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# DISCUSSIONS BETWEEN ECONOMIC AGENTS: Global Problems


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# PREFACE

The new subject of the series of "Discussion Between Economic Agents" is Global Problems. This time we have papers from Turkiye and Hungary. The dedication and seriousness of the authors raises the papers quality. The fifth book of the series has various subjects from all over the world. On the other hand, used econometric methods are interesting and crucial to follow. There are six valuable works in the book. In this context, articles mentioned below are discussed together.

In the first chapter of the book, Kubra GOGER prepared an analysis with Panel Data Analysis in the study named "Effects of Productive Capacities on Economic Growth: Panel Data Analysis on OPEC Countries". Author used the data for the period 2000 to 2018 including 38 OECD countries. Recent literature of econometric methods are used to get the result. It has been observed that productive resources, entrepreneurial talents, and production links in OECD countries have a positive effect on economic growth and development.

In the second chapter Nursac DEGERLI in her work called "A Structural Break Time Series Analysis of the Sensitivity of Foreign Trade to Exchange Rate Changes in Turkish Economy(1994-2019)", aimed to learn whether real effective exchange rates as an explanatory variable has an effect on exports and imports. She used Zivot Andrew unit root test and ARDL bound test. The result shows that it contradicts the theory. Foreign income had a significant short-term impact on exports.

In the third part of the book, Ayse Nur SAHINLER, author of the study called" Volatility Spillover Effect Between Green Bonds and Clean Energy Markets: Atime Varying Granger Causality Perspective", analyzed Nasdaq Clean Edge Green Energy, S&P Global Clean Energy, S&P Renewable Energy and Clean Technology, MAC Global Solar Energy, ISE Global Wind Energy, and Global Water as the clan energy indices which were obtained from Bloomberg using monthly data in

the period of August 2011 and March 2022. Author used Multivariate GARCH models to investigate the presence of volatility spillovers. Moreover she added a causality test to give the relationship between the variables.

In the forth chapter of the book, Lajos KASZA and Katalin LIPTAK conducted the study named "Analysis of the Entrepreneurial Environment and Attitudes in Hungary", in which they have aimed to present an outstanding international entrepreneurship survey (GEM) and to examine the entrepreneurial ecosystem in Hungary. They focused the importance of attitudes and entrepreneurial aspirations on entrepreneurship. As a result, they introduced a novel approach to the entrepreneurial ecosystem, followed by a presentation of the Hungarian perceptions.

In the fifth chapter, Gamzenur COSKUN conducted a VAR analysis using January 1999- March 2022 period in the study named "Exchange Rate Impact on the BIST 30 Index: VAR Analysis Approach". The main objective of this study is to analyze the existence of the relationship between the BIST-30 index and the USD/TL, EUR/TL, and GBP/TL parities, if any. Author used Phillips Peron unit root test for her Time Series data. Following this, cointegration test and relating VAR analysis was done. As a result, author found a bi directional relationship between the variables.

"The Effect of Climate Change on Agricultural Production and Food Security: Quantile Regression Analysis" is the last chapter of the book. The authors, Esra SOYU YILDIRIM, Cuma DEMIRTAS and Munise ILIKKAN OZGUR, investigated the the effect of climate change on agricultural production and food security. The study consists of eleven countries namely Australia, Canada, China, France, Germany, India, Pakistan, Russia, Turkiye, Ukraine, USA. Like POLS, Quantile Regression Analysis, puts forward that variables are statistically significant for all quantiles and have similar coefficient signs.

I would like to express my sincere gratitude to all the authors for their high-quality contributions. All errors and references used are the responsibility of the authors. In addition, I would like to thank the ISPEC managers and workers for their support during the publishing process of this book.

Prof. Okyay UÇAN

# CHAPTER 1

## EFFECTS OF PRODUCTIVE CAPACITIES ON ECONOMIC GROWTH: PANEL DATA ANALYSIS ON OPEC COUNTRIES

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## INTRODUCTION

From the past to the present, every country's goal has been to provide long-term and consistent economic growth. When the data is examined, it is clear that some countries have slower growth than others. Although there are numerous growth theories in the literature, the power of traditional factors in explaining growth may remain limited, particularly after the 1990s.

In this regard, some recent studies emphasize the importance of productive capacities in achieving economic growth and development. Human capital, natural capital, energy, transportation, information and communication technologies, institutions, the private sector, and structural change are subcategories of these productive capacities. Within these eight subheadings, the economies of 193 UNCTAD-designated countries are individually scored, and the averages of the scores are used to create a general productive capacity index.

Productive capacities refer to the ability to produce goods and services that will help a country's economy grow and develop. They are determined by productive resources, entrepreneurial abilities, and production links. Furthermore, the productive capacities index appears as a practical and dynamic tool that aids in understanding the state of developing countries' productive capacities and how to improve them.

Human capital includes the population's health, education, and skill requirements. It captures the general research and harmony at the base of society, along with the expenditures and number of researchers that comprise the research activities. As the fertility rate rises, the human

capital score decreases. Natural capital is defined as the profit generated by the extraction of a natural resource, as well as the existence of agricultural resources, after deducting the cost of extraction. Energy also assesses power source efficiency, availability, and continuity. Deficits in the renewability and distribution of energy components impede access to and use of energy. The gross domestic product generated by the oil unit is included.

Another category that includes the index is transportation, which measures a system's ability to move goods and people from one location to another. It is defined by its road, airline, and railway network. The availability and adaptability of communication facilities within the population are also predicted by information and communication technology. Its content includes internet access and server security for users of mobile phones and fixed lines. Another category of institutions aims to measure their effectiveness through their fight against crime, terrorism, and corruption, regulatory quality, freedom of expression, political stability, and success in their effectiveness. The private sector, on the other hand, is defined by the ease of cross-border trade, which includes assistance for business owners in terms of the time required to launch a new venture. Finally, the structural change category depicts the trend of other productive resources, including labor, from low productivity to high productivity economic activities.

A review of the literature on the relationship between economic growth and productive capacities revealed that there are few domestic

studies on OECD countries. The study's main motivation is to compensate for the deficiency by econometrically testing the said relationship in OECD countries from 2000 to 2018.

The research will continue with a review of the literature on the relationship between economic growth and productive capacities. The analysis results will be evaluated alongside the data set and the econometric method. Finally, the results of the econometric analyses will be summarized in the conclusion section.

## 1. LITERATURE

Studies on the relationship between economic growth and productive capacities can be traced back to ancient times when the subcategory of productive capacities was created. Many researchers in the field have been drawn to the fact that productive capacities have a significant impact on economic growth, the sustainability of this growth, and economic development. In this context, studies conducted in different periods and with different countries/country groups related to the subject are mentioned in the study's literature section.

Hicks (1980) investigated the link between human capital and economic growth in 83 developing countries between 1960 and 1977. As an analysis technique, he used multiple regression. In the conclusion, it was concluded that human capital has a positive effect on growth as countries' development levels progress.

While Jones (1996) examined the relationship between physical capital and growth for 90 countries between 1980 and 1990, he also

examined the relationship between human capital and growth between 1960 and 1985. He also investigated the connection between knowledge, technology, and growth. According to the study, the ratio of human and physical capital to economic growth is 72 percent. While the share of physical capital in national income was determined to be 35%, the share of human capital was determined to be 20%. The reason for developing countries' lack of technology is a lack of human capital investments.

Hall and Jones (1996) sought to explain income disparities between countries using physical and human capital. Based on data from 127 countries from 1960 to 1995. In the final section, it is shown that human capital, physical capital, and technology all have a 56%, 30%, and 14% impact on economic growth, respectively.

Bassani and Scarpetta (2001) examined the relationship between human and physical capital and economic growth in 21 OECD countries from 1971 to 1998 using panel data analysis. According to their findings, human capital has a positive effect on economic growth, but not as much as physical capital.

Between 1960 and 1990, Deliktaş (2001) examined the relationship between human capital and economic growth in 75 countries. Human capital has been found to have a positive effect on growth. Another result is that low-capital societies have larger families, whereas high-capital societies have fewer families.

Middendorf (2005) preferred the 1965-2000 period for 29 OECD countries when studying the relationship between human capital and

economic growth. Average years of education, birth rate, inflation, investment rate, and public expenditures are the variables used to investigate the effects on growth. In the conclusion section, it is concluded that an increase in investment rate and average education period positively affects growth, whereas inflation, birth rate, and public expenditures negatively affect growth.

By drawing comparisons with EU countries, Gençoğlu (2006) examined the relationship between economic growth and human capital in the Turkish economy. His work on Turkey spans the years 1965 to 2003, and his work on EU countries spans the years 1995 to 2003. While economic growth was used as the dependent variable in the study, it was discovered that schooling rate, purchasing power parity, and average life expectancy were added as independent variables to the model. In the conclusion, it was discovered that England's schooling rate has a greater impact on the gross national product than other countries. Again, the average living rate in England and Italy is higher than in other countries, and the purchasing power parity in England is higher. When applied to Turkey, it was discovered that changes in human capital have a positive impact on economic growth.

Aydın (2010) examines the relationship between energy consumption and economic growth in his work on energy, a subcategory of productive capacities. This analysis made use of quarterly and annual data. The time span is determined as 1996:01-2004:04 and 1980-2004. The ordinary least squares method was used in the analysis. The study

concluded that energy consumption has a positive impact on economic growth.

Türedi (2013) used panel data analysis to investigate the relationship between information and communication technologies and economic growth in the economies of 23 developed and 30 developing countries. The years 1995 to 2008 were chosen. According to the results of the analysis using fixed and random effects, information and communication technologies have a positive effect on economic growth in both developed and developing countries.

Hayaloğlu (2014) examined the relationship between institutional structure and economic growth, which is the other branch of productive capacities, in Turkey. The study spans the years 1972 to 2009. The political freedom index was used to represent the institutional structure in his study. According to the findings of the study, the institutional structure has a long-term positive effect on economic growth. In the short run, no relationship between economic growth and institutional structure was discovered.

Özkan and Çelik (2018) investigated the relationship between economic growth and information and communication technologies in Turkey from 1998 to 2015. While economic growth was used as the dependent variable, fixed and mobile phone usage, as well as internet usage, were added as independent variables to the model. It is concluded in the conclusion section that information and communication technologies have a positive effect on economic growth.

Doğanay and Değer (2020) used panel data analysis on 48 developed, 63 developing, and 23 less developed countries to investigate the relationship between institutions and economic growth. The implementation period runs from 2002 to 2018. The governance index serves as the foundation for representing the institutional structure. It was concluded in the conclusion section that institutions play an important role in the advancement of the country's economy. Furthermore, the effect of government effectiveness, accountability, freedom of expression, and corruption control, all of which are influential in the institutional structure, is positive on economic growth. While the absence of violence and political stability is expected to have a significant positive effect on growth, the effect is minor.

Kartal (2021) used panel data to examine the relationship between energy security and economic growth in Turkish Republic countries from 1992 to 2016. Since the variables were cross-sectionally dependent, the series' stationarity was investigated using the CIPS test. The AMG estimator results show that a 1% increase in the level of energy security risk reduces economic growth by 0.95 percent as a result of the unit root test.

Gnangnon (2021) investigated the effect of productive capacities on economic complexity in 126 developed countries. The analysis spans the years 2002 to 2018. The effect of increasing productive capacity on economic complexity was discovered to be growing. It is also

concluded that productive capacities complement each other strongly in positively influencing economic complexity.

Altıntaş (2022) investigated the assessment of productive capacities for 19 G20 member countries. As a method, he used the entropy-based topsis application. According to the findings, transportation is the most important component of these countries' productive capacity. South Korea, the United States, and Germany had the highest productive capacity.

## 2. DATA SET, ECONOMETRIC METHOD, AND FINDINGS

This study looks at OECD countries from 2000 to 2018. Real GDP, the productive capacity index, labor, and capital variables are all used in the study. The UNCTAD database was used to obtain the productive capacities index, and the World Bank database was used to obtain the variables of economic growth, labor, and capital. The period range used in the analysis was chosen based on data availability. For panel data analysis, annual data were used. The following is the application model:

$$LNRGDP_{it} = \beta_0 + \beta_1 PCI_{it} + \beta_2 LNL_{it} + \beta_3 LNK_{it} + u_{it} \quad (1)$$

In the equation, the LNRGDP variable represents real gross domestic product, whose logarithm is used as the dependent variable to represent economic growth. As an independent variable, the PCI variable depicts the productive capacities index. Labor and capital variables, which are among the basic production factors, are included as control variables in the model. In Equation 1, the “i” sub-index

represents the 38 OECD countries, and the "t" sub-index represents time. "u" is the error term, and "$\boldsymbol{\beta}_0$" is the constant term. The explanations for the series are given in Table 1.

**Table 1:** Variables Included in the Analysis and Data Sources

| Code | Definition | Source |
|---|---|---|
| LNRGDP | Economic Growth (Gdp Per Capita, Constant 2015 US$) | World Bank* |
| PCI | Productive Capacities Index With Averages of Human Capital, Natural Capital, Energy, Transport, Information and Communication Technology, Institutions, Private Sector, and Structural Change Sub-Categories. | UNCTAD** |
| LNL | Labor Force, Total | World Bank* |
| LNK | Capital (Gross Fixed Capital Formation, Constant 2015 US$) | World Bank* |

Note: *The World Bank: https://data.worldbank.org (Access: 25.05.2022)
**UNCTAD:https://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx?sCS_ChosenLang=en (Access: 25.05.2022)

Panel data analysis was used in the study to test the relationship between the series. When performing the aforementioned analysis, it was first noted that the number of sections (38) was greater than the number of observations (19), indicating that the N>T situation was valid. The cross-section dependence and homogeneity assumptions were not tested in this context because it was assumed that the unit root tests of the series would not be considered. Furthermore, it has been determined that the panel contains the same number of time series observations in each unit, resulting in a balanced panel situation. The model is tested to see if it has fixed or random effects

before performing pooled least squares. The Hausman test was used to compare these two models. The Driscoll Kraay estimation method, which is one of the estimators resistant to standard deviations, was used after determining whether the model contains heteroscedasticity and autocorrelation problems. The statistical program Stata 14 was used to analyze the variables. A summary of the tests used was provided, and the results were presented in tables.

### 2.1. In Panel Data Models, Appropriate Model Selection and Basic Assumption Tests

Before performing pooled least squares (POLS) for panel regression models, a choice between random effects and Pooled least squares with the Breusch-Pagan LM test must be made. Along with the F test, there is the option of using Pooled least squares or fixed effects. The Hausman test should be used if any of the F or LM tests pointed to a model other than Pooled least squares. The Hausman test statistic allows you to choose between random effects and fixed effects.

After it was determined that the path would continue with the fixed effects model as a result of the Hausman test, whether the model in question was suitable for the basic assumptions was tested using heteroscedasticity and autocorrelation tests. The variance test was performed using a modified Wald test, and autocorrelation was performed using Wooldridge tests.

**Table 2:** Appropriate Model Selection and Basic Assumption Test Results

| **Analysis** | **Test Type** | **Test Statistic** | **Probability Value** |
|---|---|---|---|
| Classical Model Test (1) | F Test | $x^2$ (37) = 7117.05 | 0.0000*** |
| Classical Model Test (2) | Breusch-Pagan LM Test | $x^2$ (01) = 2783.67 | 0.0000*** |
| Fixed-Effects-Random Effects | Hausman Test | $x^2$ (03) = 112.14 | 0.0000*** |
| Heteroscedasticity Test | Groupwise HC Test for FE | $x^2$ (38) = 5672.90 | 0.0000*** |
| Autocorrelation Test | Wooldridge Test | F(1, 37) = 56.572 | 0.0000*** |

Note: ***, It means that the null hypothesis is rejected at the 1% significance level.

When the table result was evaluated using the F test, which allows the user to choose between the fixed effects model and the pooled least squares model, the null hypothesis "pooled least squares" was rejected and the fixed effects model was pointed to. The null hypothesis (of $H_0$: Pooled least squares was) also rejected in the LM test, and the result of the random effects model was obtained. As a result of the tests, it was decided to use the Hausman Test, which was intermediate between the fixed effects and random effects models. The Hausman test revealed that the null hypothesis random effects model was rejected at the 1% significance level, implying that the fixed effects model was used.

The null hypothesis that there is a problem with heteroscedasticity, ($H_0$: there is no problem with heteroscedasticity), was rejected at the 1% significance level for the chosen fixed effects model. The null hypothesis (of $H_0$: there is no autocorrelation problem was) also rejected in the autocorrelation test, which is another assumption test.

As a result, it has been determined that the model has both heteroscedasticity and autocorrelation issues. The Driscoll-Kraay (1998) test was used to eliminate the aforementioned problems and deviations from the assumptions.

**Table 3:** Driscoll-Kraay Estimate Results

| **Dependent Variable: LNRGDP** | | | | | | |
|---|---|---|---|---|---|---|
| **Independent Variables** | **Coefficient** | **Drisc/Kraay Std.Err.** | **t** | **P>\|t\|** | **95%Conf. Interval** | |
| **PCI** | 0.0292 | 0.0026 | 11.04 | 0.000 | 0.0236 | 0.0348 |
| **TIME** | | | | | | |
| **1** | 0 (empty) | | | | | |
| **2** | 0.0065 | 0.0007 | 8.25 | 0.00 | 0.0048 | 0.0082 |
| **3** | 0.0159 | 0.0016 | 9.45 | 0.00 | 0.0123 | 0.0194 |
| **4** | 0.0161 | 0.0027 | 5.86 | 0.000 | 0.0103 | 0.0218 |
| **5** | 0.0187 | 0.0044 | 4.23 | 0.001 | 0.0094 | 0.0280 |
| **6** | 0.0238 | 0.0056 | 4.22 | 0.001 | 0.0119 | 0.0357 |
| **7** | 0.0310 | 0.0073 | 4.23 | 0.001 | 0.0155 | 0.0464 |
| **8** | 0.0354 | 0.0091 | 3.86 | 0.001 | 0.0161 | 0.0547 |
| **9** | 0.0390 | 0.0090 | 4.31 | 0.000 | 0.0200 | 0.0580 |
| **10** | 0.0425 | 0.0074 | 5.72 | 0.00 | 0.0268 | 0.0581 |
| **11** | 0.0609 | 0.0077 | 5.72 | 0.000 | 0.0445 | 0.0773 |
| **12** | 0.0540 | 0.0088 | 6.12 | 0.000 | 0.0354 | 0.0726 |
| **13** | 0.0594 | 0.0088 | 6.71 | 0.000 | 0.0408 | 0.0781 |
| **14** | 0.0694 | 0.0087 | 7.96 | 0.000 | 0.0510 | 0.0877 |
| **15** | 0.0767 | 0.0091 | 8.42 | 0.000 | 0.0575 | 0.0958 |
| **16** | 0.0831 | 0.0097 | 8.50 | 0.000 | 0.0625 | 0.1036 |
| **17** | 0.0922 | 0.0101 | 9.10 | 0.000 | 0.0709 | 0.1135 |
| **18** | 0.1031 | 0.0104 | 9.85 | 0.000 | 0.0811 | 0.1251 |
| **19** | 0.1151 | 0.0108 | 10.61 | 0.000 | 0.0923 | 0.1379 |
| **LNL** | -0.5824 | 0.0785 | -7.41 | 0.000 | -0.7475 | -0.4173 |
| **LNK** | 0.3689 | 0.0261 | 14.10 | 0.000 | 0.3140 | 0.4239 |
| **Constant Term** | 8.8514 | 0.6833 | 12.95 | 0.000 | 7.4158 | 10.2871 |
| F(21, 18) = 197.95 | | Prob>F = 0.0000 | | | $R^2$ = 0.8639 | |
| **Time Dummies are Significant** | | F(3, 18) = 278.96 | | | Prob>F= 0.0000 | |

According to the Driscoll-Kraay analysis, a 1 unit increase in productive capacity increased economic growth by 0.0292 percent. It

has been determined that productive capacities have a positive impact on economic growth. By increasing 0.000, the probability value of the said variable was found to be significant in the model.

A 1% increase in total labor force (labor) added as a control variable to the model reduces economic growth by 0.5824 percent. As a result, the aforementioned series has a negative impact on economic growth in the OECD countries during the specified year range. Furthermore, the variable is seen to be significant in the model. The capital series, which is yet another control variable, has a positive coefficient. A 1% increase in the capital variable increases economic growth by 0.3689 percent. The probability value of the capital series, like other variables, is 0.000. Furthermore, it was determined that it was significant in the model. When all of these results are combined, the final model obtained is as follows:

$$\widehat{LNRGDP}_{it} = 8.8514 + 0.0292PCI_{it} - 0.5824LNL_{it} + 0.3689LNK_{it} \quad (2)$$

A dummy variable was added to each year to control the time dimension in the model. When examined, it was discovered that all of the dummy variables added to the time were significant and required staying in the model. The null hypothesis, which means ($H_0$: The coefficients of all the dummy variables added to the years are zero), was rejected in the test used to determine the collective significance of the dummy variables added to time, as shown in Table 3. As a result, it was determined that the dummy variables are significant and that the time dummy variables can be included in the model collectively.

## CONCLUSION

The effect of productive capacities on economic growth was investigated in this study. The study spans the years 2000 to 2018 and includes 38 OECD countries. According to recent research, productive capacities positively contribute to economic growth. The real gross domestic product variable was used as an indicator of economic growth in the analysis of these countries. The model includes the productivity capacity index as an independent variable and labor and capital as control variables.

Because N>T was the case in the study, panel data analysis was used. Because there was no requirement to examine whether the series had unit roots, basic tests such as cross-section dependence and homogeneity assumption were not used in this analysis. The Breusch Pagan LM and F tests determined whether the model has pooled least squares, fixed effects, or random effects. As a result, the model was found to have fixed effects.

The Driscoll-Kraay estimator with power standard deviations was used because it was known that the model had heteroscedasticity and autocorrelation. The model's coefficient of productive capacities was positive and statistically significant. From this vantage point, it has been observed that the evolution of the OECD countries' productive capacity index between 2000 and 2018 has had a positive effect on economic growth.

It has been observed that productive resources, entrepreneurial talents, and production links in OECD countries have a positive effect on

economic growth and development. Data from OECD member countries were used in the study. When the effects of productive capacities on economic growth are studied more broadly with different country groups, it is expected to yield more detailed results. It is expected that by strengthening productive capacities, national economies will become more resilient and will guide policymakers in overcoming the challenges that are likely to arise in the future.

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# CHAPTER 2

## A STRUCTURAL BREAK TIME SERIES ANALYSIS OF THE SENSITIVITY OF FOREIGN TRADE TO EXCHANGE RATE CHANGES IN THE TURKISH ECONOMY (1994-2019)

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## INTRODUCTION

With the collapse of the world economy's exchange rate system in the early 1970s, in which national currencies were fixed to the dollar and the dollar to gold, most countries allowed their national currencies to fluctuate. As a result of this process, a shift toward the Bretton Woods system has occurred. National economies began competitive devaluation practices during the specified period, namely the 1930s and 1940s. Although there was a desire to return to the gold money system, also known as a fixed exchange rate, especially after World War I, it was not widely implemented. Following the war, new mercantilist policies were implemented, to create a balance of payments surplus by reducing imports and increasing exports by manipulating the value of the national currency. To prevent competitive devaluation movements during World War II, a global fixed exchange rate system was assembled in the US state of New Hampshire, and the Bretton Woods agreement, which bore the town's name, was signed. The ultimate goal of this fixed exchange rate system is to prevent the destruction of exchange rate uncertainty. Following WWII, expansionary policies were implemented in the context of the developing economy. Inflationary environments have emerged as a result of expansionary economic policies. When the dollar pegged to gold and the national currency pegged to the dollar appreciated in the early 1970s, fixed exchange rate practices were abandoned. The floating or controlled exchange rate system has been used from the 1970s to the present.

The neoliberal paradigm became an unbreakable doctrine as a result of the financial globalization that emerged in the world economies in the 1970s and the liberalization trend that began in the goods markets in 1980. The classics' view of "laissez faire, laissez passer" serves as the foundation for this thought. The concept of freedom in both goods and services and factor markets, as well as freedom in foreign exchange markets, emerged. While traditional theories of exchange rate explanation determine where the exchange rate should take, in the long run, fluctuations caused by capital movements in the short term are one of the primary causes of exchange rate instability.

With the financial globalization that occurred at this time, as exchange rate volatility increased, the balance of payments crises involving foreign currency became more common. With the effect of spreading, this phenomenon is carried to the international level. Currency crises devastate the economy by disrupting the balance of payments and causing financial and banking crises. Given these events in the global economy and the Turkish economy in general, it is clear that exchange rate volatility causes serious real and monetary problems.

Foreign trade is one of the world's most important economic issues. Countries can use their scarce resources more effectively if they divide labor and specialize. Furthermore, countries can raise their living standards and contribute to their economies through international trade. Because free foreign trade increases welfare and production in countries, it aims to increase the countries' competitiveness accordingly. Countries that face competition may strive to improve

their technologies, increase their innovation, provide X efficiency, and expand their R&D fields. It is preferable to increase the level of economic complexity to account for more information density in the production of trade-related products. Furthermore, exchange rates, another important policy tool, appear to be a tool in which countries can easily intervene in the short term. The study differs from others in that it examines the effect of real effective exchange rate changes on exports and imports, as well as explanatory variables, rather than exchange rate changes, using appropriate databases.

## 1. LITERATURE REVIEW

Many studies on the Turkish economy have discussed the relationship between the exchange rate variable and the export and import variables based on foreign trade in the study. Because the studies span different periods, the empirical analysis yields different results. The following studies in the literature on the relationship between exchange rate and foreign trade are provided.

**Table 1:** Exchange Rate and Foreign Trade Relationship Research

| Author | Period | Method | Results |
|---|---|---|---|
| Akbostancı (2004) | 1987-2000 | Cointegration Analysis, Time Series Analysis | It concluded that the foreign trade condition is sustainable in the long run. |
| Karagöz ve Doğan (2005) | 1995-2004 | Time Series Analysis | The relationship between imports, exports, and the exchange rate. The relationship wasn't thought to be important. The 2001 financial crisis |

| | | | |
|---|---|---|---|
| | | | had a statistically significant impact. |
| Şimsek ve Kadılar (2005) | 1970-2002 | Time Series Analysis | It has been determined that the Turkish economy satisfies the foreign trade condition. |
| Hepaktan (2009) | 1983-2008 | Partial Cointegration Analysis | The foreign trade condition was discovered to be untrue over the long term. |
| Vergil ve Erdoğan (2009) | 1989-2005 | Time Series Analysis, ARDL | It concluded that Turkiye had fulfilled the requirement for foreign trade. |
| Çil, Yavuz vd. (2010) | 1988-2007 | Limit Test analysis | The Turkish economy's foreign trade condition was found to be invalid. |
| Karaçor ve Gerçeker (2012) | 2003-2010 | VAR Analysis, ECM Model, and Causality Analysis | It discovered a cointegration relationship between the real exchange rate and the volume of foreign trade. In both the short and long run, a unilateral causal relationship between the real exchange rate and foreign trade volume was discovered. |
| Bal ve Demiral (2012) | 2002-2012 | Cointegration analysis | It was concluded that the foreign trade condition is long-term. |
| Okay vd. (2012) | 2003-2010 | Johansen, VAR and VEC Analizi | Foreign trade conditions were discovered to be favorable. |

| | | | |
|---|---|---|---|
| Göçer ve Elmas (2013) | 1989-2012 | Multiple Structural Breakthrough Time Series Analysis | In her study, she demonstrated the validity of the extended Marshall-Lerner condition for all ware groups. |
| Kızıldere, Kabadayı ve Emsen (2014) | 1980-2010 | Zivot-Andrews Unit Root Analysis with Structural Break, Engle-Granger Cointegration Analysis, ECM and EKK | As a result, it was discovered that the exchange rate has a significant impact on the Turkish economy's foreign trade. |
| Kemeç ve Kösekahyaoğlu (2015) | 1997-2013 | Variance Decomposition Analysis and Effect-Response Analysis | Foreign trade and the Marshall-Lerner condition were discovered to be absent. |
| Uslu (2018) | 1989-2018 | Time Series Analysis with Structural Break | The exchange rate had a significant impact on Turkiye's foreign trade balance. It was discovered to have a negative effect in the short term. If the Turkish economy relies on foreign trade, this was discovered to be false. |
| Topçu ve Özdemir (2019) | 2004-2017 | AMG Estimator | Marshall-Lerner condition was found to be valid for bilateral trade between Turkiye and the Eurozone. |
| Güneş (2021) | 2010-2019 | FMOLS | In the short run, the real exchange rate does not have a causal relationship with exports. |

| | | | |
|---|---|---|---|
| Ergin Ünal (2021) | 2000-2019 | ARDL, Limit Test | It was determined that the Marshall-Lerner condition had been met for Turkiye's and Russia's economies. In both the long and short term, the industry representing the country's income production index was found to be statistically significant. |

## 2. DATA SET AND MODEL

This study looks at the Turkish economy from 1994 to 2019. The per capita GDP of Turkiye showing import, export, and domestic income, as well as the GDP per capita of the United States showing foreign income, were obtained from the World Bank Database for this study, which aims to investigate the relationship between export and import variables and the exchange rate. The BIS database was used to obtain the real exchange rate.

Because there are two models in the study, export was used as the dependent variable and real exchange rate and foreign income were used as independent variables in the first model, which is the export function. The import function, the other model, includes imports as dependent variables and the real exchange rate and domestic income as independent variables in the analysis. The data in the study were handled on an annual basis. The logarithms of the variables were calculated in Stata and used in the analysis in this manner. The data were analyzed using the Stata 14 statistical package program. The

variables used in the analysis are listed in Table 2 along with their abbreviations.

**Table 2:** Application Variables and Their Definitions

| Code | Explanation | Source |
|---|---|---|
| lnex | Goods and Services Export | World Bank* |
| lnrdk | Real Exchange Rate | BİS** |
| lnusgdp | Foreign income- ABD | World Bank* |
| lnimp | Goods and Services İmport | World Bank* |
| lntrgdp | Domestic İncome- TR | World Bank* |

Note: *The World Bank: https://data.worldbank.org (Access: 08.04.2022)
**BİS:https://bis.org/statistics/eer.htm(Access: 25.05.2022)

## 3. ECONOMETRIC METHOD AND EMPIRICAL FINDINGS

The study employed time series analysis. This analysis covers Turkiye from 1994 to 2019. The Zivot-Andrews (1992) refractive unit root test was used to determine the stationarity levels of the variables. Because the variables' degrees of stationarity differed (assuming the dependent variable was I(1)), ARDL analysis with structural break was used in both the export and import functions.

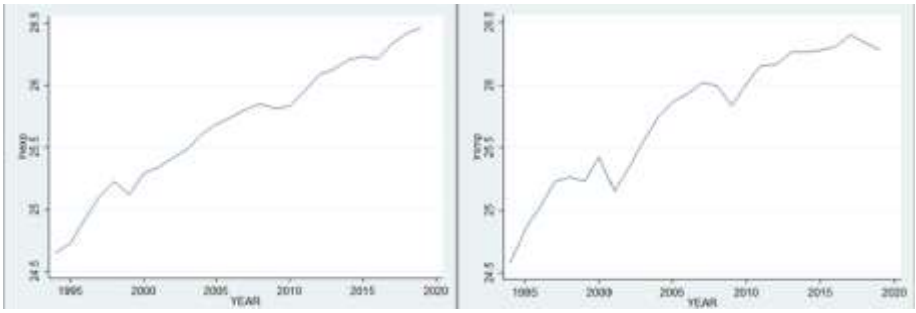
Long-term and short-term series results can be reported using ARDL analysis. To determine the existence of a long-term cointegration relationship, the Structural Fractured Bounds Test was used. Cusum analysis was used to estimate the relationship between variables using

the ARDL method with Structural Break. Autocorrelation and Varying Variance tests were used to analyze econometric problems.

### 3.1. Unit Root Test with Structural Break

The Zivot-Andrews (1992) (ZA) test, which takes into account the structural break, was used to determine the stationarity of the variables in the export and import functions. Even though the test only allows one break in the series, it states that the break period is determined internally in the model (Yıldırım vd., 2015: 94). While the null hypothesis was established as a unit root, the alternative hypothesis was determined to be stationary. The rejection of the hypothesis or vice versa can be determined by comparing the value calculated as a result of the test with the (ZA) critical values.

Traditional unit root tests may yield different results due to possible structural breaks caused by the variable analysis. The (ZA) test, which allows only one endogenous break, was used to examine the unit roots of the variables mentioned under the structural break. Figure 1 depicts the scattering diagram against time for the five series.



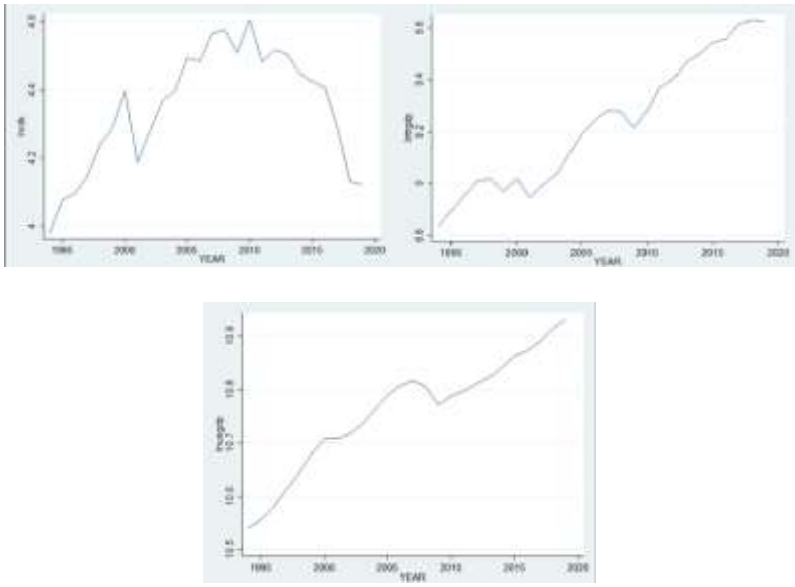


**Figure 1:** Level Value Diagram

As shown in Figure 1, because all five variables have a starting point, it is clear that they all have a trend because they exhibit constant and accelerated movements.

**Table 3:** Zivot-Andrews (1992) Unit Root Test Results with Structural Fracture

| | **LEVEL (Costant+Trend)** | | **FIRST DIFFERENCES (Constant+Trend)** | | |
|---|---|---|---|---|---|
| **Variables** | **Min T-Stat** | **Break** | **Min T-Stat** | **Break** | **Result** |
| **lnexp** | -3.558 | 2009 | -6.49* | 1999 | I(1) |
| **lnrdk** | -2.500 | 2010 | -8.649* | 2003 | I(1) |
| **lnimp** | -4.114 | 2004 | -6.415* | 2002 | I(1) |
| **lntrgdp** | -5.388* | 2001 | | | I(0) |
| **lnusgdp** | -3.809 | 2008 | -4.369 | 2008 | I(2) |
| | | | **2. Difference** | | |
| | | | -7.042* | 2010 | |

Note: *, It means that the null hypothesis is rejected at a 5% level of significance. Based on the level value graph. The results are reported in the trend and constant model for the (ZA) test based on this.

When the table results are analyzed, the test statistics (ZA) for both the fixed and trend models at the level of export, import, and real exchange rate variables are smaller than the critical values. The hypothesis of a H0 unit root cannot be rejected. When the first differences in the series are examined, the test statistics are greater than the critical values. As a result, the (ZA) test determined that the variables in question were stationary in the first order I. (1). Foreign income variable, on the other hand, has reached a plateau at the second degree. Finally, at the level, the domestic income variable is stationary. When the (ZA) structural break unit root test break dates are analyzed, the Asian crisis that included Turkiye in 1999, the foreign exchange and banking crisis that began in Turkiye in 2001, the strong economic growth period of 2003 and 2004, and the results of the 2009 US-based global economic crises are detected.

### 3.2. Limit Test

Although the dependent variable (lnexp) I(1), the independent variables (lnrdk) I(1), and the dependent variable (lnusgdp) I(2) for the export model have been identified, the cointegration relationship of the model is determined by Pesaran, Shin, and Smith (2001) Bounds test with structural break and accompanying ARDL estimation results. Similarly, the dependent variable (lnimp) I(1), the independent variables (lnrdk) I(1), and (ltrgdp) I(0) for the import function are reported in the second model, but the Bounds test with structural break and accompanying ARDL estimation results are not.

**Table 4:** Structural Fractured Boundary (ARDL) Test Results for Export Model

| k | F Statistic | Limit Values at a 5% Significance Level | |
|---|---|---|---|
| | | **Lower Limit** | **Upper Limit** |
| **2** | 2.488 | 3.79 | 4.85 |

Note: Akaike was used as the information criterion in the structural break Boundary (ARDL) lag level measurement for the export model. Because the study was annual, maximum lag 2 was used. Delays were discovered to be one for lnexp, zero for lnrdk, and one for lnusgdp.

Because the calculated value is less than the critical value's upper limit, the null hypothesis that there is no cointegration relationship cannot be rejected. As a result, no cointegration relationship between the variables in the export model was discovered.

**Table 5:** Short and long-term ARDL (1,0,1) results with structural breaks for the export model

| ***Export Model:*** $Lnexp=f(lnexp_{t-1}, lnrdk, lnusgdp, lnusgdp_{t-1})$ | | | | |
|---|---|---|---|---|
| **Long Term Results** | | | | |
| **Variables** | **Coefficient** | **Standard Error** | **t statistics** | **Possibility** |
| **lnrdk** | -0.328 | 0.892 | -0.37 | 0.717 |
| **lnusgdp** | 1.9269 | 3.8050 | 0.51 | 0.618 |
| **Short Term Results** | | | | |
| **Lnusgdp(-1)** | 2.063 | 0.666 | 3.10 | 0.006 |
| **D(Dummy-1999)** | -0.2511 | 0.044 | -5.68 | 0.000 |

| | | | | |
|---|---|---|---|---|
| **HDK** | -0.0705 | 0.0084 | -0.84 | 0.413 |
| **Model Reliability Tests** | | | | |
| **Autocorrelation Test 1** | Durbin-Watson d-stat | | There is no autocorrelation problem | |
| | (6,25)=1.96 | | | |
| **Autocorrelation Test 2** | Breusch-Godfrey LM Test | | There is no autocorrelation problem | |
| | Olasılık:0.1867 | | | |
| **Variable Variance Analysis1** | Whites Test | | No changing Variance | |
| | Olasılık:0.3789 | | | |
| **Variable Variance Analysis2** | Cameron-Trivedi IM Test | | No changing Variance | |
| | Heteroskedasticity: Olasılık:0.3789<br>Skewness: Olasılık:0.7661<br>Kurtosis: Olasılık:0.4190 | | | |
| **Normality Test** | Jarque-Bera<br>Chi(2): 0.669 | | It demonstrates normal distribution. | |
| **$R^2$** | 0.7148 | | | |

Although the error correction coefficient in the model was -0.070, taking a value between 0 and -1 made it statistically significant. In the long run, the real exchange rate and foreign income do not affect the dependent variable in the export model. This result also supports the conclusion that the Bounds test shows no cointegration relationship. Foreign income had a significant and positive effect on exports in the short run.

The export model's break date has been added externally to examine the impact of the 1999 Asian crisis. In the model, the effect of the crisis is significant and negative when compared to years other than 1999. The model did not exhibit autocorrelation, varying variance, or normality issues although the model's explanatory power is 71%, the independent variables (real exchange rate and foreign income) explain 71% of the dependent variable (exports).

**Table 6:** Import Model Structural Fractured Boundary (ARDL) Test Results

| **k** | **F Statistic** | **Limit Values at a 5% Significance Level** | |
|---|---|---|---|
| | | **Lower limit** | **Upper limit** |
| **2** | 19.122 | 3.79 | 4.85 |

Note: Akaike was used as the information criterion in the structural break Boundary (ARDL) lag level measurement for the import model. Because the study was annual, maximum lag 2 was used. Delays were discovered to be one for lnimp, zero for lnrdk, and two for lntrgdp.

Because the calculated value exceeds the upper limit of the critical value, the null hypothesis of the no cointegration relationship is rejected. As a result, the variables in the import model have a cointegration relationship.

**Table 7:** Short and Long Term Results for the Import Model with ARDL (1,0,2) and Structural Breaks

| ***Import Model:*** $Lnimp=f(lnimp_{t-1}, lnrdk, lntrgdp, lntrgdp_{t-1}, lntrgdp_{t-2})$ | | | | |
|---|---|---|---|---|
| **Long Term Results** | | | | |
| **Variables** | **Coefficient** | **Standard Error** | **t statistics** | **Possibility** |
| **lnrdk** | 0.5210 | 0.2217 | 2.35 | 0.031 |
| **lntrgdp** | 1.0666 | 0.3967 | 2.69 | 0.016 |
| **Short Term Results** | | | | |
| **Lntrgdp(-1)** | 1.8834 | 0.2588 | 7.28 | 0.000 |
| **Lntrgdp(-2)** | -0.3150 | 0.1607 | 1.96 | 0.067 |
| **D(Dummy-2001)** | -0.1176 | 0.0435 | -2.70 | 0.015 |
| **HDK** | -0.2355 | 0.1100 | -2.14 | 0.047 |
| **Model Reliability Tests** | | | | |
| **Autocorrelation Test 1** | Durbin-Watson d-stat | | There is no autocorrelation problem | |
| | (7,24)=2.02 | | | |
| **Autocorrelation Test 2** | Breusch-Godfrey LM Test | | There is no autocorrelation problem | |
| | Probabality:0.8156 | | | |
| **Variable Variance Analysis1** | White Test | | No changing Variance | |
| | Probabality:0.4561 | | | |
| | Cameron-Trivedi IM Test | | No changing Variance | |

| | | |
|---|---|---|
| **Variable Variance Analysis2** | Heteroskedasticity: Probabality:0.4561<br>Skewness: Olasılık:0.6860<br>Kurtosis: Olasılık:0.5560 | |
| **Normality Test** | Jarque-Bera<br>Chi(2): 0.8381 | It demonstrates normal distribution. |
| **$R^2$** | 0.9577 | |

The error correction coefficient (HDK) was -0.23 when the results in Table 7 were evaluated. As a result, (HDK) was discovered to be statistically significant. In the long run, there is a significant and positive relationship between the real exchange rate and imports in the import model. Similarly, it has been determined that domestic income has a significant impact on the model and a positive impact on imports. This result appears to support the conclusion that cointegration exists as a result of the Bounds test. The previous lag in domestic income had a significant and positive effect on imports in the short term.

As a break, the 2001 crisis, also known as the banking and foreign exchange crisis that began in Turkiye, was added to the import model. The impact of the crisis on the model was found to be significant and negative when compared to the years before 2001. Finally, no autocorrelation, varying variance, or normality issues were encountered during the econometric problem analysis tests. The import model explained 95% of the variance.

### 3.3. CUSUM and CUSUM SQ Test

For the model's stability, CUSUM and CUSUM SQ tests were used. If the graph of the total figure obtained by starting with the fewest number

of observations in the CUSUM test and gradually increasing it falls within the band drawn for the 5% significance level, the coefficients are stable and structural stability cannot be rejected. The CUSUM SQ test is calculated similarly to the SUM SQ test and is based on the sum of the squares of the error terms (Akçağlayan ve Kayıran, 2010: 140-141).

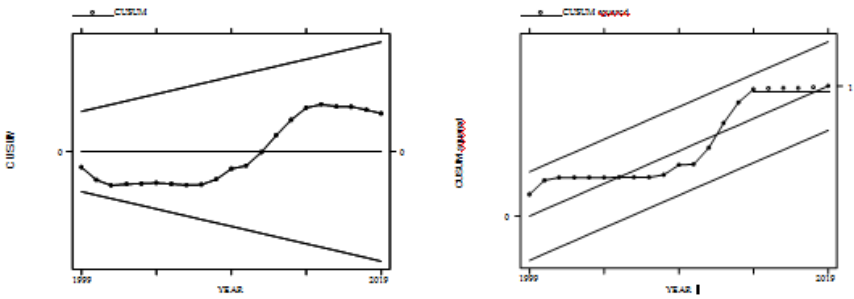



**Figure 2:** CUSUM and CUSUM SQ Graphs

Figure 2 depicts graphics of the CUSUM and CUSUM SQ tests. In both graphs, the estimated coefficients are stable because they remain within the safe band range. Furthermore, structural stability is significant because it cannot be denied and the model contains no identification error.

## CONCLUSION

Figure 2 depicts graphics of the CUSUM and CUSUM SQ tests. In both graphs, the estimated coefficients are stable because they remain within the safe band range. Furthermore, structural stability is significant because it cannot be denied and the model contains no identification error.

The coefficient signs of the variables were generally found to be following the theory in the expected direction, according to the results

obtained from the analysis of the export and import functions from the applications made in Turkiye. The primary goal of developing countries' foreign trade policies, such as Turkiye's, is to increase export rates while decreasing import rates. The factors influencing Turkiye's foreign trade, as well as the effects of the exchange rate on foreign trade, are discussed in this study. This issue, which is dealt with specifically in the Turkish economy, has been tested using time series analysis from 1994 to 2019. The Zivot-Andrews (1992) unit root test with break was used to investigate the relationship between the variables in the export and import functions. Because the variables' stability levels differed, short and long-term analyses of the export and import functions were performed using the ARDL method with a structural break. Bounds A test analysis was used to determine whether or not there was a long-term relationship between the variables. Breaks were added as a dummy variable to both functions, and the analysis was completed by including Diagnostic tests to analyze econometric problems. The Stata 14 package program was used to analyze these data. The theoretical relationship between the variables was investigated, and a literature review was conducted. The tests used are described briefly, and the results are presented in the form of tables.

In theory, the export model predicts that as the exchange rate rises, the national currency depreciates, and exports rise. When examined in terms of foreign income, another variable, a directly proportional relationship between foreign income and exports is expected. When looking at the long-term foreign trade situation, the export included in the model as the dependent variable in the export function is unaffected

by the real exchange rate and foreign income. In the model, both were insignificant. This result contradicts the theory. Foreign income had a significant short-term impact on exports. A 1% increase in foreign income leads to a 2.06% increase in exports. Domestic exports increase as the rate of the gross national product abroad rises because demand for foreign goods rises.

The 1999 crisis was incorporated into the model, and its impact was significant. The Taylan crisis, which began in the second half of 1997, impacted many countries, including Turkiye, in 1999. As a result of the crisis, market confidence was shaken, and Turkiye's export rate in 1999 was 0.25 percent lower than in years other than the year in which the crisis was added.

According to the import model, when the exchange rate rises, the relative price decrease in export goods is greater than the price increase in imported goods, resulting in a decrease in imports. On the contrary, when the exchange rate falls, the price of export goods rises, causing exports to fall and imports to rise. When the import model results are examined, the real exchange rate and domestic income are found to be significant in the long run. Imports increased by 0.52 percent for every one percent increase in the real exchange rate. Under normal circumstances, an increase in the real exchange rate should reduce imports; however, the results show a directly proportional relationship rather than an inverse one. As a result, this result does not fit the theory for the long-run import model. Although it contradicts the theory, imports rise with the exchange rate because exports rise with the

exchange rate, and intermediate goods used in exports are supplied as imported inputs. As domestic income, which is considered an independent variable in the long-run import model, rises, consumers' consumption tendencies shift toward imported goods, and imports rise along with it. This trend is expected to occur in terms of theory compliance. When the model is run, a 1% increase in domestic income raises imports by 1.06 percent. It has been observed that as domestic income increases, so do imports. As a result, it fits the theory. When we look at both the short-term and long-term results, we can see that there is a significant effect from domestic income to imports. A 1% increase in domestic income leads to a 1.88 percent increase in imports. It was discovered to be consistent with the theory in this case.

The impact of the 2001 financial crisis on the model was significant. Imports were 0.11 percent lower in 2001 than in the previous years. In the discussed foreign trade scenario, imports are expected to rise when domestic income rises and the exchange rate falls, except during the crisis period. However, when the 2001 crisis is considered, the economy has entered a bottleneck and is on the verge of an unpredictable financial crisis, while domestic stability has not been achieved and import power has also decreased.

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# CHAPTER 3

## VOLATILITY SPILLOVER EFFECTS BETWEEN GREEN BONDS AND CLEAN ENERGY MARKETS: A TIME-VARYING GRANGER CAUSALITY PERSPECTIVE

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## 1. Introduction

The twentieth century witnessed incredible economic growth and human prosperity. The population of the world increased by a factor of four, the global economy grew by a factor of fourteen, and average life expectancy grew by nearly two-thirds. Between 1900 and 2002, life expectancy in the United States increased from 47.3 to 77.3 years. However, this development has been accompanied by unanticipated and severe harm to the natural environment (Hoffman and Bansal, 2012).

"Climate has become a widely discussed topic, but practically nothing has changed because CO2 emissions have not been reduced. We cannot solve this without seeing it as a real crisis," said Greta Thunberg, attending the 2020 World Economic Forum in Davos. In fact, the "modern environmental movement," which began in the 1960s and is still growing, drew attention with its list of environmental challenges and catastrophes. What began as a media focus on water and air problems, expanded into areas of endocrine disruption, solid waste disposal, hazardous waste sites, acid rain, dangerous chemicals, ozone depletion, environmental racism, climate change, and other issues (Hoffman and Bansal, 2012). Due to this growing list of concerns, the 2015 Paris Climate Agreement, and investor interest in the environment, green bond markets have been among the fastest-growing segments of international capital markets over the last decade. (Reboredo, 2018).

The financial characteristics of green bonds and traditional bonds are similar. Green bonds are virtually like standard bonds in terms of pricing. Issuers gain from having access to various financing options and a larger pool of investors. Green bonds, on the other hand, vary from standard bonds in one way. The green bond is designed to facilitate investments that support environmentally friendly and sustainable development. Understanding how the green bond market interacts with other financial markets is also crucial for economic actors since it allows them to diversify their risks. Several hypotheses have been proposed in the theoretical literature to explain risk spillover effects between bonds and other financial products. "Financial Contagion" is the first hypothesis. Financial contagion happens when financial difficulty in one market spreads to other markets without any information being provided, or when news disclosure or noise causes an overreaction. Second, hedging demand shift hypotheses: When an asset's price deviates too much from its real value, investors will wish to hedge by switching to another safe asset. This theory states that positive stock market news will cause bond prices to fall. Finally, there are asset substitution hypotheses, in which stocks and bonds are viewed as competing assets. The desirability of these two assets is affected by any disclosure or information. If one piece of information adds to a rise in the stock price, investors will convert bonds in their portfolios to stocks, and vice versa. As a result, a positive earnings shock in one market propagates to the other market as a negative earnings shock (Ferrer et al., 2021).

The most popular econometric techniques used in empirical studies examining the relationship between green bonds and other financial markets have been cross-quantile dependence, frequency connectedness, quantile time-frequency models, and copulas - CoVaR systemic risk models. The goal of our research is to add to the literature by examining the relationship between green bonds and clean energy markets with a rolling version of causality in variance test suggested by Hafner and Herwatz (2006). This analysis provides a better understanding of how Granger-causal volatility spillover relations change during crisis periods.

The remainder of this paper is organized as follows: Section 2 provides summaries of significant studies on the interaction between green bonds and other financial markets. The methodology is detailed in Section 3, the empirical analysis, results, and conclusions are reviewed in Section 4, and the conclusion is given in Section 5.

## 2. Literature Review

A large body of empirical literature has examined the magnitude of the green bond premium. The findings of these studies remained inconclusive. For instance, Karpf and Mandel (2017), Bachelet et al. (2019), Wu (2022) find a positive green bond premium. Hachenberg and Schiereck (2018), Baker et al. (2018), Gianfrate and Peri (2019), Zerbib (2019), Immel et al. (2021), on the other hand, find a negative premium.

Another subject in this literature is the relationship between green bonds and other financial markets. The first study by Pham (2016)

shows that there is evidence of time-varying volatility spillover between the green bond market and the aggregate bond market. Reboredo (2018) investigates the dependency structure between green bonds and financial markets. According to findings, green bonds have little diversification advantages for investors in corporate and treasury bond markets but significant diversification benefits for investors in stock and energy markets. Reberedo and Ugolini (2020) also try to assess the link between green bonds and financial markets using a structural vector autoregressive (VAR) model. Their results indicate that the green bond markets are heavily influenced by the global treasury bond and USD currency markets. This market, on the other hand, is only weakly linked to the high-yield corporate bond, stock, and energy markets. Hammoudeh et al. (2020) use the time-varying Granger causality test to study the link between green bonds and other assets such as US conventional bonds, CO2 emission allowances prices, and clean energy markets from 30 July 2014 to 10 February 2020. The authors find substantial causality from the US 10-year Treasury bond market to the green bond market. Furthermore, they find a unidirectional causality link between CO2 emission allowances and the green bond market, as well as the transmission mechanism running from CO2 to green bonds. However, findings show the causality between the clean energy markets and the green bond market is limited. Another study examining the relationship between the green bond market and major traditional financial and energy markets belongs to Ferrer et al. (2021). Their study is closely related to that of Reboredo et al. (2020) but there are some important differences between their

contribution. From a methodological part, Ferrer et al. (2021) use the time-frequency connectedness model, while Reboredo et al. (2020) apply structural VAR. Another difference comes from the geographical areas covered. Reboredo et. al. (2020) focus on only the global market but other authors also include the global market, the European market, and the U.S market. Their empirical findings reveal that the global green bond market and the selected conventional markets are most closely linked in shorter time periods. The strongest connection is seen between the global green bond market and the global Treasury and investment-grade corporate bond markets, as demonstrated by Federer et al. (2021).

Recently, few studies have focused on the link between green equities and green bond markets. The article of Liu et al. (2021) is the first empirical study designed to address the relationship between green bonds and clean energy markets. Their findings reveal that green bonds and sectoral clean energy stock markets have a positive time-varying average and tail dependency. Furthermore, extreme downward or upward movements in the clean energy stock market have an impact on the green bond market, and vice versa. Asymmetric risk spillover also exists between these markets. The other article, by Pham (2021), addresses time frequency connectedness and the cross-quantile dependency between green bonds and green equities and finds a connection between them during normal market times, but not under extreme market conditions. Tiwari et al. (2021) also examine the transmission of return patterns between green bonds, carbon prices, and

renewable energy stocks employing the TVP-VAR approach and show that clean energy dominates all other markets. Lastly, Chatziantoniou et al. (2021) examine dynamic integration and return transmission across four well-established environmental finance indices, namely Green Bond Index, S&P Global Clean Energy Index, Dow Jones Sustainability Index, and World MSCI Global Environment Index using a quantile time-frequency model. Their findings demonstrate that green bonds are the primary net recipient of shocks.

There are very few studies examining the relationship between the clean energy sector and green bond markets. This study aims to examine the link between green bonds and different clean energy sources by using Hafner and Herwartz's (2006) causality in variance test, which has never been used in this empirical literature.

## 3. Methodology

This study utilizes a time-varying causality in variance test of Hafner and Herwartz's (2006) to analyze the volatility spillover between green bonds and clean energy markets. To determine the existence of volatility spillovers, two primary approaches are used in the research. Multivariate GARCH models are the first method. By imposing constraints on specific parameters, the presence of volatility spillovers is investigated. The estimation technique needs several parameter constraints to maintain covariance stationarity, which is why a substantial number of researchers critique MGARCH models. The second model is the causality in variance test which is required a

univariate GARCH model. Two alternative testing strategies have come to the fore in the analysis of volatility spillovers (Atukeren et al., 2021).

The first procedure for a causality-in-variance test was developed by Cheung and Ng (1996) and modified by Hong (2001). These two tests are based on cross-correlation functions of standardized residuals obtained from univariate GARCH estimations. When the volatility processes are leptokurtic, the cross-correlation functions-based Portmanteau test is likely to suffer from considerable oversizing in small and medium samples (Hafner and Herwartz, 2006). Furthermore, the results of cross-correlation functions-based testing are sensitive to the sequence of leads and lags, which brings into doubt the findings' robustness. The volatility spillover test developed by Hafner and Herwartz (2006), which is based on the Lagrange multiplier (LM) concept, solves the shortcomings of Cheung and Ng (1996)'s technique and is incredibly useful for empirical example (Nazlıoğlu et al., 2013).

The null hypothesis of no causality in variance is defined as follows by Hafner and Herwartz (2006)

$$H_0 = Var(\varepsilon_{it} \mid G_{t-1}^{(j)}) = Var(\varepsilon_{it} \mid G_{t-1}) \quad i, j = 1,\ldots\ldots, N, i \neq j \qquad (1)$$

Where $G_t^{(j)} = G_t \mid \sigma\ (\varepsilon_{j\tau}, \tau \leq t)$ and are the residuals from GARCH model. To test $H_0$ consider the model

$$\varepsilon_{j\tau}, = \xi_{it}(\sigma_{it}^2 f t)^{0.5},\ f_t = 1 + z_{jt}'\pi,\ z_{jt} = (\varepsilon_{jt-1}^2,\ \sigma_{jt-1}^2)', \qquad (2)$$

where $\sigma_{it}^2 = \omega_i + \alpha_i\varepsilon_{j,t-1}^2 + \beta_i\sigma_{jt-1}^2$

In equation (2), a sufficient condition for equation (1) is $\pi = 0$, so that the null and alternative hypothesis of the LM test are $H_0$: $\pi=0$, $H_1$:$\pi \neq 0$. The authors propose the following test statistic:

$$\lambda_{LM} = \left( \frac{1}{4} (\sum_{t=1}^{T} (\xi_{it}^2 - 1) z_{jt}^{'} \right) v(\theta_i)^{-1} \left( (\sum_{t=1}^{T} (\xi_{it}^2 - 1) z_{jt} \right) \underline{d} \chi^2(2) \qquad (3)$$

Where:

$$V(\theta_i) = \frac{K}{4T} \left( \sum_{t=1}^{T} (z_{jt} z_{jt}^{'} - \sum_{t=1}^{T} z_{jt} x_{it}^{'} (\sum_{t=1}^{T} x_{it} z_{it}^{'})^{-1} \sum_{t=1}^{T} x_{it} z_{jt}^{'} \right)$$
$$K = \frac{K}{T} (\sum_{t=1}^{T} \xi_{it}^2 - 1)^2 \qquad (4)$$

Hafner and Herwartz (2006) define the steps of the causality in variance test as follows:

1. Estimate a GARCH (1,1) model and obtain standardized residuals $\xi_{it}$ derivatives $x_{it}$ and the volatility process $\sigma_{jt}^2$ entering $z_{jt}$.

2. Regress $\xi_{it}^2$- 1 on $x_{it}^{'}$ and the misspecification indicators in $z_{jt}^{'}$.

3. $\lambda_{LM}$ is equal to T times the degree of explanation ($R^2$ ) of the latter regression.

Looking at the time-varying causality between green bonds and green equities helps us to see if the green bond market may provide safe havens during periods of financial turmoil. For that purpose, we use rolling samples in the GARCH model to construct time-varying LM

statistics. To account for a time-varying causality-in-variance test, the first step is to identify the appropriate rolling sample size. Because the GARCH model estimation requires a high sample size, too small a rolling sample size causes a convergence issue. However, a high rolling sample size may result in a considerable delay in recognizing causality changes. To estimate the rolling sample for the GARCH model, we choose a rolling sample size of 1000 observations (equivalent to 5 years) as a compromise. The time-varying LM test is then calculated for each rolling sample using the Hafner and Herwartz (2006) approach described in steps 1 through 3 above (Erdoğan et al., 2020).

## 4. Empirical Analysis and Discussions

### 4.1 Data

The effects of volatility spillover between clean energy markets and green bonds are investigated in this paper. Nasdaq Clean Edge Green Energy (Nasdaq), S&P Global Clean Energy (Clean), S&P Renewable Energy and Clean Technology (Tech), MAC Global Solar Energy (Solar), ISE Global Wind Energy (Wind), and Global Water (Water) are the clean energy indices. Our daily data is obtained using Bloomberg from August 2011 to March 2022. The returns are computed by subtracting the logarithms of two successive prices:

$$R_t = (\ln P_t - \ln P_{t-1})*100 \quad (5)$$

The descriptive statistics and unit root test results for the eight indexes' daily prices are shown in Table 1. The two indices with the highest variability are Solar and Wilderhill, as indicated by their substantial

standard deviations. The green bond index, on the other hand, has the lowest standard deviation value of 0.309. Negative skewness values indicate that green bonds and other financial markets are skewed to the left. The kurtosis statistics are greater than three, indicating that all of the return series in our sample are fat-tail distributions. At a 1% significance level, the Jarque-Bera (JB) test rejects the null hypothesis of normality. This test shows that none of the series under consideration do not have a normal distribution. Furthermore, the null hypothesis that the series have unit roots is rejected using the Augmented Dickey-Fuller (ADF) test and the series is said to be stationary.

Table 1: Descriptive Statistics and Unit Root Test Results

| | GB | Nasdaq | Clean | Wilderhill | Wind | Water | Tech | Solar |
|---|---|---|---|---|---|---|---|---|
| Mean | -0.01 | 0.01 | -0.02 | -0.02 | 0.02 | 0.00 | 0.005 | -0.04 |
| Median | 0.00 | 0.08 | 0.05 | 0.00 | 0.07 | 0.05 | 0.0 | 0.03 |
| Max | 0.90 | 5.32 | 3.85 | 5.68 | 3.13 | 2.47 | 3.06 | 5.61 |
| Min | -1.26 | -8.07 | -5.53 | -8.54 | -4.45 | -3.89 | -4.14 | -7.24 |
| Std. D. | 0.31 | 1.74 | 1.26 | 1.84 | 1.04 | 0.83 | 0.92 | 1.96 |
| Skewness | -0.37 | -0.52 | -0.42 | -0.43 | -0.43 | -0.58 | -0.37 | -0.35 |
| Kurtosis | 4.15 | 4.67 | 4.56 | 4.46 | 4.35 | 4.69 | 4.99 | 3.90 |
| Jarque-Bera | 217.7 | 450.5 | 364.6 | 333.7 | 295.17 | 485.1 | 523.1 | 152.4 |
| ADF | -35.2 | -19.3 | -17.9 | -18.8 | -14.6 | -26.1 | -23.9 | -32.9 |

ADF stand for the Augmented Dickey Fuller unit root tests

Table 2 shows the correlation matrix for all daily returns. Wind and water energy are the two indexes that have the highest correlation with

the green bond return. Nasdaq Clean enegy, on the other hand, is the index with the lowest correlation with green bonds. Global indices have a higher correlation with each other than sector-based indexes. For example, the correlation between Wilder Hill and Nasdaq Clean Energy is 91 percent, while the correlation between wind energy and clean technology is 43 percent.

Table 2: Correlation Matrix

| | GB | Nasdaq | Clean | Wilderhill | Wind | Water | Tech | Solar |
|---|---|---|---|---|---|---|---|---|
| GB | 1 | | | | | | | |
| Nasdaq | 0.081 | 1 | | | | | | |
| Clean | 0.192 | 0.719 | 1 | | | | | |
| Wilderhill | 0.096 | 0.917 | 0.734 | 1 | | | | |
| Wind | 0.322 | 0.487 | 0.711 | 0.478 | 1 | | | |
| Water | 0.284 | 0.549 | 0.600 | 0.529 | 0.650 | 1 | | |
| Tech | 0.084 | 0.603 | 0.541 | 0.626 | 0.434 | 0.472 | 1 | |
| Solar | 0.101 | 0.773 | 0.794 | 0.801 | 0.515 | 0.487 | 0.505 | 1 |

## 4.2 Empirical results and discussion

We initially estimate the univariate GARCH(1,1) processes to look at the volatility spillover between green bonds and clean energy. The variance equations of the GARCH model estimates are reported in Table 3. We first examine whether the GARCH model's stability criteria, which impose the restrictions $\omega > 0$, $\alpha > 0$, $\beta > 0$, $\alpha + \beta < 1$ are met. The stability criterion is satisfied by all the calculated GARCH models. All calculated coefficients, except for the constant parameter of wind energy, are statistically significant at the 5% level of

significance, according to the results provided in Table 3. The variance equations have positive coefficients. It is important to note that the α parameter represents the persistence of shocks and β is indicative of volatility clustering persistence. The persistence of shocks in clean technology volatility appears to be stronger than other market indexes. Volatility clustering for all series is extremely high.

Table 3: Results for variance equations

| | GB | Nasdaq | Clean | Wilderhill | Wind | Water | Tech | Solar |
|---|---|---|---|---|---|---|---|---|
| w | 0.0004 | 0.02 | 0.012 | 0.019 | 0.009 | 0.01 | 0.083 | 0.014 |
| | (0.041) | (0.019) | (0.01) | (0.044) | (0.11) | (0.02) | (0.011) | (0.07) |
| α | 0.036 | 0.073 | 0.063 | 0.055 | 0.062 | 0.081 | 0.083 | 0.042 |
| | (0.000) | (0.000) | (0.00) | (0.000) | (0.00) | (0.00) | (0.000) | (0.00) |
| β | 0.958 | 0.921 | 0.929 | 0.94 | 0.931 | 0.903 | 0.904 | 0.954 |
| | (0.000) | (0.000) | (0.00) | (0.000) | (0.00) | (0.00) | (0.000) | (0.00) |

Numbers in paranthesis are p-values

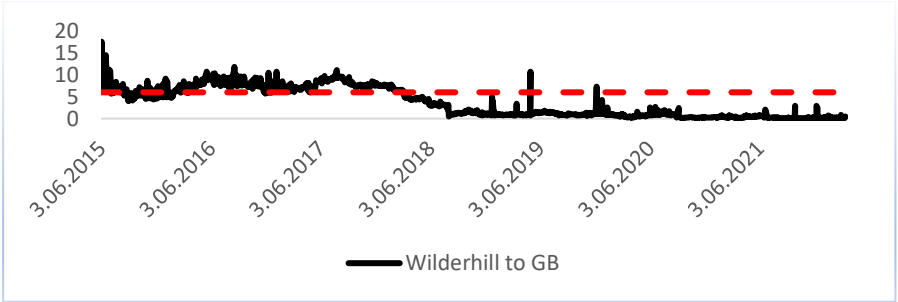
Table 4: Causality-in-variance test results.

| Causality Direction | Test Statistic | P-value |
|---|---|---|
| S&P Clean → GB | 11.915 | 0.002 |
| GB → S&P Clean | 1.45 | 0.484 |
| Wilderhill → GB | 17.169 | 0.002 |
| GB → Wilderhill | 2.974 | 0.226 |
| Nasdaq → GB | 17.481 | 0.000 |
| GB → Nasdaq | 3.808 | 0.149 |
| Wind → GB | 20.217 | 0.000 |
| GB → Wind | 106.338 | 0.000 |
| Technology → GB | 3.143 | 0.207 |
| GB → Technology | 4.505 | 0.105 |
| Solar → GB | 6.825 | 0.033 |
| GB → Solar | 11.178 | 0.003 |
| Water → GB | 15.387 | 0.002 |
| GB → Water | 1.45 | 0.484 |

Table 4 indicates causality relationship between the green bond market and green equities. The null hypothesis of no causality from green bond to clean energy cannot be rejected. The findings of the causality test also suggest that unidirectional volatility spillovers from green bonds to the other two global green equities, namely Wilder Hill and Nasdaq Clean Energy exist. We find, on the one hand, bidirectional volatility spillover between green bond and wind energy as well as green bond and solar energy. On the other hand, there is no evidence of a volatility spillover between green bond and clean technology. Lastly, we observe that there is a unidirectional volatility spillover from water energy to green bonds. Results suggest that clean energy dominates green bonds. This finding is consistent with empirical studies on green bonds and clean energy.

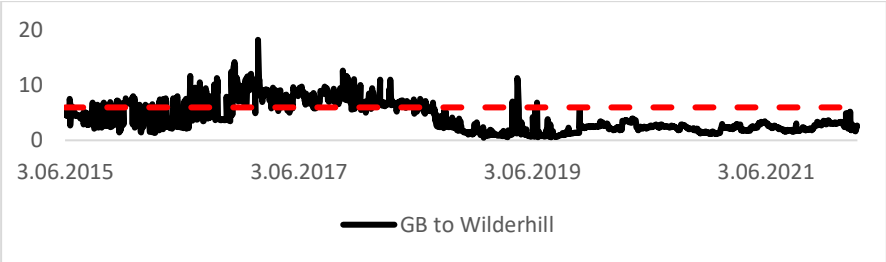
Figure 1: Time-Varying Causality-in-Variance Test Results

(a.1)

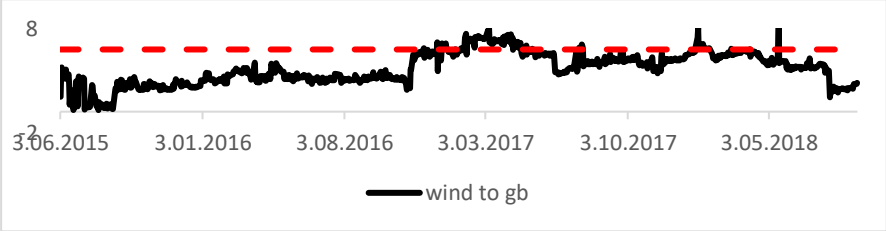



Notes: Dashed lines indicate the critical values at the 5% level.

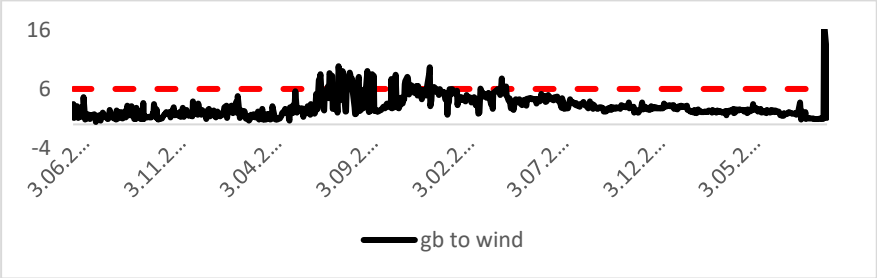
(a.2)


20
10
0
3.06.2015
3.06.2017
3.06.2019
3.06.2021
GB to Wilderhill

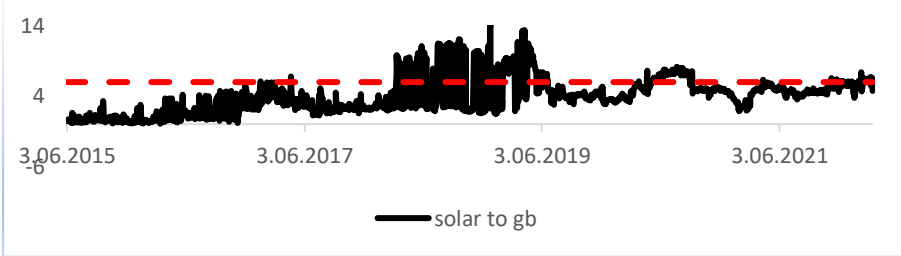
(b.1)


8
-2
3.06.2015
3.01.2016
3.08.2016
3.03.2017
3.10.2017
3.05.2018
wind to gb

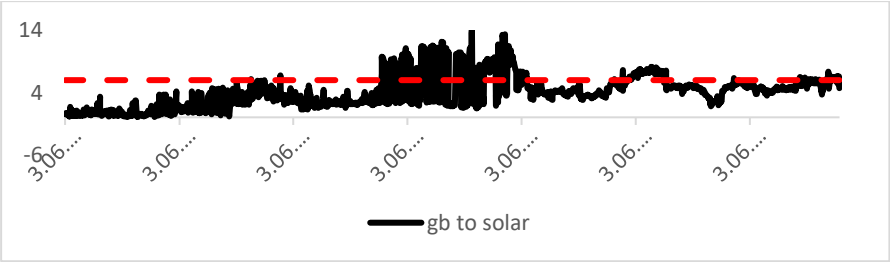
(b.2)


16
6
-4
3.06.2...
3.11.2...
3.04.2...
3.09.2...
3.02.2...
3.07.2...
3.12.2...
3.05.2...
gb to wind

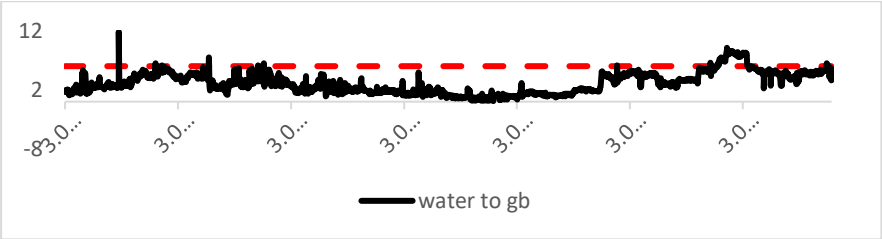
(c.1)


14
4
-6
3.06.2015
3.06.2017
3.06.2019
3.06.2021
solar to gb

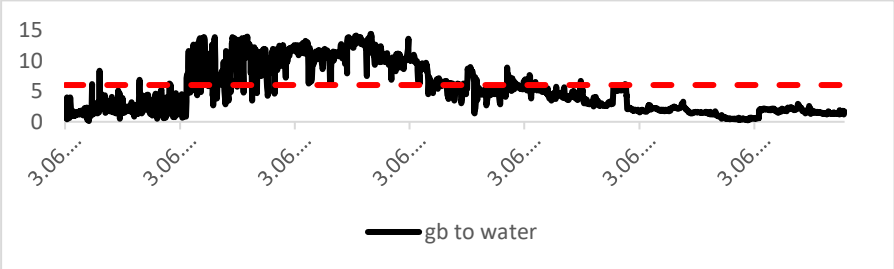
(c.2)


14
4
-6
3.06....
3.06....
3.06....
3.06....
3.06....
3.06....
3.06....
gb to solar

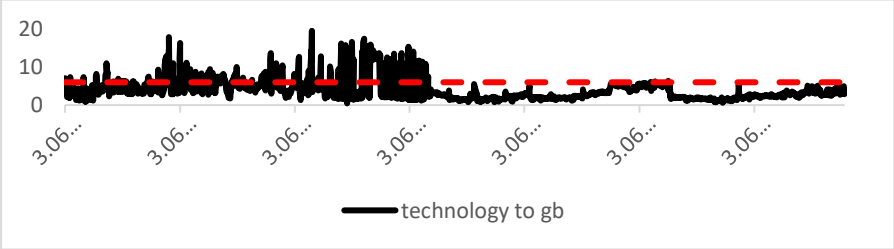
(d.1)


12
2
-8
3.0...
3.0...
3.0...
3.0...
3.0...
3.0...
3.0...
water to gb

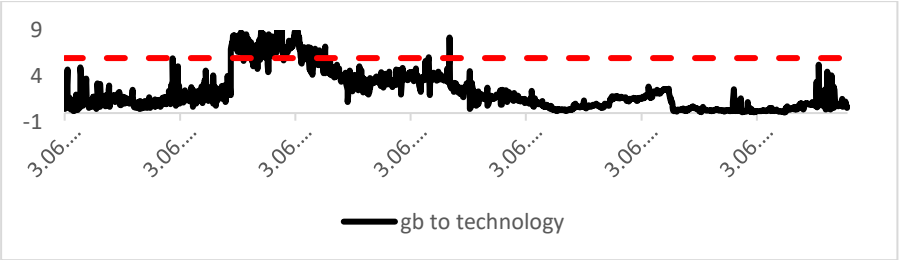
(d.2)


15
10
5
0
3.06....
3.06....
3.06....
3.06....
3.06....
3.06....
3.06....
gb to water

(e.1)


20
10
0
3.06...
3.06...
3.06...
3.06...
3.06...
3.06...
3.06...
technology to gb

(e.2)




Financial markets are widely recognized for showing consistent increases or decreases over time, with linkages between them also changing over time. Financial crises also induce structural breaks, thus the link between markets can change over time, from pre-crisis to post-crisis. Finally, investor behavior may demonstrate limited rationality, resulting in time-varying linkages between stock markets. As a result, it is crucial to look at the time-varying linkages between the green bond and clean energy markets (Bugan et al., 2022). When we compare constant and time-varying Hafner and Herwartz (2006) test, a distinct picture emerges from the time-varying causality-in-variance tests. For instance, we find that there is no causal relation between green bond and clean technology. However, the findings of the time-varying test in panel (e.1) and (e.2) of Figure 1 demonstrate a different story, since the null hypothesis of no volatility spillover from green bond to clean technology or vice versa is rejected at different times. In 2015-2018, it can be seen that there is a volatility spillover from clean technology to green bonds. It can also be observed the volatility spillover effect from green bond to clean energy in 2017. However, in constant granger causality analysis, we find a bidirectional relationship between solar

energy and green bonds, while in the rolling causality test, we observe that there is no causality between them in spesific periods. Before 2020, there are directional spillovers between green bonds and green stocks. During the COVID-19 pandemic, this spillover effect between them disappeared. In the meantime, At the beginning of COVID-19 pandemic, there are bidirectional causality between green bond and solar energy and unidirectional causality from global water returns to green bond returns. As a result of the crisis, these financial markets are becoming more contagious. However, our findings imply that, in general, green bonds can provide hedging advantages to a green equities' portfolio, especially during times of crisis.

This study holds an implication for investors. They can utilize green bonds as an alternative tool for portfolio diversification, especially in times of crisis.

## 5. Conclusion

Even though green bonds are a relatively new asset class for market participants, policymakers and environmentally friendly investors have paid close attention to this market. Because concerns about energy sustainability and climate change mitigation have increased worldwide as a result of the major economic and social problems associated with energy security and environmental degradation.

The green bond market grew at a slightly slow rate at first. In the preceding five years, though, it has increased by more than 50%. It is possible to collaborate with more stakeholders in the clean energy

sector to promote its development. Renewable energy stocks have emerged as a prominent participant in this growing market, but their important effect and role in the green bond market has received little attention. This study addresses the relationship between green bonds and clean energy markets. We use constant and time-varying Hafner and Herwats (2006) Granger causality analysis to evaluate the link between these variables. In general, the findings of the causality-in-variance test show that there is a volatility spillover effect from clean energy markets to the green bond market. On the one hand, evidence for a bi-directional linkages between solar energy and green bond as well as wind energy and green bond. On the other hand, there is no evidence of a connection between green bonds and Clean Technology. Our findings indicate that clean energy market dominate the green bond market. This paper confirms studies examining the relationship between green bonds and clean energy (Liu et al. 2021, Pham 2021) when we apply constant Hafner and Herwats (2006) Granger causality analysis. However, our rolling granger causality test find different results comparing these papers. We do not find any evidence the financial contagion between green bonds and clean energy excluding solar energy and water return series during extreme conditions.

There are few studies that look at the connection between renewable energy and green bond markets. This paper contributes the literature studying the relationship between green bonds and various clean energy sources using Hafner and Herwartz's (2006) causality in variance test, which has never been utilized before in the empirical literature.

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# CHAPTER 4

## ANALYSIS OF THE ENTREPRENEURIAL ENVIRONMENT AND ATTITUDES IN HUNGARY[1]

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## INTRODUCTION

Understanding the business environment and attitudes towards entrepreneurship at the economic and social levels is of paramount importance because businesses can create the value that our economies and communities need. The capacity of enterprises to develop and their willingness to innovate can contribute to solving many economic, environmental, and social problems. A deeper understanding of the current state of entrepreneurs and the business environment can be a useful insight and resource for policymakers. As a result of Jackson and Rodkey's (1994) research, it should be stressed that successful enterprises are essential to the functioning of the market economy and also play a significant role in job creation.

Entrepreneurial attributes, the different types of motivation, are a key determinant of the success of enterprises and determine it, as well as involving the creation, definition, and distribution of value. Entrepreneurship can also be understood as a human creative act, as Timmons and Spinelli (2003) argue. People with the 'right' competencies and motivation are capable of starting and running enterprises.

Different definitions have been given to defining entrepreneurial attitudes. According to one interpretation, attitude is a mental and nervous state of readiness organized through experience, which exerts a dynamic or directive influence on the individual's response towards the objects and situations to which the attitude applies (Rozgonyi, 2001). These approaches show that attitude is formed and reinforced by

experience, is a kind of mental representation, and reflects our value judgments about an object. Thus, in our case, we consider the attitude towards entrepreneurship (as an object) as an attitude. According to Wardana et al. (2020), entrepreneurial attitudes are nothing more than individual responses to existing opportunities, information, criticisms, and events.

Measuring entrepreneurial attitudes is in practice a complex process, including the collection of data for regional-level analyses. Little empirical research has focused on regional culture and the measurement of entrepreneurial attitudes (Kangasharju, 2000), one reason being the lack of measures that can adequately represent entrepreneurial activity. Attitude is essentially a combination of initiative, will, innovation and motivation, and is closely related to entrepreneurial competencies. Both entrepreneurial attitudes and self-employment competencies are important for future entrepreneurs.

## 1. APPROACH TO COMPETITIVENESS, COMPETITIVENESS THEORIES

There are many ways to approach competitiveness, as many experts have done over the decades. It is often mentioned in parallel with modernity and innovation. For some, the definition appears as a measure of entrepreneurial or even economic development. However, it can also interact with several economic terms such as economic growth; market position, awareness; the success of the business, and supply-demand ratio. The scientific definition of competitiveness began

in the early 1980s. It can be linked to the establishment of the President Reagan Commission on Industrial Competitiveness, which was set up by US President Reagan to propose a solution to a problem of the time, namely how to reinvigorate the weakened market position of the United States (Lengyel, 2003).

If we look at the approach of the classical economists, in this case, the names of Heckscher, Smith, Ohlin, Ricardo, and Krugman can be mentioned. The theories; trends that they represent had as their primary aim to try to clarify or define the concept as precisely as possible. In addition to the economics approach to competitiveness, the economics approach also emerged in the 1990s. This type of approach proposes ways to develop and improve competitiveness, as opposed to the approach of the other school of thought, which was to clarify conceptual problems (Lengyel, 2003). The development of competitiveness research is based on macroeconomics and international economic theories. They focus primarily on the factors that influence the development of international trade. Their explanatory theories focus on comparative advantage and demand and supply side factors (Gyuris, 2007).

In addition to the concept of comparative advantage, several other theories have been developed to define competitiveness. One of these theories is Krugman's view that the concept of competitiveness can not be applied to national economies, but only to the level of the firm (Krugman, 1994). In line with Krugman's thinking, competitiveness is most tangible and measurable in the firm and industry contexts, and we

should focus on understanding these. However, to understand what is going on in the competitive sphere and to get an overall picture of what competitiveness means in a given sphere and what are the most influential factors, we need to carry out regular observations, monitoring, and analysis.

## 2. THE ENTREPRENEURIAL ECOSYSTEMS, THEIR INNOVATIVE APPROACH

The idea of ecosystems appeared relatively early in economics, but the first real ecosystem model was published only in 1982 (Nelson & Winter, 1982). Studies to establish the basis for ecosystem thinking appeared in the 1980s and 90s when the focus of entrepreneurship research became the individual as an entrepreneur (Csákné, 2012). The ecosystem, or entrepreneurial environment, is closely related to strategy and regional development (Acs et al., 2017). The foundational studies on ecosystems first analyzed the social and economic impact of regions on entrepreneurship. It should be emphasized that businesses are part of an ecosystem and should not be considered in isolation (Csákné & Radácsi, 2020a; Csákné & Radácsi, 2020b).

The following definition is typically accepted in the literature: an entrepreneurial ecosystem is a coordinated set of independent actors and factors that result in a defined area of opportunity for competitive enterprises Stam (2015). Cavallo et al (2018) emphasize that delineating the boundaries of an ecosystem is crucial both in research and in practice. It is necessary to study the entrepreneurial environment

of countries, regions, counties, cities, or incubators depending on the focus of the research (Acs et al., 2017). When studying ecosystems, a significant consideration is whether the focus is on the entire environment or whether it is worth narrowing down the area to be analyzed. Isenberg (2010) also points out that the local ecosystem is crucial for the development of a business, and that ecosystem development can be effectively implemented by adapting it to local specificities, local culture, and needs.

### 2.1. The Hungarian approach to entrepreneurial ecosystems

We often see opinions in professional circles and in brand communication of organizations that there are strong entrepreneurial ecosystems in Hungary, but recent research shows that these are not detectable based on facts. Tóth-Pajor and Farkas (2017) used Lagrange multiplier tests (spatial econometric modeling) to confirm that there is a significant entrepreneurial activity in Budapest and Central Hungary, but unfortunately, the productivity of firms lags. In terms of the number of firms, capital is the center of entrepreneurship, but the number of firms with high capital efficiency is low (Radácsi & Csákné, 2020). According to Tóth-Pajor and Farkas (2017), in their study of entrepreneurial ecosystems, we did not find a region in the Hungarian economy where productive firms are concentrated.

The existence of Hungarian higher education institutions is not correlated with regionally interpreted indicators of entrepreneurial efficiency (Tóth-Pajor & Farkas, 2017). Among the results of Szerb's (2017) research, he highlights that the weaknesses of Hungarian

entrepreneurial ecosystems are the ability to recognize opportunities and identify them, which is based on creativity and independent thinking. In this research, he characterized the Hungarian entrepreneurial environment, and based on the results of his study, he made recommendations for entrepreneurship policy. The education system, enterprise development institutions, and incubators in higher education institutions can be responsible for its development, but the effects in this area can only be felt in the very long term. S. Gubik, A (2021)

## 3. ENTERPRISES IN HUNGARY

Table 1 shows the number of registered partnerships in Hungary from January 2020 to September 2021 and includes registered partnerships. The COVID-19 pandemic had a significant impact on businesses and many went bankrupt and ceased trading, but despite this, the indicators still increased. Looking at the two periods, we also see that the number of registered businesses increased from January to September 2021 compared to the previous period. The table is also interesting from a competitive point of view, as these figures represent that despite the virus, there is demand for different products and services, as well as unmet market needs, so it is worthwhile to start a business. They also show that entrepreneurship is growing in the country and that the entrepreneurial sector is such that it is worth starting a business. The business performance and activity of newly created enterprises will have an impact on output, and hence GDP. As a consequence, the country's competitiveness will also increase, as more opportunities for

consumption will be created, more companies may decide to enter the international market and all this will strengthen the domestic economy.

**Table 1.** Number of registered enterprises in Hungary 2020-2021

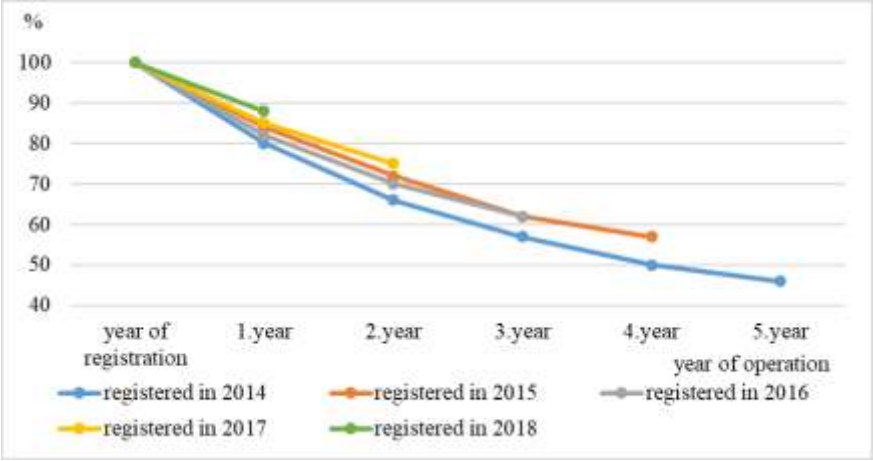
| | | Registered co-owned enterprises | Registered independent enterprise | Rotal registered enterprises | Total registered enterprises as a % of the previous period |
|---|---|---|---|---|---|
| 2020 | January | 514 470 | 1 283 198 | 1 797 668 | |
| | February | 514 219 | 1 286 727 | 1 800 946 | |
| | March | 513 409 | 1 286 393 | 1 799 802 | |
| | April | 512 027 | 1 286 885 | 1 798 912 | |
| | May | 510 737 | 1 286 706 | 1 797 443 | |
| | June | 509 768 | 1 288 236 | 1 798 004 | |
| | July | 509 846 | 1 291 751 | 1 801 597 | |
| | August | 510 379 | 1 295 125 | 1 805 504 | |
| | September | 510 868 | 1 298 879 | 1 809 747 | |
| | October | 511 998 | 1 300 123 | 1 812 121 | |
| | November | 512 976 | 1 300 444 | 1 813 420 | |
| | December | 514 481 | 1 295 875 | 1 810 356 | |
| 2021 | January | 516 060 | 1 298 953 | 1 815 013 | 101,0 |
| | February | 517 833 | 1 303 268 | 1 821 101 | 101,1 |
| | March | 519 405 | 1 305 655 | 1 825 060 | 101,4 |
| | April | 520 910 | 1 308 909 | 1 829 819 | 101,7 |
| | May | 522 476 | 1 312 653 | 1 835 129 | 102,1 |
| | June | 523 602 | 1 316 975 | 1 840 577 | 102,4 |
| | July | 524 921 | 1 317 825 | 1 842 746 | 102,3 |
| | August | 526 126 | 1 320 924 | 1 847 050 | 102,3 |
| | September | 526 932 | 1 325 441 | 1 852 373 | 102,4 |

Source: Own compilation based on Hungarian Central Statistical Office

If we look at businesses over 10 years, the time-series statistics show that the number of active businesses has increased by 25.4% over 10

years. If we also look at the deeper context of the time series analysis, we see that the number of businesses has been on a downward trend between 2010 and 2013 (the post-global crisis period), and then a steady increase from 2015 onwards. The growth dynamics accelerated after 2016. The year-on-year variation is around 10%. The most attractive region for firms is the capital, with the highest number of active firms in 2020 and a 24% growth in 6 years to 2020.

**Figure 1.** The annual survival rate of newly registered enterprises in Hungary 2014-2018




Source: Own compilation based on Hungarian Central Statistical Office

The economic recovery of recent years has improved the survival of newly created businesses (Figure 1). The proportion of businesses surviving their first year of operation has risen from 79% in 2015 to 88% in 2019, but survival rates have also typically improved later in their life cycle. Of the domestic operating businesses with 10 or more employees, 4.4 thousand (0.5% of the total) were classified as fast-growing in 2019, i.e. those that have grown their number of employees

by more than 10% per year on average over the last three years. Their number decreased by 131 in 2 years. Most of them (96%) were partnerships and around two-thirds were engaged in industrial, commercial, construction, or transport and storage activities. The share of fast-growing enterprises fell most from a year earlier in the industrial (manufacturing) sector but remained the highest (1.7%).

## 4. RESEARCH METHODOLOGY OF GLOBAL ENTREPRENEURSHIP MONITOR (GEM)

The Global Entrepreneurship Monitor (GEM) is the world's most comprehensive survey of entrepreneurial activity, with several countries collecting data every year since 1999, with a solid methodological basis. In 2021, a total of 50 countries (representative population survey in 47 countries, expert interviews in 50 countries) participated in the survey. From the outset, countries participating in the GEM have helped to understand the link between entrepreneurship and national economic development by answering the following questions:

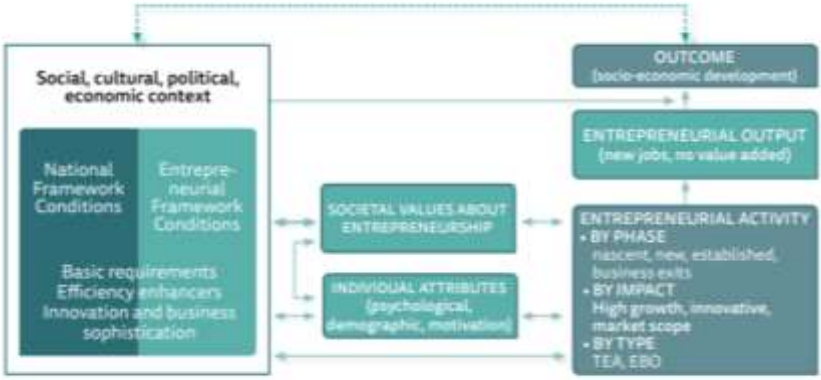
- Does the level of entrepreneurial activity differ between countries, and if so, to what extent?
- Does the level of entrepreneurial activity affect the rate of economic growth and prosperity of countries?
- What makes a country an entrepreneurial country and what factors influence entrepreneurial activity?

The GEM conceptual framework aims to describe the link between entrepreneurship and national economic development as precisely as possible. To this end, it aims to meet the following objectives: (1) Enable comparisons of the level of entrepreneurship between different countries, geographical regions, and levels of economic development. (2) Enable the identification of the extent to which entrepreneurship influences economic growth within each economy. (3) Contribute to the identification of factors that stimulate and/or discourage entrepreneurship (in particular the links between national entrepreneurial framework conditions, social values, personal characteristics, and entrepreneurship). (4) Ensure the monitoring of entrepreneurial attitudes, activities, and aspirations within countries, providing the basis for the preparation of an annual national assessment of the entrepreneurial sector. (5) Support the development of effective and targeted policies to enhance the entrepreneurial capacity of countries.

The GEM conceptual framework (Figure 2) is based on the idea that economic growth is the result of individuals' ability to identify and seize business opportunities. Individuals' decisions to start an entrepreneurial activity are influenced by environmental factors in addition to their skills and knowledge. The determinants of entrepreneurship are the individual's perception of opportunity and ability (motivation and skills) to take advantage of that opportunity, and the environment around the individual. Within the conceptual framework of GEM, the entrepreneurial framework describes the environment that influences

entrepreneurial activity, which then feeds back to the environment through social values and economic development (Csákné et al., 2022)

**Figure 2.** Conceptual framework of Global Entrepreneurship Monitor




Source: Csákné et al. 2022

The GEM provides a clear and consistent definition of entrepreneurial activity (economic activity carried out for, or in pursuit of, a business activity that generates or leads to the generation of income and wealth) and a well-established methodology for measuring and evaluating entrepreneurial activity, laid down in the conceptual framework. In each of the countries participating in the survey, the National Team is responsible for conducting the data collection and analyzing the data. The data collection consists of two complementary surveys. The Adult Population Survey (APS) examines the characteristics, motivations, ambitions, and social attitudes towards entrepreneurship of those who start a business. The National Expert Survey (NES) collects the assessments of at least 36 experts, validated by the GEM Data Team, on the framework conditions for entrepreneurship.

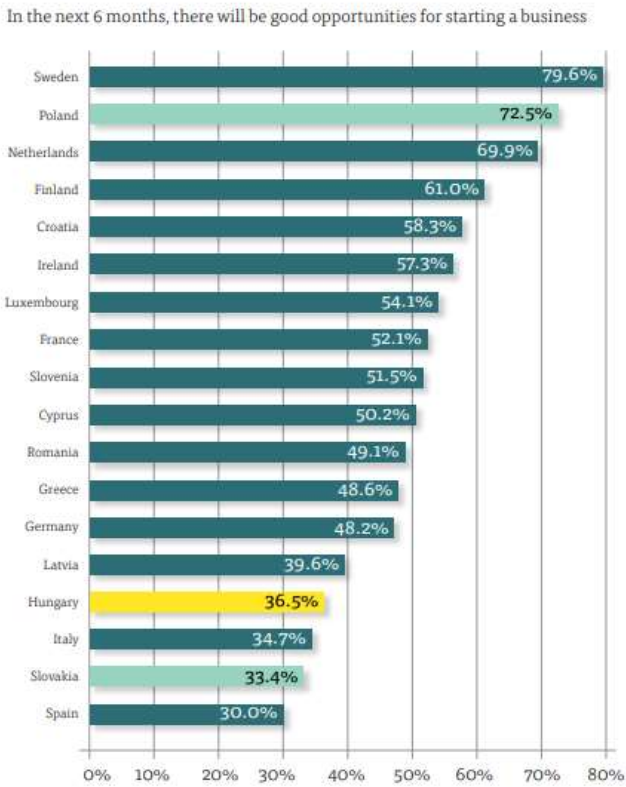
Countries in the GEM survey and their categorization Countries in the GEM data collection are categorized according to World Bank data, based on the income thresholds defined by the GEM: (1) Low-income countries, where GDP per capita is less than USD 20,000 (e.g. Brazil, Egypt, India, Iran). (2) Middle-income countries, where GDP per capita is between USD 20,000 and USD 40,000 (e.g. Hungary, Poland, Russia, Greece, Romania) (3) High-income countries, where GDP per capita is higher than USD 40,000 (e.g. USA, UK, UAE, Japan, Canada, Switzerland). In the global survey, in which renowned universities from all over the world participate, the Budapest University of Economics and Business will represent Hungary from 2020. The first data collection in Hungary since 2016, now managed by the BGE Budapest LAB Business Development Office, took place in 2021. The survey involved a representative questionnaire survey of 2014 adults aged 18-64 and 36 selected experts (Csákné et al., 2022).

The GEM system distinguishes three stages of the entrepreneurial life cycle. Start-ups and existing enterprises that have been paying wages for up to 3 months and are in the process of starting up are classified as nascent. Under the GEM scheme, new entrepreneurs have been paying wages for at least 3 months but less than 42 months (3.5 years). The third group is made up of entrepreneurs with more than 42 months (3.5 years) of wages paid, these are the established enterprises. The GEM defines the economic activity of births and start-ups as early-stage entrepreneurial activity, which is measured by the Total Early Stage Entrepreneurial Activity (TEA) indicator.

## 4.1. Some results of the GEM research in international comparison

Hungary ranks in the middle of the pack in terms of the frequency of personal contact with entrepreneurs, compared to the EU Member States participating in the GEM survey in 2021 and the Visegrad countries participating in the survey (Figure 3).

**Figure 3.** Perception of entrepreneurship as an opportunity from an international perspective

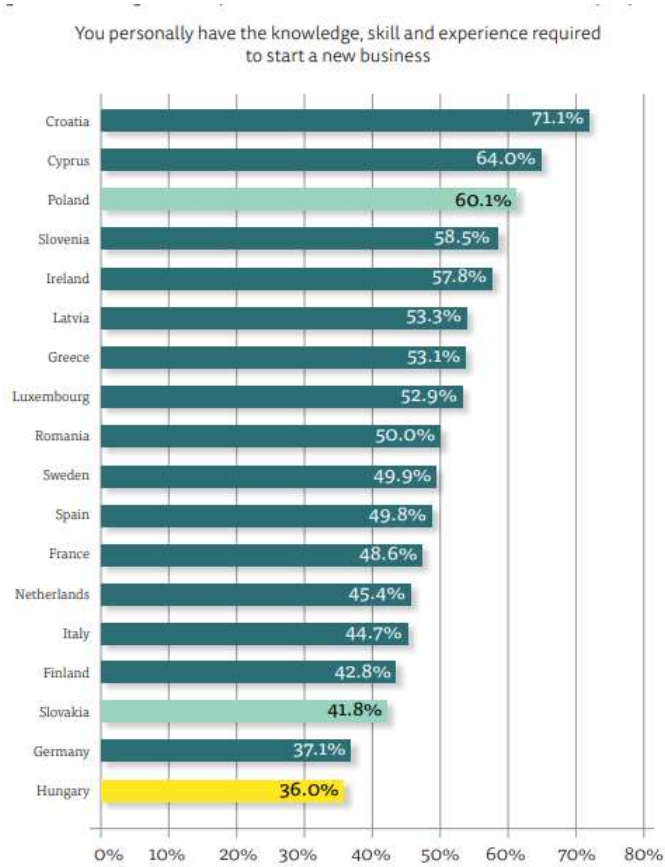



Source: Csákné et al. 2022

Otherwise, the data do not reveal a pattern typical of EU countries in general. Neither the countries at the top of the list in international

comparisons (Cyprus, Croatia, Finland), where almost two-thirds of respondents have a personal relationship with an entrepreneur, nor the countries at the bottom of the list, where only one-third of respondents know an entrepreneur personally (Greece, Romania, Spain), form a coherent group, either regionally or economically. (Csákné et al., 2022) The three Visegrad countries in the survey do not show a consistent picture for starting a business in the next six months. In Hungary, only a third of the population (36.5%) think it is a good idea to start a business in the next six months, a lower proportion compared to the EU and Visegrad countries. In Slovakia, the propensity to start a business is even lower, placing both countries in the bottom third of the list. By contrast, Poland has gained a very respectable position with a score of 72.54%. In terms of knowledge, skills, and experience needed to start a business (Figure 4), there are essentially no regional or economic development clusters in the EU, with Croatia (71.1%), Cyprus (64%), and Poland (60.1%) leading the ranking. In Hungary, a third of respondents (36%) think that they have the knowledge, skills, and experience necessary to start a business, which unfortunately puts Hungary at the bottom of the list at the EU and regional levels. The data does not support the view that fear of failure is the reason for low entrepreneurship in Hungary, with a low proportion of people (38.2%) not starting a business due to fear of failure compared to the international average. The results for the Visegrad countries in the survey are polarised, with Poland (60.1%) ranking third among the best performing economies, Slovakia in the bottom third with 41.8%, and Hungary (36%) in last place.

**Figure 4.** Knowledge, skills, experience, and fear of failure from an international perspective




Source: Csákné et al. 2022

The GEM National Expert Survey (NES) provides the basis for the analysis of the entrepreneurship ecosystem across countries, while the National Entrepreneurship Context Index (NECI) provides a cumulative measure of the comparability of the entrepreneurship ecosystem across countries. The NECI (National Entrepreneurship Context Index) is an aggregate indicator of the average state of the entrepreneurial environment in the participating economies, calculated

based on NES data. It combines into one number the 13 national entrepreneurship framework conditions identified by GEM researchers as the most reliable determinants of a favorable environment for entrepreneurship. Thus, the EFCs (Entrepreneurial Framework Conditions) encapsulates the conditions that enhance (or inhibit) the creation of new businesses in an economy. Hungary, with a NECI score of 4.5, ranks almost exactly in the middle of the GEM survey countries, in 27th place. The ranking is spread over a wide spectrum, with the top positions being occupied by the world's advanced economies (United Arab Emirates, Netherlands, Finland, USA, Germany, Canada), while at the other end of the ranking we find countries with lower economic development (Sudan, Iran, Guatemala). The ranking shows a strong correlation between the economic performance of a country and the development of its entrepreneurial ecosystem. This is consistent with Hungary's position in the middle of the ranking.

It is worth underlining that the link between economic performance and the assessment of the development of the entrepreneurial ecosystem is far from clear. There are several examples of countries with a much more favorable expert assessment of entrepreneurial ecosystems (e.g. the Netherlands, Finland, Norway) than countries with better economic performance (e.g. the USA, Germany). There are also countries with better economic performance than the NECI ranking, e.g. Croatia, and Romania. The European average NECI score is 4.9 points, placing Hungary in the lower-middle group in this ranking.

## SUMMARY

The objective of our study was to present an outstanding international entrepreneurship survey (GEM) and to examine the entrepreneurial ecosystem in Hungary. In the early 2000s, the focus of the research was on entrepreneurial activity, but nowadays, attitudes and entrepreneurial aspirations have also become increasingly important. This has gradually led from a one-dimensional view and analysis of entrepreneurship to a more complex, multidimensional perspective on entrepreneurship.

In our study, we illustrated the logical framework of the GEM, gave an insight into the global economic situation, shed light on the changes in GDP in terms of the impact of the epidemic, and also discussed the results in Hungary. In our business demography, we have made findings concerning a ten-year time series study and pointed out the correlations between business survival rates and the distribution of fast-growing businesses by industry. It should be stressed that the study sample is representative only of the adult population aged 18-64 by gender and age. It was important for us to shed light on the conceptual framework of competitiveness in the context of several academic works and theoretical approaches. We introduced a novel approach to the entrepreneurial ecosystem, followed by a presentation of the Hungarian perceptions, and then the international results of the GEM research, which also focuses on exploring, identifying, describing, and then capturing the entrepreneurial ecosystem in a National Entrepreneurship Context Index (NECI index).

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# CHAPTER 5

## EXCHANGE RATE IMPACT ON THE BIST-30 INDEX: VAR ANALYSIS APPROACH

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## INTRODUCTION

The process of globalization has given investment instruments a universal character. With the liberalization of markets and technological advancements, the sensitivity of financial markets to exchange rates has increased. As a result, financial system decision-makers examine both the movements of investment instruments and the effects of investment instruments on one another.

Individuals can manage risks more effectively if they understand the relationship between exchange rates and stock prices. Conversely, the relationship between exchange rates and stock prices is important in publicly traded companies and countries that expand sectors. Changes in economic data have an impact on many variables, particularly the stock market. The rise in unemployment, decline in industrial production, rise in interest and credit costs, and rise in exchange rates all have a negative impact on the stock market. The companies in the Borsa Istanbul 30 Index and their fields of activity are listed in Table 1.

**Table 1: The BIST-30 Companies**

| No | Code | Company Name | Sector |
|---|---|---|---|
| **1** | AKBNK | Akbank T.A.Ş | Banking |
| **2** | ARCLK | Arçelik A.Ş. | Durable Consumption |
| **3** | ASELS | Aselsan Elektronik Sanayi ve Ticaret A.Ş. | Electronics for Defense |
| **4** | BIMAS | BIM Birleşik Mağazalar A.Ş. | Retail Trade |

| | | | |
|---|---|---|---|
| **5** | DOHOL | Doğan Şirketler Grubu Holding A.Ş. | Holding Company |
| **6** | EKGYO | Emlak Konut Gayrimenkul Yatırım Ortaklığı A.Ş. | Real Estate |
| **7** | EREGL | Ereğli Demir Çelik Fabrikaları T.A.Ş. | Steel and Iron |
| **8** | FROTO | Ford Otomotiv Sanayi A.Ş. | Automotive |
| **9** | GARAN | Türkiye Garanti Bankası | Banking |
| **10** | GUBRF | Gübre Fabrikaları T.A.Ş. | Chemistry |
| **11** | SAHOL | Hacı Ömer Sabancı Holding A.Ş. | Holding Company |
| **12** | KRDMD | Kardemir Karabük Demir Çelik Sanayi ve Ticaret A.Ş. | Steel and Iron |
| **13** | KCHOL | Koç Holding A.Ş. | Holding Company |
| **14** | KOZAL | Koza Altın İşletmeleri A.Ş. | Mining |
| **15** | KOZAA | Koza Anadolu Metal Madencilik İşletmeleri A.Ş. | Mining |
| **16** | PGSUS | Pegasus Hava Taşımacılığı A.Ş. | Transportation |
| **17** | PETKM | Petkim Petrokimya Holding A.Ş. | Petrochemical |
| **18** | SASA | Polyester Sanayi A.Ş. | Textile |
| **19** | SISE | Türkiye Şişe ve Cam Fabrikaları A.Ş. | Holding Company |
| **20** | TAVHL | TAV Havalimanları Holding | Transportation |
| **21** | TKFEN | Tekfen Holding A.Ş. | Holding Company |
| **22** | THYAO | Türk Hava Yolları | Transportation |
| **23** | TOASO | Tofaş Türk Otomobil Fabrikası A.Ş. | Automotive |
| **24** | TUPRS | Türkiye Petrol Rafinerileri A.Ş. | Petrochemical |

| | | | |
|---|---|---|---|
| **25** | TTKOM | Türk Telekomünikasyon A.Ş. | Telecommunication |
| **26** | TCELL | Turkcell İletişim Hizmetleri A.Ş. | Telecommunication |
| **27** | HALKB | Türkiye Halk Bankası | Banking |
| **28** | ISCTR | Türkiye İş Bankası A.Ş. | Banking |
| **29** | VESTL | Vestel Elektronik Sanayi ve Ticaret A.Ş. | Durable Consumption |
| **30** | YKBNK | Yapı ve Kredi Bankası A.Ş. | Banking |

The methodology handles the relationship between stock prices and exchange rates in two ways. The portfolio balance approach is one of them, and the traditional approach is another. The traditional approach explains that the direction of the relationship between the series is from the exchange rate to the stock prices. According to the traditional approach, exchange rates are influenced by current account performance and thus affect real economic variables. The traditional approach works differently depending on the country's export and import weight. A fall in the exchange rate in an export-dominated country has a negative impact on the stock market. In an import-dependent country, a decrease in the exchange rate benefits the stock market.

The portfolio balance approach acknowledges that stock prices affect the exchange rate. Foreign capital inflows increase as stock prices continue to rise, according to this theory. However, a drop in stock prices reduces demand for money and causes interest rates to fall, causing the currency to depreciate. As a result, in the portfolio balance

approach, there is a negative connection between stock prices and currency rates.

Many scholars have researched the relationship between Turkish stock prices and exchange rates. The relationship between the BIST-30 index and the USD/TL, EUR/TL, and GBP/TL parities was explored in this study using data from January 1999 to March 2022.

## 1. LITERATURE

Many studies have been conducted to investigate the relationship between stock prices and exchange rates, both of which contribute to the economies of countries. The causality relationship between the variables, as well as the existence of short or long-term connections, were tested in the analyses. The results obtained in the studies in the literature differ from country to country, and different results have been obtained in different analyses for the same country. The reasons for this include the date range examined, the econometric methods used, and the characteristics of the countries' financial market structures.

### 1.1. Studies On The Relationship Between The BIST Index And The Exchange Rate

Kendirli and Çankaya (2016) investigated the causality relationship between monthly and daily closing prices using USD/TL and BIST-30 index data from 2009 to 2014. First, a unit root test was run on the

variables whose natural logarithm was used, and then a Granger causality test was run using a VAR model. According to the findings, there is no Granger causality relationship between USD/TL and the BIST-30 index based on monthly closing prices, but USD/TL parity has a 5% and 10% effect on the BIST-30 index based on daily closing prices.

Doğru and Recepoğlu (2014) investigated the existence of a linear and nonlinear cointegration relationship between the BIST stock price index and the EUR/TL and USD/TL exchange rates in Turkey using monthly time series data from 1980 to 2012. The linear cointegration relationship was examined using the Pesaran, Shin, and Smith (2001) test, while the nonlinear cointegration relationship was examined using the Breitung (2001) rank test. The examinations revealed a long-term relationship between exchange rates and stock prices in Turkey, as well as the effect of exchange rates on stocks.

Ceylan and Şahin (2015) examined the relationship between USD/TL and BIST index prices with a time series using monthly data from 2006M1 to 2015M4. Following the ADF unit root test, the Johansen cointegration test and error correction model were used. According to the results of the vector error correction model, there is a significant unidirectional causality from USD/TL parity to the BIST index.

Akdağ and Yıldırım (2019) investigated whether there is a causal relationship between positive and negative shocks in the USD/TL exchange rate and the BIST Industry and BIST Finance indexes. The

Granger causality and Hatemi-J (2012) asymmetric causality tests were utilized in the study, which utilized daily data from 2000 to 2018. The analyses revealed that positive and negative shocks in the USD/TL rate in both the Granger and Hatemi-J causality tests influence the BIST industry and finance indices. On the other hand, no connection has been observed between the USD/TL rate of the BIST industry and finance indexes.

Albeni and Demir (2005) analyzed the relationship between the BIST financial sector index and the exchange rate in their article, using data from 1991 to 2000. The least squares method was utilized in the study as part of the time series analysis, and the findings of the regression analysis revealed a negative link between the exchange rate and the BIST financial sector index.

Uğur and Bingöl (2020) in their analysis, examined daily data from the BIST sectors index and the USD-EUR currency basket variables from 2000M1 to 2017M8. To evaluate the series' stationarity, the frequency distribution causality test was done after the ADF and PP unit root tests. The study discovered that there is a causal association between stocks and exchange rates in the Turkish economy. As a result, it has been determined that the portfolio balancing technique applies to the Turkish economy.

Altıntaş and Tombuk (2011) used VAR analysis and the Granger causality approach to examine whether there is a relationship between BIST stock price and growth, money supply, total foreign currency

reserves, and exchange rate variables between 1987 and 2008. According to the findings, a long-term relationship exists between stock prices and growth, exchange rate, and international reserves. Furthermore, a positive association between stocks and exchange rates has been discovered.

Akkum and Vuran (2005) analyzed the macroeconomic factors that affect the returns of companies in the BIST-30 index using monthly data from 1999 to 2002 in their article. The study also looked at the financial, industrial, and service sectors. According to the findings of the studies, there is a negative and weak association between the financial sector and the exchange rate.

### 1.2. Studies On The Interaction Of World Stock Indices And Exchange Rates

Chen (2012) investigated the link between the Singapore stock market index and the exchange rate using the nonlinear cointegration approach proposed by Breitung (2001) and Singapore's monthly dataset from 1998M1 to 2011M10. The investigation concluded that there is a long-term association between equities and exchange rates in the Singapore economy.

Nath and Samanta (2003) in their study, examined the relationship between India's exchange rate and stock prices using daily data from 1993M3 to 2002M12. The Granger causality test was used in this study, which discovered no causality association between the stock

market and the exchange rate, even though there is capital flow from the stock market return to the foreign exchange market for the Indian economy.

Dilrukshan and Simpson (2009) examined the long-run link between Australian stocks and the AUD/USD using daily data from 2003M1 to 2006M6 in their article. According to the Granger causality study, there is a positive association between Australian stock prices and currency rates.

Hatemi-J and Irandoust (2002) used monthly data on exchange rates and Swedish stock prices from 1993 to 1998 to study the relationship between the Swedish stock index and the exchange rate. They found that there is a causal relationship between Swedish stock prices and the exchange rate as a result of the VAR analysis they conducted.

Rahman and Uddin (2008) In their analysis, looked at the relationship between the USD, EUR, JPY, GBP, and the Dhaka Stock Exchange Index. Johansen cointegration and Granger causality tests were performed on monthly data from 2003M6 to 2008M3. According to the Granger causality test results, there is causality from stock prices to USD and JPY. There was no association discovered between Dhaka stock prices and EUR or GBP.

Ghazali et al. (2008) investigated the association between the variables using data from 2005M7 to 2007M3, as well as the Malaysian USD/MYR exchange rate and the KLSE stock index. The

Johansen cointegration test was used in the investigation, and no long-term association was observed between the KLSE stock index and USD/MYR, although the Granger and Toda-Yamamoto causality tests revealed a relationship between the stock index and USD/MYR.

Kutty (2010) analyzed the relationship between stock prices and exchange rates using data from the Mexican economy from 1989 to 2006. He established that the Mexican stock index (MEXBOL) has an effect on exchange rates in the short run as a consequence of the Granger causality test used in the data set in the study. Furthermore, there is no long-run link between the Mexican stock index and the currency rate.

Akbar et al. (2019) examined the relationship between stock prices and exchange rates using monthly data from the Pakistani economy from 2001M1 to 2014M12. The VAR model and the Bayesian VAR model were employed in the study, and it was found that there was no long-term association between the variables based on the results of the investigation. It has been determined that exchange rate variations cause a fall in Pakistani stock values.

Kumar (2019) investigated the association between the real effective exchange rate and India's S&P BSE Sensex stock index. Nonlinear Granger causality and the nonlinear ARDL test were applied to monthly data from 1994M1 to 2015M12. As a consequence of the investigation, it was discovered that in the Indian economy, there is a one-way causality running from the exchange rate to the stock index.

## 2. DATASET, METHODOLOGY, AND ECONOMIC RESULTS

In the study, the relationship between the BIST-30 index, known as investment instruments, USD/TL, EUR/TL, and GBP/TL was explored with monthly closing prices. As a result, the studies included 279 monthly statistics of the variables from January 1999 to March 2022, as well as the E-Views program. In addition, the information was gathered from tr.investing.com. The following is the model of the relationship between the Borsa Istanbul 30 index and exchange rates:

$$BIST30_{it} = \alpha_i + \beta_1 USD/TL_{it} + \beta_2 EUR/TL_{it} + \beta_3 GBP/TL_{it} + \varepsilon_{it}$$

The Phillips Peron PP (1988) unit root test, which determines series stationarity, was utilized first in the analysis section of the study. Because the PP test uses parametric arrangements to calculate the test statistic, autocorrelation does not affect the asymptotic distribution of the test statistic. The PP test equation is as follows: (Çağlayan and Saçaklı, 2006: 124)

$$\hat{t}_\alpha = t_\alpha \left(\frac{y_0}{f_0}\right)^{-1/2} - \frac{T(f_0 - y_0)(s_e(\hat{\alpha}))}{\alpha f_0^{1/2} s}$$

In the following equation, $s_e(\hat{\alpha})$ is the coefficient standard error, s is the equation's standard error, T is the number of observations, $y_0$ is the consistent estimate of the error variance, and $f_0$ is the residual spectrum estimator at zero frequency. The primary hypothesis of the Phillips-Perron test is "there is a unit root," while the alternative

hypothesis conveys the "series are stationary" condition. Table 2 shows the results of the PP unit root test done in the analysis in this direction.

**Table 2.** Phillips-Perron Unit Root Test Results

| | **Level (Trend)** | | **First Difference (Trend)** | |
|---|---|---|---|---|
| | **PP Values** | **Probability Values** | **PP Values** | **Probability Values** |
| **BİST30** | 2,780445 | 0,9988 | -16,08806 | 0,0000 |
| **USD/TL** | 6,196056 | 1,0000 | -9,938613 | 0,0000 |
| **EUR/TL** | 6,577124 | 1,0000 | -10,31685 | 0,0000 |
| **GBP/TL** | 5,836289 | 1,0000 | -9,775431 | 0,0000 |

According to the results of the PP unit root test, all variables were I(1) because they were stationary at the first difference. Because all variables are stationary at the same level, a cointegration test should be performed to determine whether the variables have a long-term relationship. The lag length of the VAR model must first be calculated before performing the cointegration test.

According to Johansen and Juselius, the cointegration analysis should be applied to the VAR model's first differences. The VAR model's initial distinction is as follows: (Johansen and Juselius, 1990:174)

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \cdots + \Gamma_{k-1} \Delta X_{t-k+1} + \prod X_{t-1} + \mu + \phi D_t \varepsilon_t$$

$$\Gamma_i = -(\mathrm{I} - \Pi_i - \cdots - \Pi_i), \qquad i = 1, \ldots, k-1$$

$$\prod = -\,(\mathrm{I} - \prod_1 - \ldots - \prod_k)$$

In the preceding equation;

$\Delta = (1 - L) \quad \rightarrow \quad L$ Is the delay coefficient,

$\prod = \alpha\beta' \quad \rightarrow \quad \alpha$ Adaptation rate,

$\beta$ Is the matrix of long-run coefficients.

As a result, if all equations involving $\Delta X_{t-i}$ become stationary at the first difference, $\Pi X_{t-k}$ must likewise be stationary for $\varepsilon_t$ to be stationary in level. The following situations become critical at this point:

- If $\Pi = p$, $\Pi$ the matrix has a complete rank, and the vector $X_t$ is stationary.
- $\Pi = 0$, $\Pi$ the matrix contains numerous zeros and should be examined using a differential vector time series model.
- $0 < \Pi = r < p$, indicates that a cointegration vector based on $p \times r$ exists.

Table 3 summarizes the findings of the analysis.

**Table 3:** Lag Length Criteria for VAR Analysis

| Information Criteria /Delays | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|
| **1** | 3390,089 | 0,004053 | 5,843253 | **6,109092*** | 5,949991 |
| **2** | 81,64791 | 0,003340 | 5,649701 | 6,128212 | 5,841828 |
| **3** | 47,76854 | 0,003124 | 5,582633 | 6,273815 | 5,860150 |
| **4** | 59,83448 | 0,002779 | 5,465146 | 6,368998 | **5,828052*** |
| **5** | 34,11445 | 0,002730 | 5,446769 | 6,563293 | 5,895065 |
| **6** | 53,28695 | 0,002476 | 5,348237 | 6,677432 | 5,881923 |
| **7** | 26,20801 | 0,002503 | 5,358020 | 6,899886 | 5,977096 |
| **8** | **36,27629*** | **0,002422*** | **5,323680*** | 7,078217 | 6,028146 |

**Note:** The ***** symbol denotes the ideal delay length.

Because the LR, FPE, AIC, SC, and HQ criteria were primarily indicated at 8, the lag duration was judged to be 8. The cointegration test developed by Johansen-Juselius (1990) was used for series that were stationary at the same level. Table 4 indicates the acquired results.

**Table 4:** Results of the Johansen Cointegration Test

| **Eigenvalue** | **Statistics on Trace** | **5% of the Critical Value** | **Value of Probability** | **Cointegration** |
|---|---|---|---|---|
| 0,072849 | 39,99757 | 47,85613 | 0,2226 | None |
| 0,048356 | 19,57521 | 29,79707 | 0,4521 | At most 1 |
| 0,019165 | 6,192827 | 15,49471 | 0,6727 | At most 2 |
| 0,003579 | 0,968172 | 3,841465 | 0,3251 | At most 3 |
| **Eigenvalue** | **Stat. of Maximum Eigenvalue** | **5% of the Critical Value** | **Value of Probability** | **Cointegration** |
| 0,072849 | 20,42235 | 27,58434 | 0,3126 | None |
| 0,048356 | 13,38239 | 21,13162 | 0,4177 | At most 1 |
| 0,019165 | 5,224655 | 14,26460 | 0,7133 | At most 2 |
| 0,003579 | 0,968172 | 3,841465 | 0,3251 | At most 3 |

Cointegration was not identified in either the trace or maximum eigenvalue tests, according to the results. A long-run link between the variables requires at least one cointegration. In this example, the variables in the study had no long-term effect on each other. As a result, it should be made stationary at the level by subtracting the variables. The short-run link should then be tested using variance decomposition analysis.

**Table 5:** Test Results for Variance Decomposition

| Period | S.E. | $\Delta BIST30$ | $\Delta USD/TL$ | $\Delta EUR/TL$ | $\Delta GBP/TL$ |
|---|---|---|---|---|---|
| **1** | 58.41447 | 100.0000 | 0.000000 | 0.000000 | 0.000000 |
| **2** | 60.37296 | 93.79836 | 0.334141 | 5.781175 | 0.086322 |
| **3** | 60.86565 | 92.87747 | 1.211916 | 5.691741 | 0.218870 |
| **4** | 61.49473 | 92.57118 | 1.350235 | 5.626302 | 0.452280 |
| **5** | 65.97486 | 80.89604 | 3.216203 | 15.35797 | 0.529789 |
| **6** | 70.50925 | 76.70586 | 3.297470 | 19.46105 | 0.535616 |
| **7** | 71.02973 | 75.85481 | 3.665288 | 19.57243 | 0.907472 |
| **8** | 72.26628 | 73.37493 | 4.510826 | 20.22925 | 1.884999 |
| **9** | 74.39501 | 69.26957 | 5.742270 | 21.83485 | 3.153302 |
| **10** | 77.41010 | 64.02065 | 8.195823 | 24.02846 | 3.755066 |

**Note:** The Δ symbol indicates that the variable's difference is calculated.

The variance decomposition analysis shows how much of the change in the variable is explained by itself and how much is explained by other variables in a shock process. When Table 5 is examined, the change in the BIST30 index is 93.79% owing to itself in the second period, with GBP/TL parity accounting for 0.08 percent. After ten periods, the change in the BIST30 index was 64.02% due to itself, while the exchange rates were 24.02% EUR/TL, 8.19% USD/TL, and 3.75% GBP/TL. In financial markets, the creation of BIST30 index prices is mostly determined by its shocks. Furthermore, it experiences the least impact from GBP/TL price shocks.

It is measured in impulse-response analysis how other variables will react to a standard deviation shock that will occur in one of the variables. In bivariate VAR matrix form, the impulse-response function is as follows: (Sims, 1980: 27)

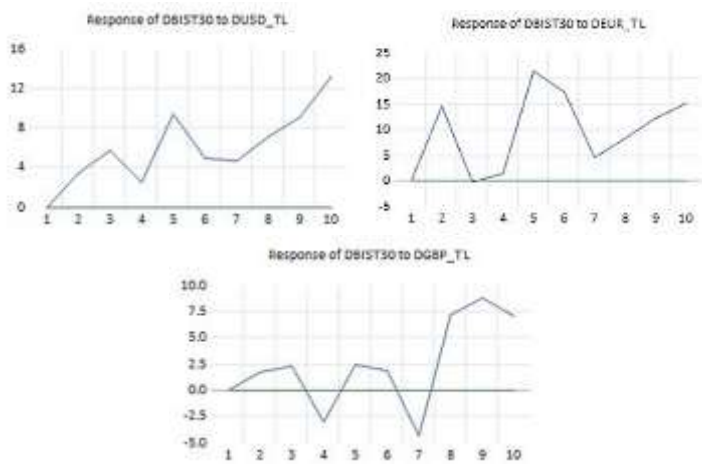
$$\begin{bmatrix} y_t \\ z_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{z} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{pmatrix} \phi_{11}(i) & \phi_{12}(i) \\ \phi_{21}(i) & \phi_{22}(i) \end{pmatrix} \begin{bmatrix} \varepsilon_{yt-i} \\ \varepsilon_{zt-i} \end{bmatrix}$$

The $\phi_i$ the coefficient will show the impacts of $\varepsilon_{yt}$ ve $\varepsilon_{zt}$ shocks on $\{y_t\}$ and $\{z_t\}$. Over n periods, the effect of the shock in $\varepsilon_{zt}$ on $\{y_t\}$;

$$\sum_{i=0}^{\infty} \phi_i$$

It will be up. This is also referred to as the long-run multiplier. The impulse-response functions are $\phi_{11}(i)$, $\phi_{12}(i)$, $\phi_{21}(i)$ and $\phi_{22}(i)$. Figure 1 depicts the analysis results.

**Figure 1:** Results of an Impact-Response Analysis




When a one-unit shock was given to the USD/TL parity, the BIST30 index experienced a downward trend in the fourth period, according to

the impulse-response study. Then, after peaking in the fifth period, it converged to the average in the seventh period. When a one-unit shock was applied to the EUR/TL parity, the BIST30 index increased rapidly in the fourth quarter before beginning to fall in the sixth period. It converged to the mean in the eighth period. When the GBP/TL exchange rate was given a one-unit shock, the BIST30 index reached the bottom in the fourth period and began to increase. The BIST30 index then retreated to the bottom level in the seventh period before returning to the average in the eighth period.

The Granger causality test was used in the study to determine the direction of the causal connection between the series. The Granger causality analysis employs the following equations: (Granger, 1969: 431)

$$Y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i Y_{t-i} + \sum_{i=1}^{m} \beta_i X_{t-i} + u_t$$

$$X_t = \lambda_0 + \sum_{i=1}^{m} \lambda_i X_{t-i} + \sum_{i=1}^{m} \gamma_i Y_{t-i} + v_t$$

If the $\beta_i$ coefficients in the preceding equation assume a value different than zero at a given level of significance, it indicates that X is the cause of Y. Similarly, it demonstrates that Y is the cause of X when the $\gamma_i$ coefficients are nonzero. These assumptions are represented as follows:

$$H_0: \sum_{i=1}^{m} \beta_i = Y_t' \ \ is\ not\ caused\ by\ 0\ or\ X_t.$$

$$H_A: \sum_{i=1}^{m} \beta_i \neq Y_t' \ is\ caused\ by\ 0\ or\ X_t.$$

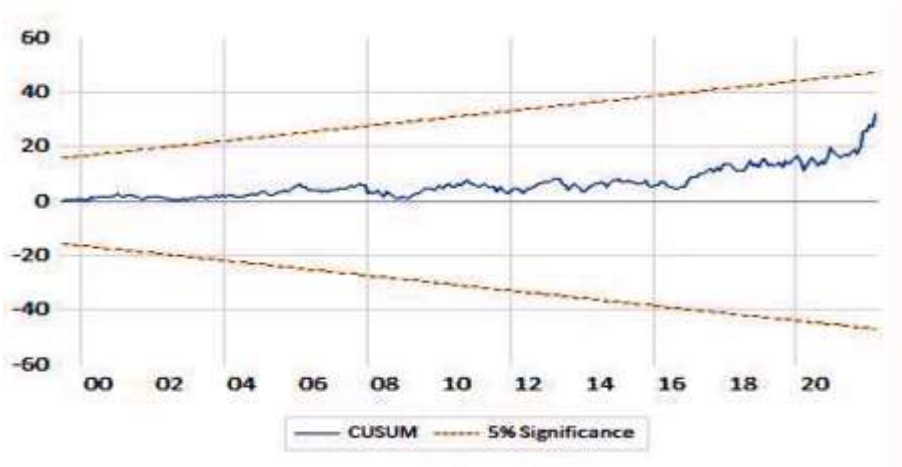
**Table 6:** Results of the Granger Causality Test

| Relationship Aspect | Length of Latency | F Statistic | Value of Probability |
|---|---|---|---|
| $\Delta BIST30 \leftrightarrow \Delta EUR/TL$ | 8 | 3.06790 | 0.0026 |
| $\Delta BIST30 \leftrightarrow \Delta GBP/TL$ | 8 | 2.92745 | 0.0038 |
| $\Delta BIST30 \leftrightarrow \Delta\ USD/TL$ | 8 | 2.65551 | 0.0082 |
| $\Delta EUR/TL \leftrightarrow \Delta GBP/TL$ | 8 | 1.97948 | 0.0494 |
| $\Delta\ USD/TL \leftrightarrow \Delta EUR/TL$ | 8 | 3.11069 | 0.0023 |
| $\Delta GBP/TL \leftrightarrow \Delta\ USD/TL$ | 8 | 2.29179 | 0.0219 |

When Table 6 is analyzed, the null hypothesis is observed to be rejected at the 5% significance level. As a result, it was discovered that all of the variables in the study had a bidirectional causality link. As a result, the chosen exchange rates have a significant impact on the BIST30 index. Changes in currency rates impact the BIST30 index, while changes in the BIST30 index impact exchange rate pricing.

The CUSUM test, which is calculated with error terms, indicates whether the data set has a structural break. Figure 2 depicts the BIST30 index's stability.

**Figure 2:** CUSUM Test Outcomes




According to the CUSUM test results, there was no structural break in the model because the curve generated from statistics remained within the crucial limits corresponding to the 5% significant level. As a result, the variables and regression parameters in the model are stable.

## CONCLUSION

Many studies have been conducted around the world and in Turkey to discover the direction of the relationship between stock market indexes and exchange rates. It has been proposed that changes in exchange rates can affect stock index prices because variations in exchange rates affect corporate profitability. As a result, the stock market is affected by this situation. This indicates that the standard paradigm explains the causality direction as being from currency rates to stock prices. According to the portfolio balance approach, an increase in domestic stock prices will result in capital inflows,

increasing domestic wealth and causing the domestic currency to appreciate. As a result, stock prices influence exchange rates.

The purpose of this study was to investigate the relationship between the BIST-30 Index, which contains the most prominent firms in Turkey's capital market, which is one of the emerging countries, and the currencies USD/TL, EUR/TL, and GBP/TL. The analysis used 279 monthly statistics spanning the years January 1999 to March 2022. The PP unit root test was done on the series in the first step of the investigation, and the analysis revealed that all variables were stationary at the first difference. Johansen cointegration analysis was performed to see whether there is a long-term link between the variables, and it was discovered that there is no long-term relationship between the variables. The appropriate lag length was determined to be 8 following the LR, FPE, and AIC criteria, and a VAR analysis was done. Variance decomposition analysis, impulse-response analysis, Granger causality analysis, and CUSUM tests were all performed within this framework.

According to the Granger causality test results, there was a causal connection between several variables at the 5% significant level. These findings suggest that BIST-30 has a bidirectional and positive association with USD/TL, EUR/TL, and GBP/TL. As a result, changes in exchange rates affect the BIST30 index, and changes in the BIST30 index affect exchange rate prices. The bidirectional causality link in the study has shown that both the traditional and portfolio balance methodologies are viable at the same time.

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# CHAPTER 6

## THE EFFECT OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION AND FOOD SECURITY: QUANTILE REGRESSION ANALYSIS

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## INTRODUCTION

One of the most alarming threats humanity is facing in the twenty-first century is to sustainably feed a population that is expected to reach 9.1 billion by 2050 while simultaneously reducing its environmental effects (e.g. greenhouse gas (GHG) emissions, loss of biological diversity, change in land use and loss of ecosystem services). Thus, the need for food security is vital (Smith & Gregory, 2013). Food and Agriculture Organization (FAO) describes the aforementioned concept as "a state in which all people always have the physical, social and economic access to sufficient, secure and nutritional food that caters for their dietary needs and nutritional preferences" (Schmidhuber & Tubiello, 2007). Still, it should be emphasized that the environmental effects of food production should be mitigated while ensuring food security since agriculture is known to cause approximately 30% of anthropogenic greenhouse gas emissions that result in climate change. Therefore, it is widely believed that potential climate change will impact food production (Smith & Gregory, 2013; Gomez-Zavaglia, Mejuto & Simal-Gandara, 2020).

From this perspective, climate change can be put forward as one of the most significant problems facing the contemporary world. Climate change represents the natural or human-induced shifts in the mean or deviation of climate-related variables such as precipitation, temperature, wind and pressure identified over a long period of time (Benson, 2008). These changes manifest themselves as various extreme weather events such as heatwaves, droughts and floods (Pipitpukdee et

al., 2020), in which a major root cause is the increased greenhouse gas emissions such as carbon dioxide ($CO_2$), methane ($CH_3$), ozone ($O_4$), sulfur hexafluoride (SF6) and nitrogen oxide ($N_2O$) (Pang, McKercher & Prideaux, 2013). The Intergovernmental Panel on Climate Change puts forward that scientific changes show that the main reason behind the surge in GHG emissions is the usage of fossil fuels and it is expected that the global average temperature will rise by 5 °C by 2100 if necessary precautions are not taken (IPCC, 2014).

The effects of climate change are multi-faceted, and their primary impact is seen on the agricultural sector, which is heavily dependent on global food production and the economy (Arora, 2019). Frequent extreme events such as long-term droughts, forest fires, floods, tropical cyclones, and heat waves influence agriculture gravely since high temperatures and carbon dioxide levels might have significant power over critical performance conditions such as optimal food levels, soil moisture, and water presence. Droughts and changes in the frequency and severity of floods can cause serious challenges for farmers and can threaten food security. Moreover, it is also possible that the rising sea temperature levels may shift the biotopes of various species of fish and crustaceans and hence spoil ecosystems. Broadly, it is likely that climate change will harm farming, stock breeding, and fishing (Gomez-Zavaglia, Mejuto & Simal-Gandara, 2020). For instance, a report released by FAO in 2016 states that agricultural efficiency in low-latitude climates is inclined to slow down due to climate change (De Medeiros Silva et al., 2019).

Because climate change and agriculture have indissoluble bonds, such fast changes in climate conditions essentially threaten food security. To illustrate, the 2018 World Food Programme report exhibits that the rise in crop yields per hectare is slow compared to the population increase. In addition, based on the FAO data released in 2016, it is assumed that if the current trend of GHG emissions and climate change is to continue, a significant drop in the production of primary grains can be expected (i.e. 20–45% for corn, 5–50% for wheat and 20–30% for rice) (Arora, 2019). Within this scope, the effects of climate change should be taken into account as a critical factor along with other factors that have a potential unfavorable impact on agricultural production, such as agricultural activities and changes in technology (Gomez-Zavaglia, Mejuto & Simal-Gandara, 2020). In this respect, the defencelessness of agricultural systems against changing climate conditions bear the potential to give rise to social, environmental and economic risks to the agricultural food supply, food safety and Gross Domestic Product (GDP) growth (Waldhoff, Wing, Edmonds, Leng & Zhang, 2020).

In light of this information, the need to assess the effect of climate change on the agricultural sector and food security comes into prominence. This study analyzes the impact of the aforementioned former variable on the agricultural sector in selected countries, namely Australia, Canada, China, France, Germany, India, Pakistan, Russia, Turkiye, Ukraine and USA. The assessment comprises six sections. The second section discusses the relationship between climate change and the agricultural sector whereas the third part reviews the existing

literature. Then, the data set and the model; the method and the findings are presented respectively, and lastly, the analysis is concluded.

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## 1.THE IMPACT OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTION AND FOOD SAFETY

It is forecasted that the world population will reach 9,1 billion by 2050 (FAO, 2009; BM, 2017) and this rise is assumed to be experienced solely by developing countries (Ezeh et al., 2020). Research shows that despite speedy population growth, agricultural production per capita is still increasing in many areas of the world, owing to the green revolution and agricultural concentration (Pellegrini & Fernandez, 2018; Filho et al., 2022). Feeding a world population of 9,1 billion in 2050 requires a 70% hike in global agricultural production from 2005/07 to 2050, which indicates significant surges in the production of various commodities. For instance, to reach a volume of 470 million

tonnes by 2050; annual grain production and meat production should swell by more than 1 billion and 200 million tonnes, respectively (FAO, 2009; Filho et al., 2022). Within this context, accelerating food demand rising from a rising world population has resulted in numerous intense agricultural activities such as the unprecedented use of agricultural chemicals, animal production (for meat and other revenue sources) and the exploitation of water resources, which have resulted in the deterioration of the world's current state and the pollution of natural resources. Even though forests act as a pool against rising CO2 levels, uncontrolled forestation mainly aimed at development and agriculture has destabilized the natural process of the carbon cycle, hence increasing carbon footprint and volatility in climate, essentially negatively impacting agricultural production (Arora, 2019). One of these unfavorable effects can be put forward as rising atmospheric carbon dioxide levels lowering the levels of vital components in yields like zinc and iron (Myers et al., 2014). Farmers face double threats stemming from droughts and floods, which are caused by rainfall shifts. While floods destroy the fertile topsoil that farmers are dependent on for productivity, droughts dry the soil. Furthermore, high temperatures increase the yields' need for water and make them more vulnerable to drought periods (Nelson et al., 2009). These aforementioned events also improve the possibility of giving rise to certain weeds, insects and other pests that can harm crops and cause financial distress among farmers. It should also be noted that changing climate conditions facilitate the dissemination of agricultural pests into new regions. With higher temperatures, the majority of the ice caps have started to recede, and

this phenomenon has affected the farmers who are dependent on glacier water for irrigation (IPCC, 2013). Rising sea levels trigger the risk of floods for coastal farms and speed up the salty-water entry into the freshwater aquifers, hence over-salting the water resources for irrigation.

Furthermore, it is expected that climate change will have an influence on ecosystems and their services rendered to agriculture (i.e. pollination, insect control by natural predators, etc.) and numerous wild plant species used in the amelioration of native plants face the threat of extinction (Gomez-Zavaglia, Mejuto & Simal-Gandara, 2020). In addition, climate change causes rising desertification and high levels of land degradation, which results in the prevalence of soils with a lack of food. The threat of land degradation has exponentially been rising and is widely accepted as a significant global threat, as the Global Assessment of Land Degradation (GLADA) and Improvement describes nearly a quarter of the global agricultural land as degraded (Arora, 2019).

As a result of all the negative developments mentioned above, the unfavorable economic and social impacts have gradually become more prevalent in everyday lives. To demonstrate, it is known that land degradation's impact on the lives of nearly 1,5 billion people, the loss of nearly 15 billion tonnes of fertile soil and land degradation have caused mass migrations. This phenomenon is also backed by a report released by the United Nations Environment Programme in 2017, where it is emphasized that 500 million hectares of agricultural land are

abandoned due to droughts and desertification and this has given rise to severe social and environmental limitations. Nevertheless, it should be stated that the foreseen climate changes are not only restricted to the hike in aridness. This phenomenon is also known to have caused increased and infrequent floods seen in recent years. A report released by European Academies' Science Advisory Council (EASAC) demonstrates that extreme events, such as floods, have risen by half in the last decade and materialized four times more than 20 years before (Arora, 2019). It is safe to say that all these disturbances related to climate will possibly have non-negligible impacts on not only the food production but also on food quality and access. Moreover, because food safety is an indispensable component of public health, the possible adverse effects the aforementioned phenomenon has on the vicious cycle of hunger, disease and crime could give rise to humanitarian concerns. FAO states that a surge from 804 million to 824 million undernourished people from 2016 to 2017 and a perpetual increase in the overall global level since 2014 have been observed (Arora, 2019). The projections made by IPCC show that by 2080, the population facing a direct hunger threat due to climate change will be 157 million, 78 million and 27 million in Africa, Asia and South America, respectively. Furthermore, research conducted by Cline avers that climate change can lead to a decrease in yield per capita by 3% to 16% in any region, thus hampering global agricultural productivity (Conceição & Mendoza, 2009). One can put forward numerous additional numerous examples and effects of climate change. Hence, it is of crucial importance that

actions/policies aimed at mitigating those impacts should urgently be developed and necessary precautions be taken.

## 2.LITERATURE

Climate change has a vast influence on agricultural food production through factors related to temperature and rainfall. Numerous recent pieces of evidence have already verified the interdependency between food security and extreme weather events such as droughts, floods and storms. Climate change might have direct and indirect impacts on agriculture, which may essentially result in a drop in crop production (Allipour Birgani et al., 2021). Various studies in the area have focused on this relationship.

Upon the review of the literature; Kumara & Parikh (2001), in their assessment of Indian agriculture and climate sensitivity, show a robust relationship between agricultural performance and climate change. Brown, Meeks, Ghile & Hunu (2010) test the impact of climate-related variables on economic growth via a panel data analysis conducted for 133 countries between 1961 and 2003. They conclude that while increasing rainfall has a positive influence on the share of the agricultural sector in GDP, rising temperatures have the opposite effect. Akram (2012) accepts a similar hypothesis in the analysis conducted for eight Asian countries spanning the period between 1972 and 2009. Dell et al. (2012), by using the historical deviations in temperature, try to find the aforementioned variables' impacts on economic outcomes and make three main inferences. First, high temperatures have a

relatively more significant impact on hampering economic growth in poor countries. Second, the former variable does not only hinder levels of output but also growth rates. Lastly, there is a negative correlation between high temperatures and agricultural production, industrial production and political stability. Iqbal & Siddique (2014) examine the impact of climate change on agricultural productivity in Bangladesh for 23 regions between the years 1975 and 2008. The results demonstrate varying impacts of long-term changes in the mean and standard deviations of climate-related-variables on rice production and therefore the aggregate impact of climate change on agriculture is unambiguous. Khalid et al. (2016) investigate the explanatory power of climate change on both the agricultural sector and the overall economy for 10 sampled countries between 1990 and 2014, finding that while the independent variable mentioned has a negative influence over GDP, a significant relationship between the former and agricultural value addition is not prevalent. Barnwal & Kotani (2013) examine the rice yields in Andhra Pradesh, a state in India known to be defenseless against climate change through a quantitative application that uses 34-year long data.

There are also numerous studies focusing specifically on Turkiye within the area discussed. Başoğlu & Telatar (2013) investigate the impact of climate change on the agricultural sector in Turkiye by constructing a regression model that uses annual data from 1973 to 2011. They find out that changes in rainfall and temperature influence the share of the agricultural sector in GDP favorably and negatively, respectively. In their research where they assess the correlation between

climate change and the agricultural sector between 1980 and 2013 for Turkiye, Bayraç & Doğan (2016) estimate the relationship between agricultural GDP and agricultural efficiency, $CO_2$ emissions, temperature and rainfall via the ARDL model. The estimates demonstrate that variations in agricultural yield and rainfall have a positive and significant effect on the aforementioned dependent variable, while changes in $CO_2$ have the opposite influence. Moreover, the authors also discover the unfavorable consequences temperature changes have on the agricultural sector. Hayaloğlu (2018) analyzes the impact of climate change on the agricultural sector and economic growth for 10 countries, using panel data analysis by gathering annual data spanning the years between 1990 and 2016. They conclude that climate change has an adverse effect on the economic growth and agricultural value added in the countries studied. Bozoğlu et al. (2019) identify that climate change causes significant losses in crop yields in their study where they assess the impacts of the former variable on the Turkish agricultural sector. Pakdemirli (2020) investigates the effects of climate change on the aforementioned sector via ARDL limit test approach and VAR analysis. The findings exhibit that $CO_2$ emission levels have a significant explanatory power over agriculture. Akcan, Kurt & Kılıç (2022) analyze the effect of climate change on the agriculture sector in Turkiye through the ARDL limit test approach, reaching to the conclusion that while the changes in precipitation and humidity have a positive and significant impact on the share of agriculture in GDP, this effect is reversed when it comes to the relationship between temperature and snow-covered days with the latter

dependent variable. Ilıkkan Özgür & Demirtaş (2022) investigate the correlation between climate change and sugar beet production for the years between 1961 and 2016, rejecting the hypothesis that a causal relationship is prevalent from the former factor to the latter. Still, when this connection is compartmentalized into sub-periods, rainfall changes are shown to have a positive impact while temperature changes have effects of varying degrees.Overall, 13 foreign studies (Kumara & Parikh (2001); Brown et al., (2010); Akram (2012); Dell et al. (2012); Iqbal & Siddique (2014); Khalid et al., (2016); Barnwal & Kotani (2013); Ray et al., (2019); De Medeiros Silva et al., (2019); Waldhoff et al., (2020); Stričević vd. (2020); Pipitpukdee et al. (2020); Horn, Ferreira & Kalantari (2022)) and 7 works focusing on Turkiye (Başoğlu & Telatar (2013); Bayraç & Doğan (2016); Hayaloğlu (2018); Bozoğlu et al., (2019); Pakdemirli (2020); Akcan, Kurt & Kılıç (2022); Ilıkkan Özgür & Demirtaş (2022)) are reviewed. Overall, it can be stated that while the effect of climate-change related factors on agricultural products varies; there is general consensus that temperature changes have a negative effect and rainfall deviations have a positive impact.

## 3. DATA AND METHOD

### 3.1. Data

This study analyzes the relationship between food (wheat) production and climate change in selected countries, namely Australia, Canada, China, France, Germany, India, Pakistan, Russia, Turkiye, Ukraine, USA. Climate change is measured by the average annual precipitation and temperature denominated respectively in millimeters and

centigrades and an average rainfall and temperature dataset is used. The analysis spans the years between 1961 and 2020, and the datasets used are described in Table 1, whereas the explanatory statistics are presented in Table 2.

**Table 1:** Description of Data

| Variables | Description | Source |
|---|---|---|
| **Lnyield** | Amount of wheat per hectare | FAO 2022 |
| **Lnrainfall** | Average rainfall | World Bank 2022 |
| **lntemperature** | Average temperature | World Bank 2022 |

**Table 2:** Explanatory Statistics

| | lnyield | lntemperature | lnrainfall |
|---|---|---|---|
| **Mean** | 4.508808 | 2.790872 | 1.122375 |
| **Med.** | 4.483202 | 2.813488 | 1.050380 |
| **Max.** | 5.133737 | 3.095016 | 1.406029 |
| **Min.** | 3.863263 | 2.273048 | 0.824776 |
| **S. D.** | 0.313225 | 0.167753 | 0.184764 |
| **Skew.** | -0.009074 | -0.776262 | 0.300726 |
| **Kurt.** | 1.929103 | 3.486968 | 1.458814 |
| **J-B.** | 22.89520 | 52.83909 | 54.62589 |
| **Prob.** | 0.000011 | 0.000000 | 0.000000 |
| **Sum** | 2159.719 | 1336.828 | 537.6174 |
| **Sum Sq. Dev.** | 46.89666 | 13.45138 | 16.31776 |
| **Number of obs.** | 479 | 479 | 479 |

Note: For Russia, Ukraine and China, data on wheat yields are only available from 1992 onwards

## 3.2. Method

Traditional methods, using standard techniques such as OLS, instrumental variables, generalized method of moments and generalized

least squares, deliver the average effect of explanatory variables on the overall distribution of the dependent variable. This assessment adopts the panel quantile regression approach.

This method was first developed by Koenker & Bassett (1978). Then, numerous studies such as Koenker & Machado, 1999; Koenker & Hallock, 2001; Zhang, Wang & Zhu, 2019; have utilized the quantile regression approach. This method has two distinct advantages. First, compared with OLS regression, it is more robust vis-a-vis outliers and non-normal distributions. Second, it allows for the estimation of the impact of the explanatory variables at different points in the distribution of wheat yield (Keho, 2017).

$$q\left(\frac{He_{it}}{\Omega_t}\right) = \theta_{0\tau} + \theta_{1\tau}E_{it} + \theta_{2\tau}I_{0\tau} + \theta_{2\tau}I_{0\tau} + \theta_{2\tau}I_{0\tau} + \mu_{it} \qquad (1)$$

Here, $q\left(\frac{He_{it}}{\Omega_t}\right)$ is the conditional quantile of wheat yield whereas Ωt includes the current information at time "t" . The equation can then be rewritten as:

$$y_{it} = x_{it}\theta_\tau + \varepsilon_{it} \qquad (2)$$

In the equation $x_{it}$ is the explanatory variables vector and $\theta_\tau$ is the kx1 regression coefficient of the dependent variable in the $\tau^{th}$ quantile. Unlike the POLS approach which focuses on minimizing the sum of squares of residuals, θ, being τ's quantile regression estimator, asymmetrically minimizes the weighted absolute errors.

$$Min\ \theta \left[\sum_{y_{it}^{3} x_{it}\theta_{\tau}} \tau |y_{it} - x_{it}\theta_{\tau}| + \sum_{y_{it}\S x_{it}\theta_{\tau}} (1-\tau)\ |y_{it} - x_{it}\theta_{\tau}|\right] = \min\ \theta \sum_{t=1}^{T} \varphi_{\tau}(\ y_{it} - x_{it}\theta_{\tau}) \quad (3)$$

Quantile regression method estimates θτ by using different τ values and allows for the deviation of the marginal impact of joint variables at different points of the conditional distribution of wheat yields. Therefore, quantile regression facilitates the heterogeneity of parameters within the wheat yield-climate change (temperature and rainfall) connection.

### 3.3. Empirical Findings

The effectiveness of the regression analysis is mostly dependent on the correlation structure of the independent variables. Prevalence of high correlation among explanatory variables causes the multicollinearity problem, in which the regression coefficients are estimated with bias, the variance and hence the standard deviation of those coefficients increase, and the statistical power is reduced (Gujarati, 1999). Therefore, a multicollinearity test should be performed before the model is estimated. A correlation matrix is formulated to identify this potential problem and the correlation coefficients being lower than 0,9 show that the aforementioned concept is not a threat for the model in question (Asteriou, 2005). Related results are presented in Table 3.

**Table 3:** Correlation Matrix

| Variable | lnyield | lntemperature | Lnrainfall |
|---|---|---|---|
| **lnyield** | 1.0000 | | |
| **lntemperature** | -0.6677 | 1.0000 | |
| **lnrainfall** | 0.3776 | -0.2038 | 1.0000 |

The correlation coefficients calculated range between -0.66 and 0.37. Consequently, the hypothesis that there is a significant multicollinearity problem can be rejected and the model therefore can be estimated.

This study uses the POLS and quantile regression approaches to investigate the impact of climate change on agricultural efficiency. The results are presented in Table 4.

**Table 4.** Estimation Results

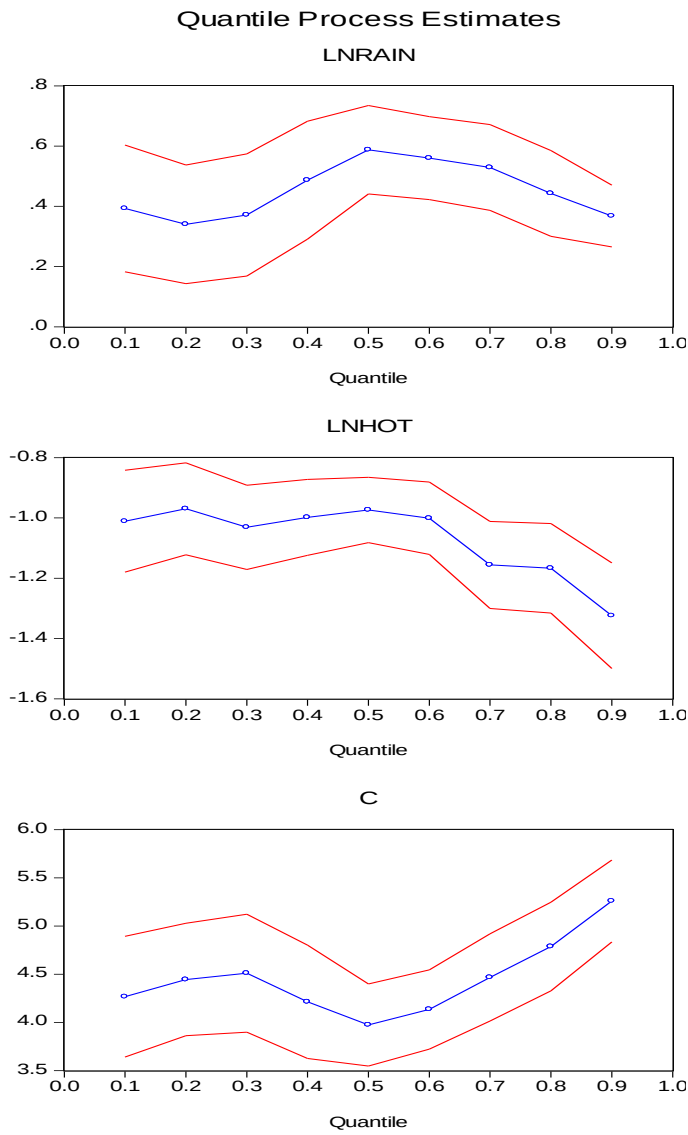
| Varib. | OLS | Quantile Regression | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 10th | 20th | 30th | 40th | 50th | 60th | 70th | 80th | 90th |
| **lnrain** | 0.47* | 0.39* | 0.34* | 0.37* | 0.49* | 0.59* | 0.56* | 0.53* | 0.44* | 0.37* |
| | (0.06) | (0.10) | (0.10) | (0.10) | (0.09) | (0.07) | (0.07) | (0.07) | (0.07) | (0.05) |
| **lntemp.** | -1.04* | -1.01* | -0.97* | -1.03* | -0.99* | -0.97* | -1.00* | -1.15* | -1.17* | -1.32* |
| | (0.05) | (0.08) | (0.08) | (0.07) | (0.06) | (0.06) | (0.06) | (0.07) | (0.08) | (0.09) |
| **C** | 4.36 | 4.27* | 4.44* | 4.51* | 4.21* | 3.97* | 4.13* | 4.46* | 4.78* | 5.25* |
| | (0.19) | (0.31) | (0.29) | (0.31) | (0.29) | (0.22) | (0.21) | (0.23) | (0.23) | (0.21) |

Not: *, **,*** *denote the significance levels of 0.01, 0.05, 0.10 respectively.*

Two methods, POLS and quantile regression are undertaken to analyze the effect of climate change on wheat yields. POLS technique suggests that all variables are statistically significant and are compliant with theoretical expectations. Accordingly, a unit increase in average rainfall increases wheat yields by 0.47%, whereas a similar rise in average temperature causes a -1.04% decrease in the latter variable.

Likewise, the quantile regression approach also verifies that for all quantiles, variables are statistically significant and have similar signs of coefficients. The effect of average rainfall on wheat yield is significant and positive for all quantiles. However, while the magnitude of this impact is increasing from the second to the sixth quantile (0.34-0.59); it decreases after the sixth quantile (0.56-0.37). Correspondingly, the

effect of average temperature on the dependent variable is significant and negative for all quantiles, yet this effect varies within quantiles of whose trend that is presented in Graph 1.




**Graph 1:** Quantile Regression Results for Variables

As seen in Graph 1, the effect of average rainfall on wheat yield is positive for all quantiles. Nevertheless, while this impact decreases from the first quantile to the second, it then moves towards a rising path from the second quantile onwards up to the fifth and then, again, reverses to a downfall trend. In addition, while the effect of the average temperature rises from the first to the second quantile, it stays stagnant between the second and fifth quantiles and then follows a downward trend onwards, hinting at the increase of the unfavorable effect.

## CONCLUSION

The impact of the climate and environmental problems on the world is being felt at an exponential rate, and the effect of this phenomenon on agriculture and food is ever-prominent. Within this context, this study investigates the effect of climate change on food (wheat yields) for the selected sample of countries (Australia, Canada, China, France, Germany, India, Pakistan, Russia, Turkiye, Ukraine, USA) through two techniques, POLS and quantile regression. Findings obtained from both techniques verify each other. Nevertheless, it should be stated that the quantile regression method is deemed more reliable than its mentioned counterpart due to being more advanced and conducting interpretations via segregating the results into various quantiles.

POLS approach suggests that all variables are statistically significant and are in line with the theoretical expectations. Accordingly, an increase in average rainfall has a positive impact on wheat yield, whereas this relationship is the opposite when the explanatory power is

the average temperature. Still, when it is taken into account that because the sampled countries are based in different geographical regions and bear distinct climatic characteristics, it seems plausible that the respective degrees of exposure will most likely differ. Therefore, it is believed that the outcomes of the quantile regression are more reliable. This approach, similarly to what POLS suggests, puts forward that variables are statistically significant for all quantiles and have similar coefficient signs. The effect of average rainfall on wheat yield is significant and positive for all quantiles. Nevertheless, while this effect rises from the second to sixth quantile, it follows a negative trend from the sixth quantile onwards. Correspondingly, the effect of average temperature on wheat yield is significant and negative for all quantiles, yet this impact varies among quantiles and its unfavorable effect is continuously increasing.

A handful of suggestions can be put forward for academics and policymakers. First, the effect of climate change on food can be analyzed by extending the data set to include other products like rice, corn and a more exhaustive span of country groups.

For policy making, it should be emphasized that the level of vulnerability of each country vis-à-vis climate change varies. While the effect of average temperature is generally positive, this impact becomes negative and of a deviating nature when it is assessed through the quantiles. This assessment shows that, when the projections that the global average temperatures are on the rise are taken into account, that a food crisis may be imminent. Moreover, taking into consideration the

recent wars (Russia-Ukraine) and countries' tendency to stock food (China and India) the problems arising from the food crisis are likely to deepen in the upcoming years. These all, once again, emphasize the urgent need for countries to design and implement policies focusing on mediating the impact of climate change.

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