandemic. Further research and implementation of these technologies in practice are recommended to achieve sustainable economic development and successful crisis management.

Keywords: *information technology, machine learning, COVID-19 pandemic, data usage and analytics, digital trans-formation, digital inclusion, cyber security*

1. INTRODUCTION

In today's global business environment, every company, regardless of its size, strives to improve its operations and achieve higher profits. However, the emergence of the COVID-19 virus pandemic has suddenly impacted many businesses, forcing them to reduce production or even temporarily suspend their activities to alleviate financial obligations. The economic situation, both at the global level and in countries like Bosnia and Herzegovina, has rapidly deteriorated due to frequent work stoppages, business closures, and mass layoffs. This has resulted in an increase in unemployment rates and added pressure on budgets, particularly in poorer

countries. Furthermore, we are facing a trend of increasing emigration among young people and dissatisfied employees from Bosnia and Herzegovina, who are leaving the country in search of a better, safer, and more promising life. This phenomenon of emigration is not specific to our country alone; it is also occurring in other countries in the region. However, Bosnia and Herzegovina is experiencing a significantly higher emigration trend compared to other countries.

The pandemic also had a tremendous impact on the economy, and China became the first country to demonstrate that the spread of the virus could be halted. However, the question arises as to the cost of such a victory. In addition to economic losses in terms of lost income, business failures, and increased unemployment, it is important to emphasize the significance of timely, quality, open, and categorized data and statistics during the pandemic. Such data is crucial for understanding, managing, and mitigating the human, social, and economic effects of the pandemic, as well as designing short-term responses and accelerated actions to get countries back on track towards achieving sustainable development goals.

Managing the economy in crisis scenarios, such as the recent COVID-19 pandemic, requires innovative solutions that can provide adequate responses to the challenges faced by the global community. One key aspect of such solutions is the application of information technology (IT) to improve economic management and ensure its stability in these extraordinary situations. Integrating IT into economic strategies during crisis scenarios can bring significant advantages, but it also presents challenges that require careful planning and implementation.

Accordingly, this research aims to explore the applications of information technology as innovative solutions for managing the economy in an international crisis scenario, with a particular focus on the COVID-19 pandemic. The main objective of the research is to identify key factors, advantages, and challenges in integrating information technology into economic strategies in such crises.

Within this study, the focus will be directed on the impact of the COVID-19 pandemic on the economy, specifically on economic management and the application of information technology (IT) as a key factor for effective crisis management. This paper will address the theoretical framework encompassing information technology in economic management, crisis management, and the economy, the integration of information technology into economic strategies during crises, as well as the theoretical foundations and models of applying information technology in economic management during crises.

This research aims to analyze theoretical concepts and models to gain a deeper understanding of the integration of information technology into economic practice during crises. In this way, the research will contribute to a better understanding of the importance of information technology in overcoming the economic challenges posed by the pandemic and provide guidelines for managing and applying information technology in the economic context of crises.

The subsequent chapters will delve into a detailed examination of the theoretical framework and previous research to gain a broader understanding of this topic and identify key aspects for further analysis. The research methodology, data collection, and analysis of results will also be presented, which will contribute to a better understanding of the role of information technology in economic management during crises.

2. THEORETICAL BACKGROUND

Information technology (IT) has become a key factor in modern economic management. In the context of crises, such as the global COVID-19 pandemic, IT has the potential to transform

the way economy is managed and enables organizations to effectively respond to unforeseen changes and minimize negative impacts. IT provides organizations with tools and resources for real-time data collection, processing, storage, and analysis. This allows decision-makers to have timely and relevant information at their disposal, which is crucial for efficient management of the economy during crises.

Crisis management involves a set of strategies, policies, and measures that organizations implement to deal with crises and mitigate their negative effects. In the economy, crises, such as natural disasters, economic recessions, or global pandemics, can have a wide range of negative consequences on various sectors and aspects of the economy. Managing the economy during these crises requires the ability to adapt quickly, allocate resources efficiently, and make informed decisions. In this context, the integration of information technology into economic strategies becomes critical for achieving successful outcomes.

Bessonova and Battalov (2021) consider digitalization to drive the strategic development of the global economy. Digital technologies accelerate economic progress by enabling the flow of ideas and data (Wendt, Adam, Benlian & Kraus, 2021). Governments worldwide are increasing investments in innovation in response to the COVID-19 pandemic, aiming to assist humanity in coping with the crisis through intensified scientific research, expanded research and development activities, and increased patent applications (Guderian, Bican, Riar & Chattopadhyay, 2021; Soumitra et al., 2021). Innovative technologies enhance business analysis and forecasting, new product creation, order processing, logistics, factory automation, quality control, and marketing (Jemala, 2021). Wang, Zhang, and Verousis (2021) examine the impact of the pandemic duration on innovation output and suggest that policies guiding innovative firms are on the right path and their recovery time is reduced. Business Model Innovation (BMI) can help small and medium-sized enterprises remain competitive during crises while focusing on revenue generation and value addition (Adam & Alarifi, 2021; Clauss, Breier, Kraus, Durst & Mahto, 2022; Ibarra, Bigdeli, Igartua & Ganzarain, 2020). Open innovation activities (interaction with consumers and open exchange of knowledge on market requirements and technological possibilities) can be beneficial in minimizing the impact of COVID-19 on education, the economy, and leisure time (Almeida, 2021; Surya et al., 2021). In the future, innovation differences will be evident in various industries and economies. Therefore, it is necessary to enhance innovation ecosystems to reduce imbalances between sectors (such as ICT, the pharmaceutical industry, research and development, hospitality, or the automotive industry) by investing in new technologies and business strategies.

Over the past two years, various research studies have focused on innovation as a cutting-edge strategy for surviving situations like the COVID-19 pandemic, emphasizing the critical importance of innovation (e.g., Sharma, Lopes de Sousa Jabbour, Jain & Shishodia, 2022). The outbreak of the COVID-19 pandemic has caused damage to economies worldwide (García-Carbonell, Martín-Alcázar & Sánchez-Gardey, 2021). Additionally, due to the COVID-19 pandemic, small and medium-sized enterprises, in particular, face various problems and obstacles (e.g., Emami, Ashourizadeh, Sheikhi & Rexhepi, 2021). The lockdowns and movement restrictions imposed by governments in many countries have severely impacted the operations of small and medium-sized enterprises, weakened their financial status, and exposed them to financial risk (Omar, Ishak & Jusoh, 2020). As a result, many organizations have been unable to solve the problem (Ozili, 2020). Insufficient research has been conducted on the impact of external support received by small and medium-sized enterprises after the COVID-19 epidemic on their efficiency and survival (except for Song, Yang & Tao, 2020). In the case of a pandemic, organi-

zations need to adapt to new technologies and financial applications. The role of innovation and initiatives is crucial in the post-COVID-19 period.

Mićić and Mastilo (2022) provide general effects of the pandemic to digital transformation of businesses all over the globe, mostly connected to analysis of the employees' workplace preference. The research focus is on digital workplace transformation. Results show that COVID-19 has embraced and sped up the process of workplace innovation and that it created new opportunities to further workplace developments in accordance to employee preferences.

Mašić, Vladušić and Nešić (2018) explore and present the importance of digital transformation and innovations. Companies should strive to build collaborative relationships as a means to creating transformational growth. Results show that information and communications technologies are significant in the process of strategic planning. The Paper also emphasizes the importance of organizational structure and culture required for implementing strategies that are aligned with digital transformation.

Integrating information technology into economic strategies during crises is a key factor in achieving efficient economic management. The integration of IT tools, systems, and infrastructure allows organizations to collect, analyze, and interpret data in real-time. These data provide deeper insights into market changes, consumption trends, changes in consumer behavior, and economic indicators. Based on this information, organizations can make informed decisions regarding resource allocation, strategy selection, and future planning. The integration of information technology also facilitates the automation of business processes, leading to greater efficiency and productivity.

Various theoretical foundations and models can be applied to the integration of information technology in economic management during crises. Some of these models include the theory of digital transformation, which emphasizes the need for organizational change and adaptation to the digital era; the theory of data and analytics, which highlights the importance of data collection and analysis for informed decision-making; the theory of digital inclusion, which deals with access to information technology and ensuring a balance in digital development; and the theory of cyber security, which focuses on protecting information technology from cyber-attacks and threats.

3. MATERIALS AND METHODS

3. 1. RESEARCH DESIGN AND HYPOTHESES DEVELOPMENT

The research subject encompasses the role of information technology in economic management during the COVID-19 pandemic. Different aspects of digital transformation, data and analytics, digitalization of the financial sector, digital inclusion, and cyber security will be analyzed in the context of economic management during the pandemic.

The main research problem is how to effectively integrate information technology into economic strategies to adequately manage the economy during the COVID-19 pandemic. Additionally, the research will focus on identifying challenges that may arise in the implementation of information technology and finding solutions to overcome these challenges in the context of the pandemic. This research aims to explore the applications of information technology as innovative solutions for economic management during the COVID-19 pandemic. The focus will be

on identifying key factors, benefits, and challenges in the integration of information technology into economic strategies in the context of the pandemic.

Based on these considerations, the hypothesis for this study is as follows: **"Integrating information technology into economic strategies during the COVID-19 pandemic enhances overall economic management."**

This research employed a questionnaire survey as the primary method for data collection. The survey aimed to gather insights from experts in the fields of information technology, economics, and crisis management regarding the applications of information technology in economic management during the COVID-19 pandemic. The survey questionnaire was carefully designed to address the research objectives and included questions related to various aspects of information technology integration, such as digital transformation, data and analytics, digitalization of the financial sector, digital inclusion, and cyber security.

The participants in this study were selected based on their expertise in the relevant fields. A purposive sampling approach was employed to ensure that the respondents had a strong background in information technology, economics, or crisis management. The sample consisted of professionals and experts from various organizations and sectors in Bosnia and Herzegovina. The total number of participants included in the study was 100.

The online survey was conducted electronically using an online survey platform in January and February 2023. The participants were invited to complete the survey, which consisted of multiple-choice and open-ended questions. The survey was administered over a specified period, allowing participants to respond at their convenience. The collected data included responses to the survey questions, demographic information, and any additional comments or suggestions provided by the participants.

3. 2. DATA ANALYSIS

The collected data were analyzed using the IBM SPSS Statistics 26 software. Descriptive statistics were employed to examine the distribution of responses and demographic characteristics of the participants. Furthermore, inferential statistical techniques, including Chi-Square tests, were utilized to assess the relationships between variables and test the research hypotheses. The significance level was set at $p < 0.05$ to determine statistical significance.

Ethical guidelines were followed throughout the research process. Participants were assured of the confidentiality and anonymity of their responses. Informed consent was obtained from all participants, and they were informed about the purpose of the study. The research was conducted in compliance with relevant data protection and research ethics regulations

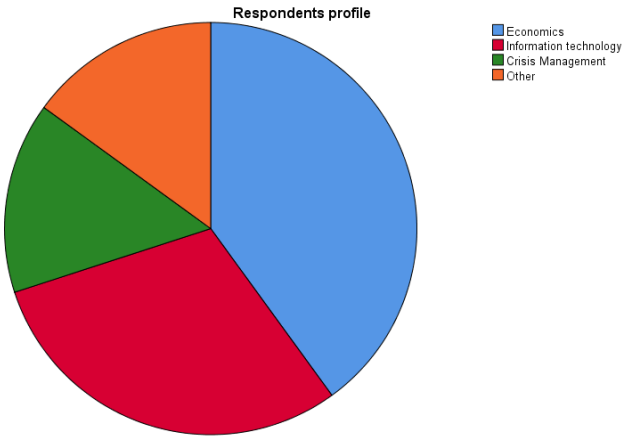
3. 3. LIMITATIONS

It is important to acknowledge certain limitations of this study. Firstly, the findings are based on self-reported data, which may be subject to response bias. Secondly, the generalizability of the results may be limited due to the specific sample characteristics and the use of a questionnaire survey. Finally, the study focused on a specific context (COVID-19 pandemic) and may not fully capture the long-term implications of information technology integration in economic management.

4. RESULTS AND DISCUSION

40% of the respondents belong to the field of economics, 30% of the respondents work in the field of information technology, 15% of the respondents work in the field of crisis management, while 10% of the respondents indicated belonging to other categories. The total number of respondents is 100, which constitutes 100% of the total population included in the research.

Figure 1. Respondent's profile



Source: Author's independent creation

Table 1 shows how familiar respondents are with the integration of information technologies (IT) during a crisis period.

Table 1. Familiarity with the integration of information technologies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very familiar	50	50,0	50,0	50,0
	Partial familiar	40	40,0	40,0	90,0
	Not familiar	10	10,0	10,0	100,0
	Total	100	100,0	100,0	

Source: Author's independent creation

According to the table, 50% of the respondents identified themselves as "Very familiar" with the integration of information technologies. Partial familiarity with the integration of information technologies was stated by 40% of the respondents, while 10% of the respondents claimed to be unfamiliar with this topic.

Table 2. Do you believe that the integration of information technologies can improve the efficiency of economic management in an international crisis scenario?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	80	80,0	80,0	80,0
	No	10	10,0	10,0	90,0
	Not sure	10	10,0	10,0	100,0
	Total	100	100,0	100,0	

Source: Author's independent creation

Out of a total of 100 respondents, 80% (80 respondents) answered affirmatively, believing that the integration of information technology can improve the efficiency of economic management in a crisis scenario. The remaining respondents, 10% (10 respondents), answered negatively, while another 10% (10 respondents) stated that they are not sure or had no specific opinion on this topic. These results indicate a majority positive opinion among the respondents regarding the role of information technology in enhancing the efficiency of economic management in an international crisis scenario.

Table 3. How much do you believe that the use of machine learning can provide relevant information for decision-making in crises?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Can provide relevant data completely	60	60,0	60,0	60,0
	Can provide relevant data partially	30	30,0	30,0	90,0
	Cannot provide relevant data	10	10,0	10,0	100,0
	Total	100	100,0	100,0	

Source: Author's independent creation

Out of a total of 100 respondents, 60% (60 respondents) believe that the use of data and analytics can provide relevant information completely for decision-making in crises. An additional 30% (30 respondents) state that the use of machine learning partially provides relevant information for decision-making in crises. Only 10% (10 respondents) believe that the use of machine learning cannot provide relevant information for decision-making in crises. These results indicate a majority positive opinion among the respondents regarding the importance of using data and analytics for making informed decisions in crises.

Table 4. Do you think that the digital transformation of the financial sector can enhance the stability and transparency of financial flows in times of crisis using statistical methods?

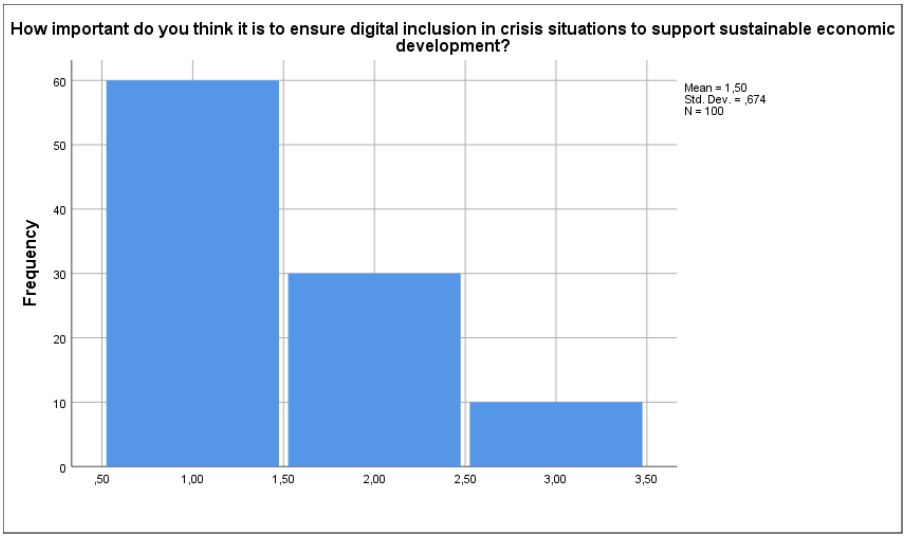
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	70	70,0	70,0	70,0
	No	20	20,0	20,0	90,0
	Not sure	10	10,0	10,0	100,0
	Total	100	100,0	100,0	

Source: Author's independent creation

70% (70 respondents) believe that digital transformation can enhance the stability and transparency of financial flows in times of crisis. 20% (20 respondents) state that digital transformation

cannot improve the stability and transparency of financial flows in times of crisis. 10% (10 respondents) are unsure about it.

Figure 2. Digital inclusion



Source: Author's independent creation

Figure 2 provides answers to the question "How important do you think it is to ensure digital inclusion in crises to support sustainable economic development?" When we connect the results from Table 4 and Figure 2, we can see that the majority of respondents believe that digital transformation of the financial sector can enhance the stability and transparency of financial flows in times of crisis. Additionally, most respondents consider it important to ensure digital inclusion in crises to support sustainable economic development. These results indicate the recognition of the importance of digital technologies in the financial sector and their role in improving stability, transparency, and inclusion in crises.

Table 5. Do you consider cybersecurity to be crucial for protecting information technologies and economic systems in crises?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	80	80,0	80,0	80,0
	No	10	10,0	10,0	90,0
	Not sure	10	10,0	10,0	100,0
	Total	100	100,0	100,0	

Source: Author's independent creation

The results in Table 5 indicate that the majority of respondents recognize the importance of cybersecurity for protecting information technologies and economic systems in crises. This highlights an awareness of the potential threats that cyber attacks can pose to the information infrastructure and economy during crises. These results emphasize the need for adequate cybersecurity measures to ensure the protection of information technologies and economic systems. Cybersecurity is a crucial factor in preserving the confidentiality, integrity, and availability of data, as well as preventing financial losses and maintaining business continuity during times of crisis. It is important to note that there are also respondents who are unsure or have an unclear stance on this issue. This may indicate a lack of awareness or information regarding the importance of cybersecurity in the context of protecting information technologies and economic

systems in crises. Therefore, it is necessary to provide education and raise awareness on this matter to improve understanding and support for cybersecurity in crises.

Table 6. The greatest challenge in the application of information technologies in an international crisis scenario is:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	cyber attacks	50	50,0	50,0	50,0
	lack of infrastructure	32	32,0	32,0	82,0
	lack of expertise	18	18,0	18,0	100,0
	Total	100	100,0	100,0	

Source: Author's independent creation

The results in Table 6 indicate important factors that can limit the effective implementation of information technologies in managing the economy in international crisis scenarios. Cyber attacks are considered the greatest challenge (50% of respondents), highlighting the increasing threat of cybercrime and the need for adequate cybersecurity measures.

The lack of infrastructure (32%) is also highlighted as a significant factor that can hinder the application of information technologies in crises. Insufficient or inadequate infrastructure can limit the availability and reliability of information technologies, making it more difficult to effectively manage the economy in a crisis scenario.

Furthermore, the lack of expertise (18%) has been identified as a significant challenge. The shortage of skilled professionals with relevant skills and knowledge can diminish the ability to effectively implement information technologies in crisis management. These results emphasize the importance of investing in cybersecurity, infrastructure, and the development of skilled workforce to overcome challenges and maximize the benefits of information technologies in international crisis scenarios. They also underscore the need for continuous education and training of professionals to ensure their proficiency in effectively utilizing information technologies in crisis management.

Table 7. The aspect of information technologies considered most significant for effective management of the economy in crises is:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Integration of IT	30	30,0	30,0	30,0
	Use of data and analytics	40	40,0	40,0	70,0
	Digital transformation	20	20,0	20,0	90,0
	Digital inclusion	5	5,0	5,0	95,0
	Cybersecurity	5	5,0	5,0	100,0
	Total	100	100,0	100,0	

Source: Author's independent creation

The results indicate the importance of integrating information technologies, using data and analytics, digital transformation, digital inclusion, and cybersecurity for effective management of the economy in crises. The integration of information technologies stands out as a crucial aspect, implying the need to align IT infrastructure, applications, and systems to achieve synergy and better coordination in crisis management. The use of data and analytics is also recognized

as a key aspect of making informed decisions in crises. Efficient data collection, analysis, and interpretation can provide relevant information and support real-time decision-making.

Digital transformation, which encompasses changes in business models, processes, and technologies, is also recognized as a significant aspect of achieving stability and transparency of financial flows in crisis times. The importance of digital inclusion emphasizes the need to ensure access to information technologies for all segments of society to overcome inequalities and support sustainable economic development in crises. Cybersecurity is also considered a significant aspect, given the increasing threat of cyber attacks. Protecting information technologies and economic systems from cyber threats is crucial for preserving stability and trust in times of crisis.

These results highlight the importance of various aspects of information technologies in managing the economy in crises. Proper integration, use of data and analytics, digital transformation, digital inclusion, and cybersecurity can be key factors in successfully addressing challenges and achieving effective economic management in times of crisis.

Table 8. Additional comments or suggestions regarding the application of information technologies in managing the economy in crises:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	strengthening collaboration between sectors	75	75,0	75,0	75,0
	the need for training and education	15	15,0	15,0	90,0
	establishment of clear regulations	10	10,0	10,0	100,0
	Total	100	100,0	100,0	

Source: Author's independent creation

Out of a total of 100 respondents, 75% (75 respondents) emphasize strengthening collaboration between sectors as a key suggestion for the application of information technology in managing the economy in crises. This implies the need to establish cooperation and coordination between the public sector, private sector, and civil society to achieve a synergistic approach in the implementation of information technology in crises.

15% (15 respondents) mention the need for training and education as an additional comment or suggestion. This highlights the importance of continuous education and training of IT professionals to ensure their proper implementation and use in crisis management.

Another 10% (10 respondents) emphasize the establishment of clear regulations as an additional suggestion for the application of information technology in managing the economy in crises. This underscores the importance of legal regulations and policies that will support security, transparency, and accountability in the use of information technology in crises.

These additional comments or suggestions indicate the need for collaboration among sectors, continuous training and education of professionals, and the establishment of clear regulations to achieve successful implementation of information technology in managing the economy in crises. These suggestions are important because they emphasize that the application of information technology is a complex process that requires a holistic approach and coordinated efforts from various stakeholders.

Table 9. Test Statistics

Test Statistics			
	Chi-Square	df	Asymp. Sig.
Do you consider that the integration of information technologies can enhance the efficiency of managing the economy in an international crisis scenario?	98,000[a]	2	,000
How much do you believe that the use of ML techniques can provide relevant information for decision-making in crises?	38,000[a]	2	,000
Do you think that cyber security is crucial for protecting information technologies and economic systems in crises?	98,000[a]	2	,000
Do you believe that the digital transformation of the financial sector can improve the stability and transparency of financial flows in crisis times?	62,000[a]	2	,000
How important, in your opinion, is it to ensure digital inclusion in crises for supporting sustainable economic development?	38,000[a]	2	,000
a. 0 cells (0,0%) have expected frequencies less than 5. The minimum expected cell frequency is 33,3			

Source: Author's independent creation

The results presented in the table represent the values of the test statistic, degrees of freedom (df), and p-values for each hypothesis. The p-value indicates the statistical significance of the results, and lower values indicate higher statistical significance. In our case, all p-values are very small (0.000), indicating statistically significant results for all tested hypotheses. This means that our hypotheses are confirmed based on the available data. Based on the results of the conducted research, we can draw the following conclusions:

The results of the survey questionnaire indicate that all questions related to the integration of information technology into economic strategies during crisis times are statistically significant. All Chi-square tests have very low p-values ($p < 0.001$), indicating significant associations between the integration of information technology and aspects of economic management during the pandemic.

Specifically, the results show that survey participants believe that the integration of information technology can enhance the efficiency of economic management in crisis scenarios (Chi-square = 98.000, df = 2, p = 0.000). They also believe that the use of machine learning (ML) can provide relevant information for decision-making during crises (Chi-square = 38.000, df = 2, p = 0.000). Furthermore, they consider cybersecurity to be crucial for protecting information technology and economic systems during crises (Chi-square = 98.000, df = 2, p = 0.000). Survey participants also recognize that the digital transformation of the financial sector can improve the stability and transparency of financial flows in crisis times (Chi-square = 62.000, df = 2, p = 0.000). Additionally, they believe that ensuring digital inclusion is important for supporting sustainable economic development during crises (Chi-square = 38.000, df = 2, p = 0.000).

Based on the statistically significant results, we can conclude that the survey results support the hypothesis. The integration of information technology into economic strategies during the COVID-19 pandemic enhances overall economic management, as suggested by the survey participants.

5. CONCLUSION

The COVID-19 pandemic represents a global crisis that has had a dramatic impact on the economy and requires innovative approaches to management. In this context, information technologies have proven to be a key tool for improving the efficiency of economic management, making informed decisions, and ensuring the stability of financial flows.

Our research has confirmed that the integration of information technologies into economic strategies can significantly improve the efficiency of management during the COVID-19 pandemic. Test results show a statistically significant correlation between the integration of information technologies and management efficiency. The use of data and analytics also stands out as a crucial factor in providing relevant information for decision-making in crises. The analysis has shown a statistically significant relationship between the use of data and analytics and informed decision-making in economic management during the pandemic.

The digital transformation of the financial sector also has significant potential for enhancing the stability and transparency of financial flows during the pandemic. Our research has confirmed a statistically significant correlation between the digital transformation of the financial sector and improved stability and transparency of financial flows. This highlights the importance of continued investment in digital technologies and innovations to strengthen the financial sector and reduce vulnerability during crisis times. Ensuring digital inclusion has also been shown to be an important factor in supporting sustainable economic development during the pandemic. Our research has confirmed a statistically significant relationship between digital inclusion and overcoming inequalities in access to information technologies. Involving all segments of society in digital processes and providing access to information technologies can create balance and support sustainable economic development during crisis times. We have also demonstrated that cybersecurity is crucial for protecting information technologies and economic systems during the COVID-19 pandemic. Cyberattacks can seriously compromise the stability and integrity of information technologies and economic systems. Therefore, it is imperative to pay attention to strengthening cybersecurity and adopting appropriate measures to protect digital resources. Overall, the results of our research confirm that information technologies are a key factor in improving economic management during the COVID-19 pandemic. The integration of information technologies, the use of data and analytics, digital transformation of the financial sector, ensuring digital inclusion, and cybersecurity play a critical role in enhancing efficiency, transparency, and stability during crisis times. However, it is important to note that information technologies alone are not the solution to all problems. Their successful implementation requires a clear strategy, adequate investment, employee education, and partnerships between the public and private sectors. It is also necessary to consider security aspects and protect data privacy to maintain user trust and prevent potential misuse. In light of our findings, it is recommended that governments, organizations, and economic actors actively promote the integration of information technologies, invest in digital resources, ensure digital inclusion, improve cybersecurity, and support innovation in economic management during the pandemic. These efforts will contribute to strengthening economic capacities, overcoming crises, and creating a more resilient economic environment. Additionally, future research can deepen our understanding of specific mechanisms and factors that influence the success of implementing information technologies in economic management during crisis times. This knowledge can be valuable for developing

policies, strategies, and practices that better address specific needs and challenges in a given context.

In conclusion, information technologies are a powerful tool for improving economic management during the COVID-19 pandemic. The integration of information technologies, the use of data and analytics, the digital transformation of the financial sector, ensuring digital inclusion, and cybersecurity have the potential to enhance efficiency, transparency, and stability during crisis times. Overall, investment in information technologies and their proper implementation can provide sustainable solutions for economic management in challenging situations such as a pandemic.

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THE GEOPOLITICAL "PUZZLE" OF THE CENTRAL BANK'S SWITCH TO GOLD

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ABSTRACT

Gold holdings increased during recent time. Geopolitical factors could be responsible for such shift taking into account rising number of conflicts in the world since 2014. However, optimal share for gold in external assets is still disputable. The paper provides empirical tests to identify political economy factors of central bank's gold holdings. The paper imply two empirical approaches: analysis of how gold reserves in tones and as a share of reserves distributed among the countries with different political regimes; logit regression to identify role of political economy factors that may push countries' switch to gold. Results of empirical analysis shows that political regime itself is not obvious driving force of gold share. Excluding developed countries, it is possible to see that autocracies do not outperform democracies in terms of mean and median share of gold systematically. Countries demonstrated shifts toward gold early then reference point of 2014 year despite political regime. Logit regression also helps to see that countries heavily have being exposing to gold are more likely hoarding large exchange reserves and politically stable. Proxies of geopolitical aggressiveness are valid with some covenants. While Global Peace Index is well proxy to identify geopolitical preconditions of countries' switch to gold, military expenditures are not. This means that geopolitical motives of gold hoarding probably work directly and indirectly through exchange reserves accumulation and supportive political stability. Geopolitical aggressiveness that coincides with only large military expenditures but not with reserves accumulation is likely to stand on weak economic ground.

Keywords: *gold, currency reserves, central banks, geopolitical risks, reserve diversification, military expenditures*

1. INTRODUCTION

After moscow started an aggressive war against Ukraine and Western allies imposed sanctions against its foreign assets, the signals of increasing pressure on the gold market became stronger. A number of central banks increased their investments in the precious metal. There is an easy temptation to explain this situation from viewpoint that gold is a unique asset used to hedge geopolitical risks. There are sufficient reasons for such an argument. The world has become a more dangerous place, contrary to estimates by the Rand Corporation (Szaynaetal, 2017). Monetary authorities of individual countries fear that their international reserves are no longer protected as they once were.

Increasing geopolitical tension between the United States and a number of countries prompts a rethinking of the dollar's role in the international political economy. Actually, such arguments fully correspond with the unique properties of gold as a reserve asset. Such properties are that gold embodies intrinsic value. It follows that it is not someone's obligation. In other words, the precious metal is not subject to sovereign solvency risk. Moreover, owning gold makes it impossible to depend on the behavior of the issuer of reserve assets, which may be subject to certain restrictions. In light of the fear of such restrictions and geopolitical risks, the growing interest of central banks in gold should be justified. In addition, in a broader sense, geopolitical risks should have a systematic impact on the decision to hold a larger share of gold in foreign assets.

On the other hand, there is evidence that the geopolitical role of gold is clearly overestimated. In particular, (Koziuk, 2022a) shows that the aggregate share of gold in global currency reserves has returned to the level of 2000. Its dynamics are more sensitive to the uncertainty of economic policy and reserve management decisions than to geopolitical risks. In addition, the recent increase in interest of central banks in gold may be due to economic rather than geopolitical considerations. Until recently, low interest rates lowered the opportunity cost of holding precious metal. The acceleration of inflation in the world affected the fact that fixed income instruments generate negative yields in real terms. Expectations of rate hikes provoke the appearance of strong valuation effects due to the fall in market prices for instruments issued at lower rates in previous years.

Moreover, the question of gold demand driven by discussions about the diversification of hoarded reserves. And if autocracies have accumulated larger reserves (Koziuk, 2021a), (Jager, 2016) and are more prone to provoking geopolitical tension, is the growing demand for the precious metal driven by non-economic motives has an indirect form? Besides, differences in the motives of reserve management arise from the peculiarities of political regimes.

Obviously, from a fundamental point of view, the advantage of holding precious metal should demonstrate a more systematic manifestation, not so much in the last few years. The year 2014 can be called a kind of watershed. The violent annexation of part of one country by another and the introduction of sanctions in response fell on this year. In addition, if geopolitical factors matter when choosing in favor of gold, then they should indicate that central banks increase their holdings of the metal and its share in reserves after 2014. This paper shows that political regimes are not an unequivocal criterion for choosing a greater role of gold in external assets. At the same time, if geopolitical factors of reorientation towards gold exist, then they act through the channel of significant currency reserves and political stability, which enables their accumulation. However, this does not rule out that in some cases geopolitical motives for diversification in favor of gold are dominant.

2. LITERATURE OVERVIEW

The ambiguity of the role of gold in central banking practices is quite expected. The greater the growth in holdings of foreign exchange reserves prompts the introduction of the portfolio approach to their management, the more the economic arguments rest on a reliable foundation. However, this does not mean that there are no opinions that emphasize the special political and economic aspects of central bank decisions. At the same time, the geopolitical dimension of the special role of gold can be conditionally reduced to the question of whether hoarding gold helps to hedge geopolitical risks and to the question of the central bank motives for such hoarding.

The study of gold's ability to hedge geopolitical risks is based on the tradition of analyzing its role as a "safe haven". Moreover, some of studies are relatively unanimous that gold can be a fairly reliable instrument for hedging the risks of inflation (Reboredo, 2013a), (Reboredo, 2013b), stock price fluctuations (Baur and McDermott 2010, Gürgün and Ünalmis, 2014), decline bond yields (Baur and Lucey, 2010). In most cases, the emphasis is on the opposite movement of the yield of gold and the corresponding asset class at certain times, or on the inverse correlation between them. However, in some papers the ability of gold to be a "safe haven" challenged. In recent paper Iaccurci (2021) shows that gold is not a good solution as inflation hedge. The similar results performed by Fabris and Jesic (2023) in case of some European financial indicators. Joachim (2015) stress on volatility and unpredictability of gold prices. The non-linearity in relations with inflation and interest rates should make gold less attractable from "safe haven" viewpoint. COVID crisis and economic development are also challenging factor to financial indicators behavior (Fabris, 2022), (Mastilo et. al. 2021).

Regarding geopolitical risks, Qinet et al. (2020) show that the dynamics of gold prices are sensitive to significant negative changes in the behavior of indicators characterizing geopolitical tension. They conclude that holding gold improves risk hedging in "times of chaos". Baur and Smile (2020) also confirm that gold prices rise when geopolitical risks increase. At the same time, Baur and Smile (2020) also state that the increasing profitability of assets in gold reacts more to geopolitical threats than to manifested geopolitical events. This may indicate that the gold market is more sensitive to geopolitical signals. Moreover, geopolitical risks are not a reason for the automatic reaction of central banks in the direction of changing the management of external assets. In Koziuk (2021), the dominance of geopolitical factors in the behavior of gold prices is questioned. Uncertainty of economic policy has a more pronounced effect on the behavior of prices for precious metal.

Regarding the geopolitical factors of gold holding, research is less clear-cut. For example, Koziuk (2022) a showed that the aggregate share of gold in global reserves over the past 20 years hardly reflected geopolitical problems. It is more sensitive to uncertainty about economic policy and the opportunity costs of holding reserves. Besides, Koziuk (2022b) argues that gold hoarding for geopolitical reasons against economic expediency is some kind of manifestation of imperial narcissism. Similar conclusions correspond to the results obtained by Aizenman and Inoue (2012), who claim that the imperial past significantly affects the size of the gold share in a country's external assets. Moghadam Bahrami and Bahernia (2021) emphasize that it is the factors of the international political economy determine the role of gold in currency reserves. Elements of the historical consequences of the power of the countries represented in the categories of export scale are also considered to be significant drivers of the gold share in foreign assets (Aizenman and Inoue, 2012), (Sousa Barros, 2020), (Oktay et al. 2016). At the same time, for a third of central banks, geopolitical factors are important criteria for the adoption of external asset management decisions (GoldCouncil,2020). Arslanalp et al. (2023) in the same time more clear about geopolitical role of gold. Results reached by Arslanalp et al. (2023) are interesting and generally are in line with this paper. They show that motivation to diversify toward gold is twofold. One reason is a traditional "safe haven" effect. Another reason is the geopolitical tensions. Multilateral sanctions found to be strong driver of propensity to diversify toward gold because of unique features of gold as reserve assets.

Despite the debatable validity of approaches linking the scale of exports to the volume of gold reserves, especially in the case of developed countries (Oktay et al. 2016), non-economic motives for central banks' decisions regarding gold fit into the tradition of the political-economy approach. For example, Eichengreen et al. (2017) shows that geopolitical orientation signifi-

cantly influenced the choice of the currency structure of the country's external assets from a historical perspective. In addition, political and economic approaches to the analysis of foreign exchange reserves indicate that the political regime is a powerful factor that potentially determines a country's tendency to accumulate reserves (Koziuk, 2021a), Aizenman and Marion (2004), Jager (2016), Dreher and Vaubel (2009), Son B. (2020), (Leblang and Pepinsky, 2008). Moreover, taking into account that the volume of reserves can affect the propensity to diversify them more (Beck and Weber, 2010), decisions about the gold will reflect the complexity of portfolio approaches, to which non-economic factors can be added. Arslanalp et al. (2023) identify 14 "active diversifiers" toward gold and all of them are emerging market countries. At the same time, commodity economies show a shift towards the possession of larger gold reserves (Koziuk, 2021c). And the analysis of the distribution of gold reserves among resource-rich countries (Koziuk, 2021c) demonstrated the presence of strong asymmetries, which are determined by how much a country is able to conduct a balanced macroeconomic policy under each political regime.

As for studies on the optimal gold share in exchange reserves, they mostly use a portfolio approach, which to one degree allows taking into account the peculiarities of the behavior of gold prices in the spirit of a "safe haven". That is, if gold stabilizes the portfolio as in the case of institutional investors (Emmrich and McGroarty, 2013), then it can do the same in the case of central banks. In other words, a certain gold share performs a positive role in the management of external assets, since its prices are not correlated with the prices of other classes of assets (O'Connor, 2015, Baur and McDermott, 2010, Baur and Lucey, 2010). However, there is no consensus on what this proportion should be (Zulaica, 2020). According to a survey of central bank external asset managers, most of them agree that the optimal share of precious metal should not exceed 25% (Gold Council, 2020).

Zulaica (2020) points out that optimal gold share conditioned by composition of reserves and the risks they are exposed. If short-term instruments denominated in reserve currencies dominate the structure of foreign exchange reserves, then the optimal gold share will not exceed 5%. If instruments with duration of more than 2 years play a significant role, then gold at the level of 10% share of exchange reserves will reduce the sensitivity of the portfolio of external assets to the risk of yield fluctuations. If the portfolio is sensitive to fluctuations in exchange rates and yield levels, then a 20% share will help stabilize it. And even a significant holding of gold (about 50%) can be optimal if the portfolio of external assets has a significant component denominated in non-traditional reserve currencies, which, in addition, has a duration of more than 5 years (Zulaica, 2020). It follows from this that the optimal gold share rather results from the specific case of the goals and criteria of external asset management. In addition, it is quite natural that geopolitical considerations can correspond to the portfolio approach, or even be covered by it. Moreover, in cases of expectations of aggressive behavior or the desire to demonstrate "sovereignty" the advantage is in favor of gold may be a demonstrative choice. This also raises the question of some relativity of reserve management criteria, where domestic motivations for increasing the gold share may mask more complex geopolitical idiosyncrasies (Ghosh, A. 2016, Koziuk 2022b).

On the other hand, gold holdings do not exclude the increased risk of fluctuations in its value, significant costs for its physical possession, and a decrease in the profitability of external assets. Moreover, greater external vulnerability should theoretically lead to a lower share of gold for reasons of liquidity of foreign exchange reserves (Gopalakrishnan and Mohapatra, 2017). In Abduloev et all (2020) and Mastilo (2021) specific vulnerabilities of emerging markets are shown. Taking into account the dependence of the optimal share of gold on the composition

of external assets (Zulaica, 2020), and the dependence of the composition of assets on the volume of reserves, it can be seen that there are strong fundamental economic drivers of holding the precious metal. By itself, the gold share in external assets rather plays an autonomous role mostly in the case of gold-mining countries (for example, Uzbekistan, Tajikistan, Kazakhstan, etc.).

In addition, the nature of vulnerability to external shocks, the ability to accumulate reserves, and the alternative adjustment channels (through reserves or through exchange rate fluctuations) can be considered economic criteria for decisions on the management of external assets. Political tolerance for fiscal losses from the possession of suboptimal reserves or geopolitics is the non-economic motive, which is still possible. Moreover, the tension in the world contributes to this. Therefore, the paper puts forward two hypotheses. Firstly, political regimes cannot purely be a criterion of greater or lesser propensity to gold holding due to the limitations arising from the ability to accumulate and maintain exchange reserves. Secondly, as shown in Arslanalp et al. (2023) and Koziuk (2022a) and Koziuk (2022b), geopolitical motives perform as individual cases and unlikely common tendency. Due to this proxy of a country's propensity to aggressive behavior could be a predictor of a shift in favor of gold. For example, Arslanalp et al. (2023) identify "active diversifiers" and geopolitical motivation among them combining empirical criteria and case study approach. At the same time, the paper emphasizes that shift toward gold should take place after 2014, since this is the year of the annexation of Crimea by russia, the introduction of the first wave of sanctions against it, and the year after which the number of conflicts in the world increased. Arslanalp et al. (2023) are not clear about this defining moment. Based on a comparison of data on the distribution of the average and median gold share in exchange reserves across countries with democratic and autocratic regimes, the first hypothesis can be considered confirmed. The application of logit regression showed that the second hypothesis can be considered confirmed with certain warning. The switch to gold for geopolitical reasons rather acts not directly, but through the ability to accumulate currency reserves and maintain political stability.

3. METHODS

Methodologically, the study consists of two parts according to the question of whether the political regime affects the nature of the distribution of the gold share in exchange reserves, and whether certain indicators of geopolitical aggressiveness can be predictors of decisions regarding the diversification of reserves in favor of the precious metal. List of countries are available in the Annex.

In the first case, a comparison of the average and median value of the gold share in exchange reserves is used. Such a comparison based on data over the past 20 years. Countries defined in terms of political regimes (see the Annex). A political regime is identified based on the Democracy Index, according to which an index value of less than 4 qualifies as an autocracy and more than 4 as a democracy. A persistent excess of the average and median value for one group of countries of similar indicators for another group of countries will indicate that the factor of the political regime is important.

In the second case, logit regression is used. The choice of this empirical approach is due to a number of reasons. According to the purpose of the study, the question of whether the events after 2014 led to changes in the behavior of central banks regarding the accumulation of gold reserves is of interest. The selection of central banks among others seems to be more fruitful using a binary variable, rather than, for example, the OLS method. We assume the presence of a

relatively autonomous tendency to maintain a certain implicit gold share in exchange reserves. In the case of a trend towards the accumulation of reserves by most central banks, a similar trend will be observed with respect to gold in general. This will make it difficult to understand which central banks stand out from the rest. To identify such central banks, the average growth rates of gold reserves in tones and the average growth rates of the gold share in exchange reserves for the period from 2015 to 2021 are calculated. Next, the average value of such growth rates is determined for the group of countries for which information is available based on Gold Council data.

Two models for defining a binary variable are used. According to model 1, value 1 is assigned to the country if, during the specified period average growth rates of gold in tonnes and the gold share in exchange reserves are exceed the average in the world. Otherwise, the value of the binary variable is 0. Since this option may appear too severe in cases of significant initial holding of reserves (diversification in favor of gold of substantial reserves can significantly shake the precious metal market), model 2 is additionally applied. According to it, the value 1 is assigned to a country if for the indicated period at least one condition is hold: gold reserves growth in tones for country i is > then for the world or gold share for country i is > then for the world. Otherwise, the value of the binary variable is 0. In this respect we are differ from Arslanalp et al. (2023), who identify active diversification based on empirical criteria (raised gold share "in total reserves by at least 5 percentage points over the last two decades"). Our empirical criteria for logit model looked more severe and more focused to neutralize the problem of collective trend toward larger gold reserves holdings.

Three groups of variables are used as predictors in the logit model.

First, these are variables characterizing the number of accumulated currency reserves. Here, the indicator of the volume of foreign exchange reserves to GDP in % and the coverage of import reserves in months is chosen. Both variables are presented as averages for 2015-2021 (source: World Bank Development Indicators). In the empirical model, both variables are used separately to confirm the robustness of the significance of the relationship between reserve holdings and the propensity to diversify into gold. Theoretically, there should be a direct relationship, but this is not imperative, since the choice in favor of gold is not necessarily determined solely by the fact that the priority of diversification of larger reserves.

Secondly, these are variables that indicate the geopolitical aggressiveness of the country, namely the ratio of military expenditures to GDP in percentage (data from World Bank Development Indicators) and the Global Peace Index (The Institute for Economics and Peace). For example, Acemoglu and Yared (2010) indicate that the volume of military expenditures is an indicator that reduces the country's propensity for trade openness. This indicator directly attests to the country's ability to confront for reasons of potential. Nevertheless, Acemoglu and Yared's (2010) understanding, also illustrates less loss from breaking global ties in the event of escalation. The Global Peace Index is a more comprehensive indicator designed to measure the level of violence and propensity to it within the framework of the political agenda in a particular country. If military expenditures can also reflect a defensive aspect, then this index will more clearly indicate aggressiveness as a predictor of the tendency to geopolitical escalation.

Thirdly, it is an indicator characterizing the political stability of the country, namely Political Stability and No Violence/Terrorism (source: World Bank Governance Indicators). The political stability of a country is an important prerequisite for the ability to accumulate foreign exchange reserves, regardless of the political regime. It is also a prerequisite for a lower tendency to aggression when resolving internal conflicts or participation in external ones, which should

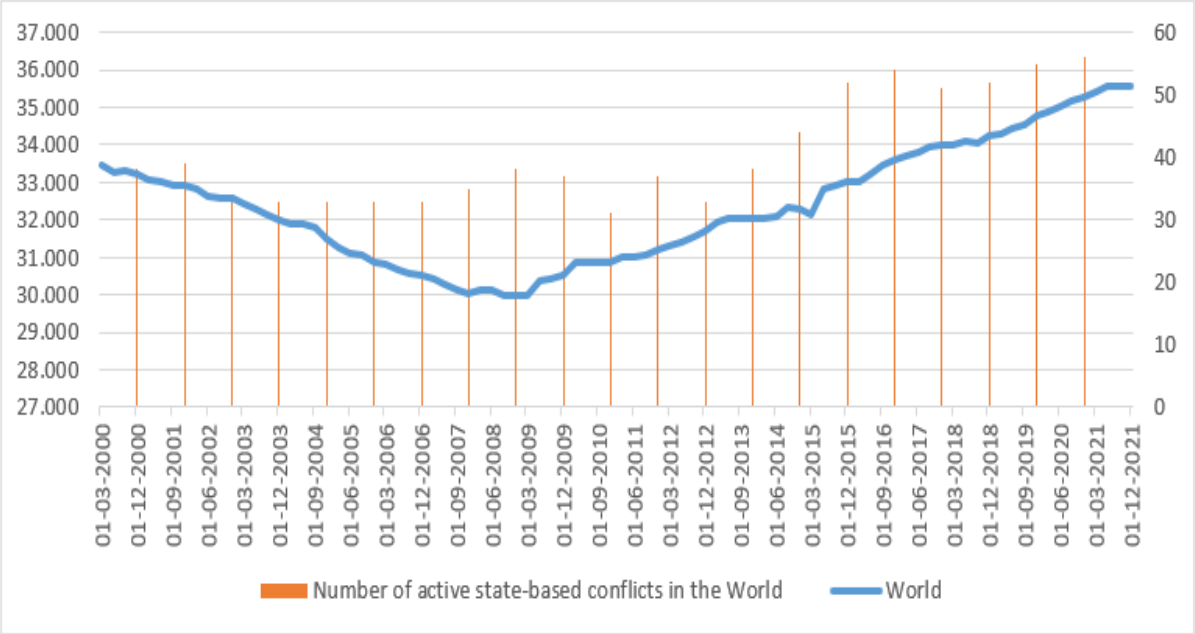
indicate a lower sensitivity to macroeconomic shocks. Moreover, this, in turn, will allow a lower need to maintain exchange reserves in the most liquid form and, accordingly, will allow maintaining a larger gold share without risk to macrofinancial stability.

The applied methodology made it possible to obtain results that generally confirm the stated hypotheses.

4. RESULTS

The change in the trend in gold hoarded by central banks is obvious (Fig. 1). After a long period of declining interest in holding the precious metal, a clear opposite trend is observed. However, have geopolitical factors affected this? The answer to this question depends on a closer look.

Figure 1. Gold holdings by central banks in the World (tonnes) (l.s.) and number of active war conflicts in the World



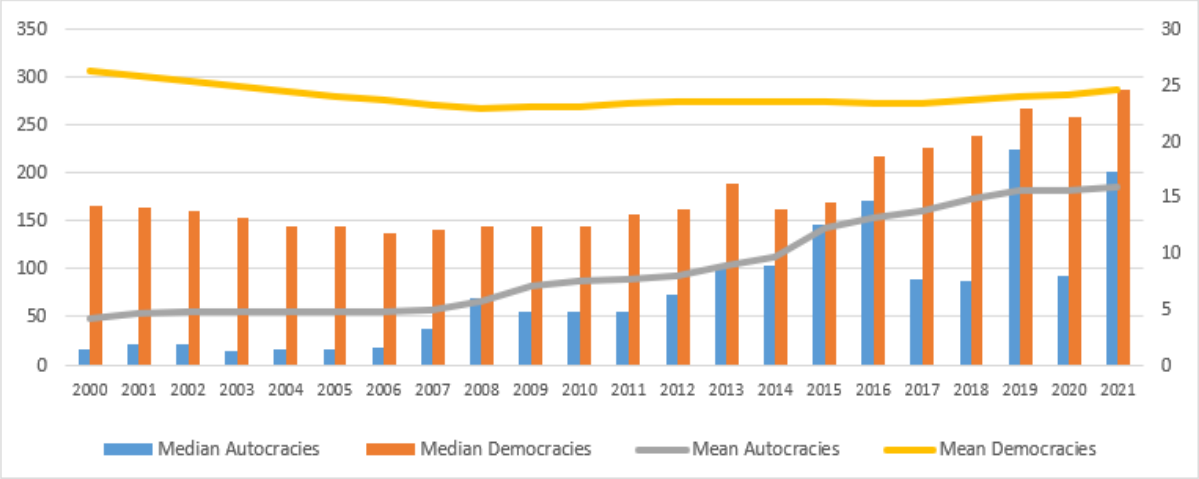
Source: Gold Council (gold holdings) and The Uppsala Conflict Data Program (number of conflicts)

The increase in the number of conflicts in the world occurred after 2014. 2014 is the year of the kremlin's aggression against Ukraine and the annexation of Crimea. It is obvious that the level of aggression in the world and geopolitical tension has increased under the influence of these events, which should affect changes in the behavior of central banks. However, the data in Fig. 1 indicate that the change in the gold accumulation trend occurred earlier. A geopolitical factor alone is unlikely to have contributed to this, given other motivations for hoarding gold reserves, such as falling global interest rates.

The division of countries according to the criterion of political regimes allows us to see a more complex situation. Theoretically, it can be assumed that autocracies are more likely to generate geopolitical tension. Likewise, they may be more inclined to pursue external asset management policies to minimize the likely impact of restrictions on reserve asset transactions by developed democracies. The data in Fig. 2 indicate that the increase in gold holdings in tonnes occurred mostly at the expense of autocracies and also began after the global financial crisis, as in the

case of the data in Fig. 1. But for the period of 2014-2015, there was a strengthening of the tendency to “escape” toward metal.

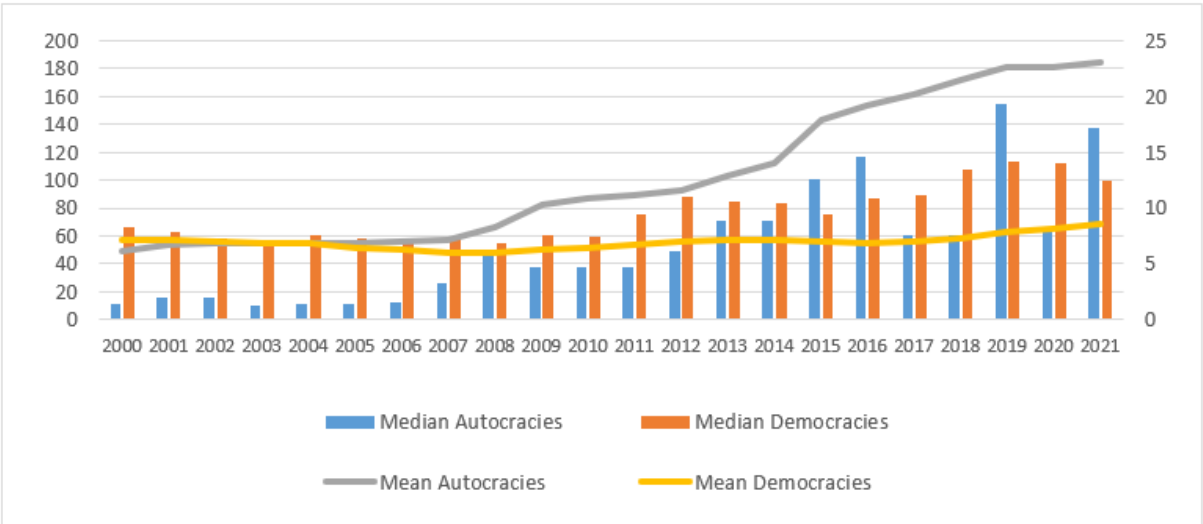
Figure 2. Distribution of gold reserves (tonnes) across political regimes



Source: Gold Council. Author’s calculations

Characteristically, developed countries almost do not change the amount of gold holdings. In categories of Aizenman and Inoue (2012), their management strategy is passive. Amount of such holdings is determined by historical factors that is in line with some previous research (Aizenman and Inoue (2012), Sousa Barros (2020), Oktay et al. (2016)). This partly explains why both the mean and median values of gold holdings in tonnes for democracies are significantly higher than for autocracies. The increase in median values with practically unchanged averages suggests that a number of countries with a democratic regime also reoriented themselves to holding larger amounts of gold. Excluding developed countries significantly changes the situation (Fig. 3).

Figure 3. Distribution of gold (tonnes) across political regimes (excluding developed countries)

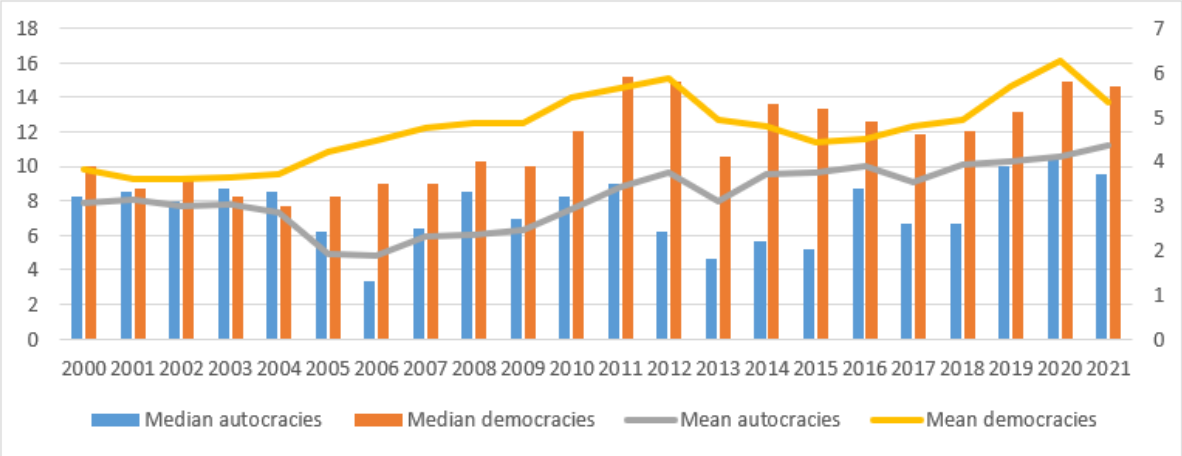


Source: Gold Council. Author’s calculations

Excluding developed countries, average gold holdings for democracies also appear stable over time. However median values began to increase again after the global financial crisis. At the same time, the average values for autocracies began to exceed the corresponding values for democracies even before the global financial crisis, but their significant increase occurred after 2014. Median values for autocracies tend to exceed their corresponding values for democracies after 2014 as well, although they are not stable from year to year. Moreover, it can be assumed that the interest in holding larger reserves of gold is mainly driven by autocracies and individual democracies. The shift toward gold is hardly geopolitical in its purest form, but a geopolitical factor can be seen in the increased interest, if you consider which autocracies and democracies are behind it.

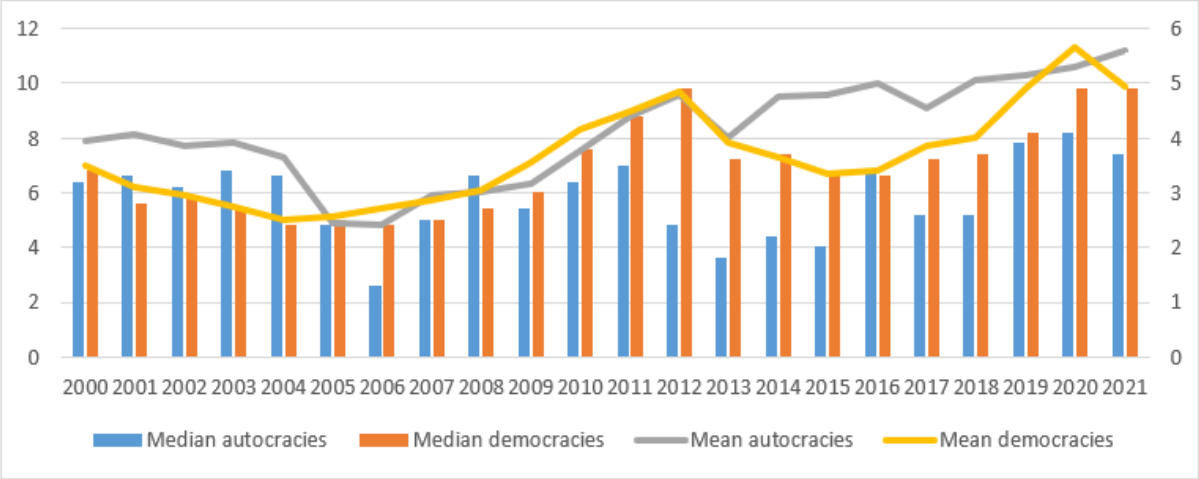
Nevertheless, the data on the distribution of gold share in exchange reserves (Fig. 4 and 5), which is of more interest to us in terms of research hypotheses, are more convincing from the point of view of reevaluating the geopolitical factors of gold holding (Koziuk (2022a), Koziuk (2022b)).

Figure 4. Distribution of gold share in exchange reserves across political regimes



Source: Gold Council. Author's calculations

Figure 5. Distribution of gold share in exchange reserves across political regimes (excluding developed countries)



Source: Gold Council. Author's calculations

From the data in Fig. 4 and 5 it can be seen that the tendency towards a certain increase in the gold share in exchange reserves, measured by both the average value and the median, was formed even before the global financial crisis. This tendency is almost equally characteristic of democracies and autocracies. However, fig. 1 shows that world gold reserves in tonnes started to increase after global financial crisis. The period after 2014 is not indicative due to increased diversification in favor of gold. If it accounts for the trend to increase the gold share, then it is more likely a return to the previous trend. The exclusion of developed countries does not change the situation as it did in the case of the possession of gold in tonnes (Fig. 2 and 3). Autocracies are not consistent leaders in holding a larger gold share, either on average or median. As with physical gold holdings, autocracies show a much less even distribution of gold share in exchange reserves. This indicator is more volatile in time, compared to democracies.

This situation can be explained based on the assumption that among autocracies there is a larger share of gold-mining countries. Politically unstable autocracies face pressure on foreign exchange reserves, responding to it by selling gold. When the situation stabilizes, they restore its stocks. Moreover, unlike the case of gold in tones, the gold share in exchange reserves is not an indicator that shows radically different patterns of behavior across political regimes. For example, the difference in the accumulation of currency reserves across political regimes is much more obvious (Koziuk (2021a), Jager (2016)). The advantage of autocracies in this process is influenced by a greater concentration of commodity rent, less independent central banks, and a greater propensity for limited exchange rate fluctuations, etc. (Koziuk (2021a), Aizenman and Marion (2004), Jager (2016)). But in the case of the gold share in exchange reserves, this is not obvious, which is confirmed by the data in Fig. 4 and 5. If in terms of political regimes there is no obvious advantage in favor of diversification with respect to gold, as well as differences in the time of switching to a larger gold share, then we can conclude that this refers to the weak role of geopolitical factors influencing the management of external assets. In other words, in most cases, the choice regarding this or that share of gold is dictated by economic considerations, not geopolitical ones.

At the same time, such conclusions do not exclude that individual countries may demonstrate a higher level of sensitivity to geopolitical factors. Taking into account the increase in the number of conflicts after 2014 and the subsequent geopolitical events, it can be assumed that such individual countries should show signs of aggressive behavior that correspond to their choice in favor of a larger gold share. This concerns the second part of the research methodology. It identifies countries that are more oriented towards gold, compared to the world average. And with the help of logit regression, the ability of proxy geopolitical orientation to act as appropriate predictors is tested.

The empirical test (Tables 1 and 2) demonstrates that the hypothesis about the geopolitical role of motives for a reorientation towards the possession of larger reserves in gold has the right to exist, but it is not an unequivocal statistically robust fact. Based on the obtained data, a number of generalizations can be made.

Table 1. Results of empirical test using logit model 1

	(1)	(2)	(3)	(4)	(5)
Reserves, % GDP	0,0156		0,087		
Reserves in month of import		0,085		0,037	
Military Expenditures, % GDP	-0,205	-0,254			-0,0927
Global Peace Index	3,480	2,793	2,9521	2,4910	2,9703
Political Stability	2,107	1,765	1,908	1,6079	1,872
Chi^2	9,3886	7,4098	7,6720	5,3910	7,1851
p-value	0,05211	0,11578	0,05332	0,14533	0,06625

Source: Calculated with STATISTICA package

Table 2. Results of empirical test using logit model 2

	(1)	(2)	(3)	(4)	(5)
Reserves, % GDP	-0,062		-0,0611		
Reserves in month of import		-0,235		-0,2279	
Military Expenditures, % GDP	0,0397	0,088			-0,0282
Global Peace Index	-0,705	0,078	-0,5984	0,2074	-0,557
Political Stability	0,069	0,177	0,103	0,232	-0,063
Chi^2	16,007	16,087	15,928	15,771	1,541
p-value	0,00301	0,00291	0,00118	0,00127	0,67282

Source: Calculated with STATISTICA package

First, it is important that the criteria under which the binary variable acquires the value 1 is play role. In addition, in the stricter case of identifying a country as one that reorients itself to gold (Table 1), the relationships between the variables are not identical, compared to a softer approach (Table 2). Above all, this applies to such independent variables as the volume of accumulated reserves and military expenditures. From this, it can be concluded that the nature of country identification matters. With a more rigorous approach, all variables have the theoretically predictable sign, except for military spending. Moreover, countries that accumulate more gold than the world average, and increase the gold share in exchange reserves more than the world average definitely have a larger amount of reserves and are characterized by a greater tendency to aggression and violence, but at the same time, they are politically stable. This is more consistent with the political-economy line of arguments, according to which the ability to accumulate reserves, determined by a favorable political environment, also enables greater exposures in gold in terms of volume and share. At the same time, political stability predicts greater interest to gold and in a softer approach (Table 2). In all specifications except (5), the sign is theoretically correct.

Secondly, in the case of a more rigid approach (Table 1), both variables characterizing the volumes of accumulated reserves have a theoretically predictable positive sign. In addition, in the case of a softer approach (Table 2), they have not. Moreover, with a more rigid approach to the identification of a country switch to gold, exchange reserves and political stability play a more significant role, and with a less rigid one, military expenditures and political stability. Regardless of the country's geopolitical orientation, only those countries that rely on larger reserves

can afford more aggression for less military spending. If defense spending is significant, it may interfere with the ability to accumulate reserves, even if they are diversified in favor of gold.

Thirdly, taking into account that the variable of political stability in both cases (Tables1 and 2) is the most stable, the countries reorienting to gold must also be stable in terms of the political situation. This creates a positive feedback loop: political stability enables reserve accumulation, accumulated reserves allow for greater geopolitical aggressiveness, and opportunities for greater geopolitical aggressiveness rely on domestic political stability.

Fourth, the variables characterizing geopolitical aggressiveness do not demonstrate the stability of sign depending on the models with the identification of countries and the specification of the equations. In the case of a tougher approach (Table 1), military expenditures and the Global Peace Index behave in different directions. This can be explained by the fact that geopolitical aggressiveness does not always mean direct readiness for aggression. Perhaps this is evidence of a domestic political agenda of the type of right-wing populism or right-wing sovereignism. In the case of a softer approach (Table 2), military expenditures behave predictably with the exception of specification (5) of Table 2, which is not statistically significant. Moreover, the Global Peace Index has the correct sign only in specifications (2) and (4), where the variable reserves in months of imports used. Nevertheless, here the proxy of reserves is not in the theoretically correct direction of relation. This nature of the relationship can be explained by the fact that if the volume of reserves does not play a major role in the switch to gold, then this means that geopolitical aggressiveness can rest on a weak economic background.

Fifth, outside the channel of military expenditures (specifications (3) and (4) in Tables 1 and 2), the theoretical correctness and stability of the directions of relation takes place only in the first model (Table 1). In the second model, the sign in the case of the Global Peace Index is not stable. This is a confirmation of the thesis that the switch to gold should take place in terms of substantial reserve accumulation, regardless of the reasons for this. Moreover, there is a positive feedback loop between political stability, reserve accumulation, geopolitical orientation, and focus on gold.

Sixth, outside the exchange reserves channel (specification (5) in Tables 1 and 2), geopolitical interest in gold does not look convincing. In the case of a stricter approach to the identification of countries, military expenditures behave unpredictably, although in the same way as in other specifications (1-4) of Table 1. But in the case of a softer country identification, the failure to take into account currency reserves (specification (5) in Table 2) leads to the fact that the model sharply loses statistical significance with the appearance of an incorrect direction of relation the case of all other variables. Taking into account the data from specifications (3) and (4) for both variants of country identification, it is obvious that the channel of foreign exchange reserves is even more important than the channel of military expenditures.

It follows from the conducted analysis that the geopolitical drivers of reorientation towards gold in the management of external assets do not work independently. Such a reorientation can occur even with lower military expenditures. The main thing is that the country has more reserves and is politically stable. Geopolitical aggressiveness expressed by the Global Peace Index may reflect manifestations of right-wing populism/sovereignism.

5. DISCUSSIONS AND CONCLUSIONS

The results of the empirical analysis, however, are not completely unambiguous. But they help deepen the discussion in some directions.

Beck and Weber (2010) were among the first to show that larger reserves tend to lead to greater diversification. Gold has long been considered as one direction for such diversification, especially given the ambiguous prospects of traditional reserve currencies (Arslanalp et al. (2022)). Zulaica (2020) provides arguments based on the model that an increase in gold share is more optimal the fewer external assets are exposed in traditional reserve currencies. It is in this direction that the geopolitical role of gold should be manifested. Countries-potential-violators of the world order will most likely be less inclined to maintain external assets in traditional reserve currencies, and therefore gold will be a natural direction of diversification for them. From this, it follows that geopolitical risks in themselves do not push countries to hold more gold, whatever the advantages of this in terms of the behavior of its prices. Moreover, the direct channel of the "safe haven" is unlikely to work in its pure form, which is confirmed by data on the aggregated behavior of the gold share in global currency reserves (Koziuk (2022a), Koziuk (2022b)). Switching to gold for geopolitical reasons requires an economic basis, which is the already accumulated volume of reserves, and political stability, which enables their accumulation. That is why the role of political regimes is less pronounced when it comes to switching to larger gold holdings. Autocracies may allow greater fiscal losses from holding the precious metal, but they are not significantly different from democracies in terms of the gold share in exchange reserves. And this means that geopolitical factors are not distorted by political regimes. And this, in fact, is a bad signal. The defining line between aggressive democracies and autocracies could be too narrow in case of external assets management.

As it has already been shown, the nature of the country's identification as one that switches to gold is important (Tables 1 and 2). However, not always the expected empirical connections indicate that there may be questions about military spending and whether the Global Peace Index correctly reflects a country's geopolitical aggressiveness. It is a difficult question. The country that suffers from external aggression, but is peaceful, has the specified variables at a level comparable to aggressive countries. And a country that is an aggressor, but significant in terms of scale and influence, may have these indicators at a relatively lower level. Likewise, an exclusively "military" approach to identifying the country's geopolitical orientation cannot always explain cases of switching to gold due to a shift to right-wing populism/sovereignism. It is unlikely that the increasing interest in gold in Poland and Hungary can be explained solely by issues of geopolitical tension. Similarly, Brazil and India are unlikely to show overt signs of geopolitical aggression, but their so-called policy of neutrality is little different from a policy of tolerance towards those who oppose the conventional Western world. At the same time, Saudi Arabia, being in a geopolitical conflict with Iran and being involved in the conflict in Yemen, does not show any interest in holding significant gold reserves.

Moreover, this paper allows us to look at the question of the predictability of the actions of this or that country in the geopolitical arena from a different angle. Political regime and military spending are most likely not predictors of pure aggressiveness. Most likely, a complex of socio-ideological, military and economic factors together will indicate in which direction particular country is moving in the geopolitical coordinate system. In addition, the reserve accumulations, with the decline in the value of traditional reserve currencies and increasing interest in gold, may in the early stages better indicate the intentions of countries.

It terms of gold holdings the results shows that reserve accumulation is more likely to push gold share up. Only a few countries may afford to increase role of gold in the external assets. Then

such countries are strong reserves hoarders, this may affect some aggregate shifts toward more gold in reserve assets.

Recently, the central bank's holdings of gold have grown significantly. The number of conflicts in the world has also increased significantly after 2014. Geopolitical motives of foreign asset management continue to be in the focus of interest regarding the drivers of the sovereign demand growth for the precious metal. And the research literature does not demonstrate consensus regarding the role of gold in currency reserves. Empirical tests on the role of gold as a "geopolitical safe haven" correspond very tentatively with research on the optimal gold share in external assets. Did the switch to gold after 2014 take place in light of the increased geopolitical tensions in the world, taking into account that a number of economic factors also contributed to this? Despite the assertion of overestimation of the geopolitical motives of gold holding (Koziuk (2022a), Koziuk (2022b)), the factors of international political economy cannot be completely ignored. The conducted empirical tests of the distribution of gold share in exchange reserves and the identification of geopolitical predictors of switching to gold allowed us to state the following. First, the political regime is not a robust criterion influencing decisions on the management of external assets. The average and median values of the distribution of gold holdings in tonnes differ much more between democracies and autocracies than similar indicators of the gold share in exchange reserves. Secondly, the conditionally direct channel of geopolitical aggressiveness is not a sufficient criterion for a reorientation towards gold. Most likely, such a reorientation requires sufficient economic prerequisites in the form of the possession of a larger volume of foreign exchange reserves and political stability, enabling geopolitical aggressiveness. However relevant proxies may not be sufficiently reliable predictors of switching to gold if the motive for this is right-wing populism/sovereignism. Fourth, the approach to identifying a country as switching to gold is important. The more rigid it is, the more important the role of exchange reserves, rather than military spending, and vice versa. In addition, political stability is equally important in both cases.

Interest in gold for reasons of freedom from possible sanctions imposed by issuers of reserve currencies is unlikely to be an effective long-term strategy, taking into account the possibility of imposing sanctions on transactions with gold. A corresponding shift in the portfolio in favor of non-traditional reserve currencies can push up the optimal gold share (Zulaica, 2020). But this brings us back to the question that geopolitical factors may not directly encourage countries to hold a larger gold share, but indirectly through the economic motives of managing foreign exchange reserves in the new environment. Under any circumstances, the very fact of hoarding substantial reserves appears to be a weightier criterion for decisions regarding their structure. However, this does not rule out that some countries are really preoccupied with geopolitical considerations.

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Annex A.

Country list

Autocracies (Democracy Index < 4)	Democracies (Democracy Index > 4)
Afghanistan	Albania
United Arab Emirates	Argentina
Burundi	Armenia
Bahrain	Australia
Belarus	Austria
Central African Republic	Belgium
China	Bangladesh
Cameroon	Bulgaria
Congo, Dem. Rep.	Bosnia and Herzegovina
Comoros	Bolivia
Algeria	Brazil
Egypt, Arab Rep.	Canada
Eritrea	Switzerland
Gabon	Chile
Jordan	Colombia
Kazakhstan	Costa Rica
Kuwait	Cyprus
Lao PDR	Czech Republic
Libya	Germany
Myanmar	Denmark
Mauritania	Dominican Republic
Nigeria	Ecuador
Oman	Spain
Qatar	Estonia
Russian Federation	Finland
Saudi Arabia	Fiji
Syrian Arab Republic	France
Chad	United Kingdom
Tajikistan	Ghana
Uzbekistan	Greece
Yemen, Rep.	Guatemala
	Honduras
	Croatia
	Haiti
	Hungary
	Indonesia
	India
	Ireland
	Iraq
	Iceland
	Italy
	Japan
	Kenya
	Kyrgyz Republic
	Cambodia

Autocracies (Democracy Index < 4)	Democracies (Democracy Index > 4)
	Korea, Rep.
	Lebanon
	Sri Lanka
	Lithuania
	Luxembourg
	Latvia
	Morocco
	Mexico
	Malta
	Mongolia
	Mozambique
	Mauritius
	Malawi
	Malaysia
	Nicaragua
	Netherlands
	Norway
	Nepal
	Pakistan
	Peru
	Philippines
	Papua New Guinea
	Poland
	Portugal
	Paraguay
	Romania
	Singapore
	El Salvador
	Serbia
	Suriname
	Slovak Republic
	Slovenia
	Sweden
	Thailand
	Trinidad and Tobago
	Tunisia
	Turkey
	Trinidad and Tobago
	Ukraine
	Uruguay
	United States
	Venezuela, RB
	South Africa

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CO2 EMISSIONS AND ECONOMIC GROWTH IN SOME SELECTED COUNTRIES OF ECOWAS: PANEL DATA APPROACH

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ABSTRACT

Climate change and its impact on economic growth or vice versa is an important burning issue in the present world and therefore the present world and its population, especially in West Africa, are bound to face various calamities in recent times and the excessive emission of carbon (1.8 per cent of total carbon emission by the world's emission) is one of the important reasons behind it. Therefore, it is very important to examine the relationship between carbon emissions and economic growth in the region and for this, the present article is focusing over some selected countries of Economic Community of West African States (ECOWAS) and therefore the 10 ECOWAS countries are selected randomly, out of 15 ECOWAS countries and 32 years of data from 1991-2022 are utilized which is sourced from World Development Indicators (WDI), World Bank and Central Bank of Nigeria (CBN) Bulletins. A panel data regression technique employed for the analysis of data. The Fixed Effect Model (FEM) estimates indicates that the out of eight explanatory variables four are negatively associated with Co2 emissions and one is statistically significant while other three are insignificant statistically. The Random Effect Model (REM) estimates pointed out that the out of eight independent variables three are having negative effects over the Co2 emission and five are having positive impact over the emissions. Therefore, the study perceived that emission of Co2, Gross Domestic Product (GDP) and industrial growth are not enough to lead the climate change in the region.

Keywords: *Co2 Emission, Economic Growth, Panel Data, Clean Energy*

1. INTRODUCTION

Climate change is one of the core agenda of the sustainable development and even it is an important goal of the Sustainable Development Goal (SDG). The present world is on race to achieve a higher economic growth at any cost and without degrading the environment and its components it is quite impossible to achieved. Because in most of the cases, the carbon emission and use of energy are having negative impact over the economic growth over the developing countries (Azam, et. al. 2016) and due to the energy consumption and industrial activities, global corban dioxide (Co2) emission is rises by 0.9 per cent and equivalent of 321Mt in 2022 and reached at 36.8Gt (IEA, 2022). Sectoral wise carbon emission is, out of 36.8Gt carbon Emission, 116mt is from natural gases, 243 from coal burn, 11.2 Gt from use of oil and the biggest sectorial increase in carbon emission in year 2022 is came from use of electricity and it

went up by 1.8 per cent or 261 Mt, while emission from industrial activities got declined by 23 Mt or 0.2 per cent (IEA, 2022). Though the world wise carbon emission grew in 2022, however, Europe administered declined in it at the rate of 2.5 per cent (70Mt), and due to Covid-19, it is relevantly flat for Chinese economy (0.2 per cent) while emission by United States of America is relatively grew by 0.8 per cent (36Mt.), emission from Asia's emerging and developing economy, excluding China, witnessed 4.2 per cent (206Mt) increased in carbon emission (IEA, 2022). In Africa, it is having smallest share among the all-world's region, and it is ranging between 3.4 to 3.8 per cent since last two decades (IEA, 2022). While the contribution of carbon emission by Economic Community of West African States (ECOWAS) is only 1.8 per cent of total carbon emission by the world (Reginal Climate Strategy Reports on ECOWAS climate change, 2022). Per capita average carbon emission of 10 selected countries of ECOWAS from 1991-2022 and Nigeria is placed on at the top in terms of per capita average carbon emission among the ten selected countries of ECOWAS with 97067.97Mt since 1991-2022 (World Bank, 2022), and Cote D'Ivoire is placed on second highest emitter with 6683.86Mt from 1991-2022 while Guinea Bissau is placed on tenth out of ten ECOWAS countries and it average emission is 288.06Mt since 1991-2022 and Liberia placed on second lowest carbon emitter with 727.42Mt from 1991-2022. Due to the excessive use of energy, most part of the ECOWAS is facing different types of calamities in the present world such landslides, cyclones, droughts, and excessive case of flooding in most part of the world. Furthermore, the effect of carbon emission is not limited only the harming environment, it is also affecting the level of employment of a country along with Gross domestic Product (Mitić, P., Fedajev, A., Radulescu, M. et. al., 2023). There is another important study (Ayanthi, et. al. 2022) has established a positive relationship between economic growth and carbon emission. Therefore, the current work is tried to point out the association between economic growth and carbon emission and seven more independent variables with the panel data from 1991-2022. The contribution of the study is to fill the time gap, variables gap and employed new Methodology, such as Hausman test used to check the endogeneity in to the taken variables, for ten selected ECOWAS countries. Therefore, to bridge the research gap, the study set three objectives such as to study the effects of economic growth on Carbon dioxide Emission, to investigate the impact of Energy Consumption, Electricity Consumption, and Population growth rate over the emission of Carbon dioxide, and to examine the association between Carbon dioxide Emission and Exports, Exchange Rate and Gross Capital Formation. Therefore, it is pertinent to examine the association between corban emission and economic growth (GDP) in ten selected countries of Economic Community of West African States and for this, it is important to visit the existing literature.

2. LITERATURE REVIEW

In any study, literature review is having an important place to get the research gaps and based on it to sets the objective/s of the study to provide a possible solution of the stated problem. Therefore, the present study is also tried to visit some important literatures pertaining the problem and they are following.

Firmin, V. & Rémy, H. (2020) have done a comparative analysis of some selected countries of Economic Communities of West African States (ECOWAS) for the period of 38 years. They used Vector model of the environmental curve of ECOWAS countries and found that a long-run U shaped relationship and invalidated the hypothesis of inverted U shaped of Kuznets. Moreover, they reported that as per capita increases for poor countries, their carbon emissions decreases while for relatively reach countries, when per capita income increase, their carbon

emission has increases. Based on their findings, they advise to implement a common policy of environmental protection in EOWAS.

Douglason (2017) has explore the relationship between the environmental degradation and per capita income corroborates the inverted U shape hypothesis in some selected countries of Economic Community of West African States (ECOWAS). He checked the emissions of So2 and Co2 and employed a Fix Effect and Random Effect model. The study reported that in some cases U shape hypothesis exists and in some cases are not. The estimate of the study shows that the environmental quality is relatively low for two indicators (SO_2 and Co2) which indicates the existence of low level of economic development and therefore suggests are being made to use a fuel tax which can be progressive for some African countries and need to be implement a functional pollution policy.

Mamoudou (2022) tried to explore the impact of shadow economy on economic growth and Co2 emission in Economic community of West African States (ECOWAS) and for this purpose he used System Generalized Method of Moment (SGMM) and Common Correlated Effects Mean Group (CCEMG) on 14 ECOWAS countries for the period of 36 years data sets. Findings of the study indicates that the shadow economy decreases economic growth and having more significant impact on it rather carbon emission. Based on the findings, the study suggests that there is need to implement a proper pollution policy for the region.

Qi et. al. (2022) employed three variables Toda-Yamamoto model to examine the dynamic relationship among energy consumption, economic growth, and trade in West Africa. They found out that there is a positive impact of energy consumption on economic growth in West Africa. Based on the findings of the study, they advise to develop an integrated energy and trade policy to achieve and maintain long-term economic growth in the region.

Alex et. al. (2022) have examined the relationship among human capital, foreign direct investment (FDI) and economic growth in Economic Community of West African States (ECOWAS) while controlling carbon emissions, urbanization and renewable energy. For this purpose they categorise the ECOWAS into two regions, lower middle income countries (LMIC) and lower income countries (LIC) and took panel data for the period of 27 years. Findings of the study indicates that the rate of human capital, FDI, Co2 emissions, and urbanization are affecting economic growth of LMIC and LIC. Based on findings, they suggests that the LMIC's and LIC's should have to focus on investing more in human capital development via more expenditure on education and health and to frame a policy to reduce Co2 emissions by focusing more on renewable energy.

Hongxing et. al. (2020) are tried to fill the gap with the recent empirical methodology to expose the impact of foreign aid, Co2 emissions, trade openness, and energy consumption on economic growth. Findings of the study revealed that the energy consumption, trade openness, Co2 emissions foreign aid are having positive correlation with economic growth. Further, study suggest that there is an urgent need to shift from fossil energy to renewable energy and introduce new techniques to derail the pollutant emissions from economic growth.

Another important study has done by Espoir et. al. (2021) and with use of panel data and they reported that the 1 percent increase in temperature reduces income by 1.08 percent and rise of 1 percent in Co2 emissions hike income by 0.23 percent. Therefore, they suggest that the environmental policies need to design to reduce Co2 emissions in Africa.

Asongu et. al. (2015) have used panel data and examined the relationship between Co2 emissions, energy consumption, and economic growth of 24 African counties. They found out that there is a long run relationship between energy consumption, Co2 and economic growth and error

correction mechanism are stable. Therefore, they advise to focuses on short run mechanism and use new technology to reduce the carbon emissions.

Ibrahim et.al.(2015) have examined the possibility to use of nonlinear model with the data sets of 15 African countries for the period of 30 years. They found out that the evidence of inverted U shape in five African countries and confirmed Environmental Kuznets Curve (EKC) hypothesis in these five countries. Furthermore, the study also confirmed that the countries like Sudan and South Africa are having low regime energy consumption therefore their economic growth are not so high such as Algeria, Morocco, and Senegal which they have high energy consumption.

Ezeokoye et.al. (2021) employed profit and trend analytics approaches with panel data to examine the impact socioeconomic indicators over the 15 West African countries' economic growth. They used seven variables such as poverty head count ratio, under five mortality rate, government expenditure on education, government expenditure on health, Co2 emission, electricity consumption, food security and real GDP. After careful analysis of date, they found out that the 15 West African countries economies are diverse over the selected indicators of development. Furthermore, it indicates that except Nigeria, the performance of other countries is average in relation to the selected socioeconomic indicators. Based on findings, they suggest that there is an urgent need to implement a sound socioeconomic policy in the region that can be based on pro-development agenda to enhance the socioeconomic status of these countries.

Orekoya & Oluleke (2021) have been examined the nexus of trade openness, energy consumption, and economic development for seven oil producing countries in Africa. These employed Autoregressive Distributed Lag Model for the analysis of the data. The findings indicates that the trade openness and energy consumption having significant impact over the economic development of selected countries. Furthermore, it is recorded that a per cent increase in trade openness decreases economic development about seven per cent in the short run however it increases by twenty eight percent in the long run due to trade openness. Based on the findings of the study, it is suggested that the policies should be in a way to encourage an enabling environment, free trade zone, energy efficiency, and ease of doing business.

Ahmed et.al. (2021) have explored the effects of carbon emissions over the Foreign Direct Investment (FDI), human capital and biocapacity, and energy consumption in some selected West African countries for the period of 47 years. For this purpose, the study employed long run cointegration estimators. The results of the study revealed that there is an existence of inverted U-shaped and N-shaped tends between the variables. Moreover, the estimates indicates that the N-shaped exist only for high carbon emission countries. The study suggests that the new technology should be adopted as soon as possible reduce the carbon emissions in the region.

Bosede & Akintunde (2021) have tried to examine the dynamic linkages between energy consumption, development of Information and Communication Technology (ICT) and quality of environment for six countries in West Africa. The study employed secondary data which are sourced from United States Energy Information and World Development Indicators (WDI). For the analysis of data, study used Generalised Method of Movement (GMM). The results indicates that Co2 emissions increased because of higher energy consumption in the selected countries. Moreover, the development of ICT having negative but statistically significant impact over the quality of environment. Furthermore, the study advises to encourage to formulate such policies which reduces carbon emissions and therefore one can achieve the goal of sustainable development.

Mbanda et.al. (2022) revealed in their study that there is a short run and long run relationship between Carbon emissions and economic growth in Cameroon. Furthermore, they have con-

firmed the existence of EKC hypothesis in the country. For this, they use 44 years of data sets and employed ARDL model for the analysis of it. Based on their findings, they recommended to the government to gear a policy related to reducing th emissions of greenhouse gases and facilitate to adopt the other renewable source of energy in the county.

Umar et.al. (2023) **e**xplored the nexus between export, capital formation, use of energy and Co2 emission for Pakistan. They employed ARDL model with the data ranging from 1981-2020. The results indicate that the export is having inverse relationship with carbon emissions in both short and long run. Furthermore, it indicates that the increase in carbon emission also lowering the export. However, the uses of energy having higher impact over the emission both in the short and long run. Based on the findings, the study suggests that it is urgent need to facilitates the use of renewable energy in the country to reduce emission for sustainable development.

From the above literature review, one can concluded that most of the studies have tried to establish the relationship between economic growth and energy consumption. To satisfy the objectives of the study, all most all the studies have employed secondary data and used different techniques such as ARDL estimators, Fixed Effect Model and Random Effect Model for panel data. The present study has also used updated secondary data from 1991-2022 and employed Fixed Effect Model, Random effect Model techniques for the data analysis over the eight independent variables with the emissions of Co2. Furthermore, to check endogeneity in the models a Hausman test are used.

3. METHODOLOGY

For the possible solution of the problem, the study relied on panel data analysis technique on secondary data for the period of 1991-2022 which are sourced from World Development Indicators, Central Bank of Nigeria (CBN) Bulletins and employed Fixed Effect Model (FEM) and Random Effect Model (REM) and further to check the feasibility of the model a Hausman Test is employed. The functional model of the panel data regression can be expressed as follow:

$$CO2 = F\ (GDP, EXP, EXCRT, ENRGCON, ELECTRCON, GCF, POPGRO, INDUSTGRO) \quad (1)$$

Where, GDP= Gross Domestic Product, Exp=Exports, ExcRt= Exchange Rate, EnrgCon= Energy Consumption, ElectrCon=Electricity Consumption, GCF= Gross Capital Formation, PopGro= Population Growth Rate, IndustGr = Industrial Growth Rate.

Equation 1 shows functional relation among the dependent and independent variables and cannot be estimated. For the estimation, one can need to transform equation 1 into the regression equation 2 which is given below in the log form and Equation No2 can be transform into equation No3.

$$LnCo2_{it} = ß_o + ß_1 LnGDP_{it} + ß_2 LnExp_{it} + ß_3 LnExcRt_{it} + ß_4 LnEnrgCon_{it} + ß_5 LnElectrCon_{it} + ß_6 LnGCF_{it} + ß_7 LnPopGro_{it} + ß_8 LnIndustGr + \mu_{it} \quad (2)$$

$$LnY_{it} = \alpha + \beta_1 LnX_{it1} + \beta_2 Ln_{it2} + \beta_3 LnX_{it3} + \beta_4 LnX_{it4} + \beta_5 LnX_{it5} + \beta_6 LnX_{it6} + \beta_7 LnX_{it7+} + \beta_8 LnX_{it8} + \mu_{it} \quad (3)$$

Therefore, to satisfying the objectives of the study one can need to frame the hypotheses, as others have set such as Bosede & Akintunde (2021), Ahmed at.al. (2021), which are following: **Ho1:** Economic Growth does not have any impact over the Carbon dioxide Emission, **Ho2:** Emission of Carbon dioxide does not influence by Energy Consumption, Electricity Consumption, and Population growth rate, and **Ho3:** Carbon dioxide Emission does not have any impacts by Exports, Exchange Rate and Gross Capital Formation.

4. DESCRIPTIVE STATISTICS

One can see the growth rates of ten selected ECOWAS countries and per capita carbon emission from table 1. Since Nigeria placed on top of the carbon emitter in the region but tin terms of average economic growth it placed on second (4.02%), while Ghana registered highest average economic growth in the region (5.37%). It is evident from the table 1 that the Gross Domestic Product and Co2 emission is not in same direction which is invalidate the assumption that if the country emitting more Co2 then its economic growth will be high. At least in case of ECOWAS region it is not sustained.

Table 1. Average Value of Eight Indicators for Ten Selected ECOWAS in 31 Years

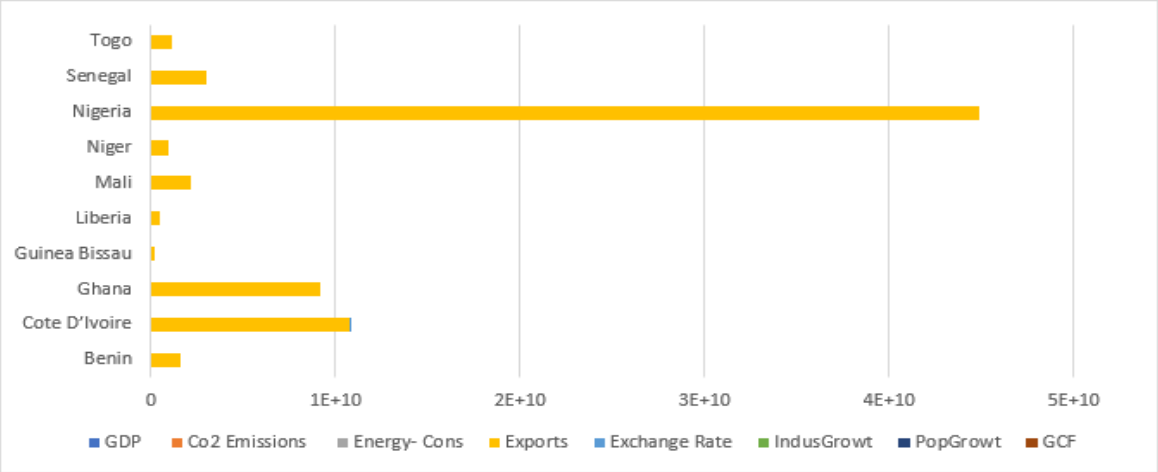
Country	GDP	Co2 Emissions	Energy-Cons	Exports	Exchange Rate	Indus Growth	Pop Growth	GCF
Benin	4.57	3472.58	357.60	1641629782	528.13	16.81	2.98	18.03
Cote D'Ivoire	3.55	6683.86	473.20	10794353505	528.17	18.15	2.70	16.47
Ghana	5.37	9985.16	320.94	9157961598	1.71	25.25	2.46	21.15
Guinea Bissau	2.39	288.06	51.54	156161399.4	528.17	13.12	2.42	15.66
Liberia	2.48	727.42	DNA	434575966.1	76.64	8.99	2.76	0.76
Mali	4.54	2088.71	DNA	2116998969	528.17	20.08	2.89	20.26
Niger	4.00	1174.84	168.96	906162928.41	528.17	20.85	3.53	21.00
Nigeria	4.02	97060.97	685.73	44885092395	153.04	28.22	2.60	28.10
Senegal	3.81	6125.81	259.85	3036106597	519.42	23.56	2.58	22.91
Togo	3.44	1683.55	414.96	1169883143	528.17	18.54	2.53	19.09

Source: Author's Calculation is based on World Development Indicators, World Bank

Note: Gross Domestic Products (GDP) taken as in per centage, Co2 Emission in kilo ton (kt), Energy Consumption is taken as kilogram oil of equivalent per capita, Net Exports in US Dollar, Exchange Rate is an Average Official Exchange Rate against per US Dollar, Industrial Growth is taken as percentage of GDP, Annual Population Growth Rate is taken in percentage, Gross Capital Formation (GFC) taken as percentage of GDP.

DNA: Data not available.

Figure 1. Average Value of Eight Indicators for Ten Selected ECOWAS in 31 Years



Source: Author's Calculation is based on World Development Indicators, World Bank

Table 2. Total Value of Eight Indicators for Ten Selected ECOWAS in 31 Years

Country	GDP	Co2 Emissions	**Energy-Cons**	**IndusGrowth**	**PopGrowth**	**GCF**
Benin	141.81	107650.00	11085.66	520.99	92.53	592.70
Cote D'Ivoire	110.06	207200.00	14669.22	576.18	83.60	510.45
Ghana	166.57	309540.00	9949.13	754.36	76.15	655.79
Guinea Bissau	74.00	7070.00	1597.58	393.30	74.99	485.55
Liberia	76.93	22550.00	DNA	278.59	85.45	23.58
Mali	140.65	64750.00	DNA	622.58	89.71	628.09
Niger	123.85	36420.00	5237.91	646.30	109.36	651.10
Nigeria	154.56	3008889.99	21257.73	874.70	80.70	837.35
Senegal	118.14	189900.00	8055.28	758.74	79.99	710.12
Togo	106.64	52190.00	12863.83	574.76	78.44	591.84

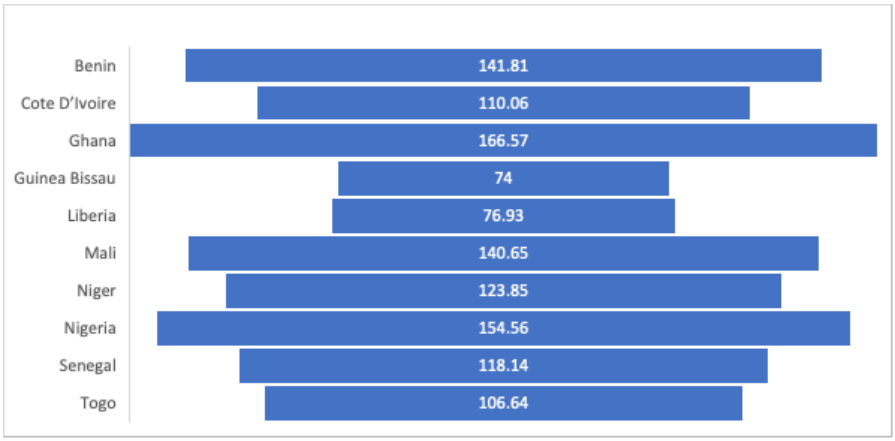
Source: Author's Calculation is based on World Development Indicators, World Bank

Note: Gross Domestic Products (GDP) taken as in per centage, Co2 Emission in kilo ton (kt), Energy Consumption is taken as kilogram oil of equivalent per capita, Industrial Growth is taken as percentage of GDP, Annual Population Growth Rate is taken in percentage, Gross Capital Formation (GFC) taken as percentage of GDP.

DNA: Data not available.

Table 2 shows the total value of Eight indicators for ten selected ECOWAS countries and here also Nigeria is on Top in terms of Gross Domestic Product (GDP), carbon emissions, energy consumption, industrial growth rate, and Gross Capital Formation (GFC). While Guinea Bissau is having tenth position in terms of carbon emission, Gross Domestic Product (GDP), energy consumption, and population growth. From the total value of all eight selected indicators, carbon emission and economic growth are showing positive association which is opposite to the average value. Therefore, it is needed to see the association between carbon emission and economic growth in totality instead of in average.

Figure 2. Total Value of Eight Indicators for Ten Selected ECOWAS for the Periods of 31 Years



Source: Author's Calculation is based on World Development Indicators, World Bank

5. RESULTS AND DISCUSSION

The study relied on panel data set for the period of and for the appropriate analysis of the data a Fixed effect model (FEM) and Random Effect Model (REM) are employed. The result of FEM is given below 3 and estimates of the FEM indicates that the Gross Domestic Product (GDP) and Carbon dioxide are having negative association, and it is contrary because as economic growth increase carbon dioxide emission increase and vice versa. However, in this case, it shows negative and statistically insignificant relation, and this result is supported by Douglason (2017). Which means ECOWAS countries does not reached at that level of economic growth where the emission of carbon dioxide will be more. Furthermore, out of eight explanatory variables 4 are having negative association with Co2 such as energy consumption, Gross Capital Formation (GCF), Gross Domestic Product (GDP), and population growth while other four are having positive relation with emission of Co2 such as access of electricity, exports, exchange rate, and industrial growth. Moreover, out of eight independent variables, four are having statistically significant at one per cent level such as access of electricity, energy consumption, exports, and exchange rate while other four are having significant impact over the emission of Co2 such as GFC, GDP, industrial growth, and population growth however they are statistically insignificant. These results are supported by Mamoudou (2022). Furthermore, the probability of F statistics is showing significant at one per cent which indicates that the estimated equation is highly specified.

Table 3. Fixed Effect Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9167.826	1990.064	4.606	0.000
ELECTRICITY	147.334	19.622	7.508	0.000
ENERGYCONS	-15.983	4.1783	-3.825	0.000
EXCRATE	6.217	2.248	2.765	0.006
EXPORTS	9.470	2.320	4.083	0.000
GCF	-7.686	37.789	-0.203	0.839
GDP	-1.627	49.587	-0.032	0.973
INDUSTGRO	44.726	60.609	0.737	0.461
POPGRO	-106.426	170.370	-0.624	0.532
R-squared	0.985			
Adjusted R-squared	0.984			
F-statistic	1144.968			
Prob(F-statistic)	0.000			

Source: Author's Calculation

After running the Fixed Effect Model (FEM), we run Random Effect Model (REM) and the results of it is given in table 4. The estimates of REM revealed that the out of eight explanatory variables, three are having negative impact over the emissions of Co2 such as access to electricity, GFC, and Industrial growth while other five are having positive association with emissions of Co2 such as energy consumption, exchange rate, exports, GDP, and population growth. Moreover, out of eight four are having statistically significant at one per cent level such as access to electricity, energy consumption, exchange rate, and population growth while other four are having impact over the emission of Co2 while they are statistically insignificant. Furthermore, the probability value of F statistics indicates that the REM equation is perfectly specified.

Now we need to compare table 4 results with the table 3 and one can easily concludes that the estimates of FEM revealed that the association among the emission of Co2 and GDP are having negative relation while REM estimates indicates that there is positive relation between the Co2 emission and GDP, and therefore the REM results is quite admissible which is also supported by Qi et.al. (2021). Finally, to verify the feasibility of the chosen model for the estimates and to make an appropriate policy suggestion, we need to ran a Hausman test over the both REM and FEM results and after the analysis of both Hausman test results, we found that the probability value of Chi square is not significant statistically in case of FEM (results of FEM is not included), while it is statistically significant at one percent level in case of REM (table 5), which indicates that the Random Effect Model is an appropriate model for the analysis of the data sets.

Table 4. Random Effect Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6740.396	3451.556	1.952	0.051
ELECTRICITY	-9.069	4.026	-2.252	0.025
ENERGYCONS	5.280	2.215	2.383	0.017
EXCRATE	1.160	2.310	5.035	0.000
EXPORTS	7.831	37.659	0.207	0.835
GCF	-23.781	49.466	-0.480	0.631
GDP	77.584	60.341	1.285	0.199
INDUSTGRO	-77.567	170.259	-0.455	0.649
POPGRO	141.850	19.524	7.265	0.000
R-squared	0.290			
Adjusted R-squared	0.271			
F-statistic	15.419			
Prob(F-statistic)	0.000			

Source: Author's Calculation

Table 5. Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	94.713088	8	0.0000

Source: Author's Calculation

6. CONCLUSION AND RECOMMENDATIONS

Present study is examined the relationship between emissions of Co2 and GDP, electricity consumption, energy consumption exchange rate, exports, Gross Capital Formation (GFC), industrial growth, and population growth of some selected countries of Economic Community of West African Studies (ECOWAS). For this purpose, 22 years of secondary panel data are used. For the analysis of data FEM and REM estimates are employed and to check the endogeneity of the model a Hausman test are used. Results of Hausman test is in favour of REM and one can see from the table 5.

Therefore, the study suggests that there is an urgent need to encourage the use of renewable energy and related technique in this region to reduce the carbon emissions. Since the impact of population growth over the emissions of Co2 is positive (very high) and statistically significant (Table 4) therefore, it is important to make a proper population policy to have control over the population growth in the region. Moreover, the exchange rate is also having positive and statistically significant impact over the emissions of Co2, therefore it urgent need to have check and balance over the exchange rate in the region and for this there is a need to diversify the economies rather to dependent over the one source of revenue specially in Nigeria.

Based on the discussion, findings, and suggestions are limited and therefore it is having a scop for further research and for this it is needed to include more variables and extend the timeframe up to 2023. Moreover, one can see it country wise problem because the nature of the country, such as population, economic growth, industrial growth, and other factors are different therefore it can be seen separately.

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CONFLICT OF INTEREST

The author/s declares no conflict of interest.

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COMPLIANCE WITH ETHICAL STANDARDS

Not Applicable.

ETHICAL APPROVAL

Not Applicable

DATA AVAILABILITY:

On request one can get the data. Email: bholakhan1512@gmail.com

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Serial number of components	The actual characteristic values of PCA	Values obtained by parallel analysis	Decision
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2	1,913	1.4326	Accept
3	1,107	1.3287	Reject
4	0,967	1.2433	Reject

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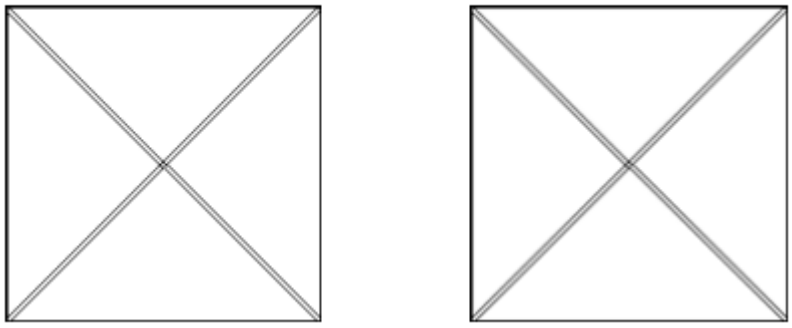

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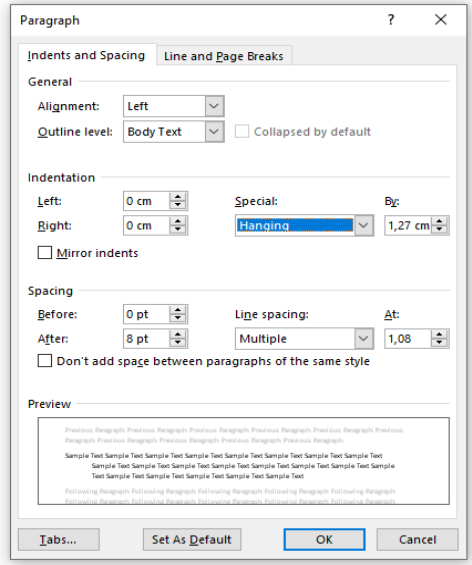

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Simic, J. [Jovan]. (2019).
Simic, J. [Juraj]. (2019).

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One author

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Author, M., Author, B., Author, E., Author, G., Author, D.,Author, R., ... Author, P. (2001)

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