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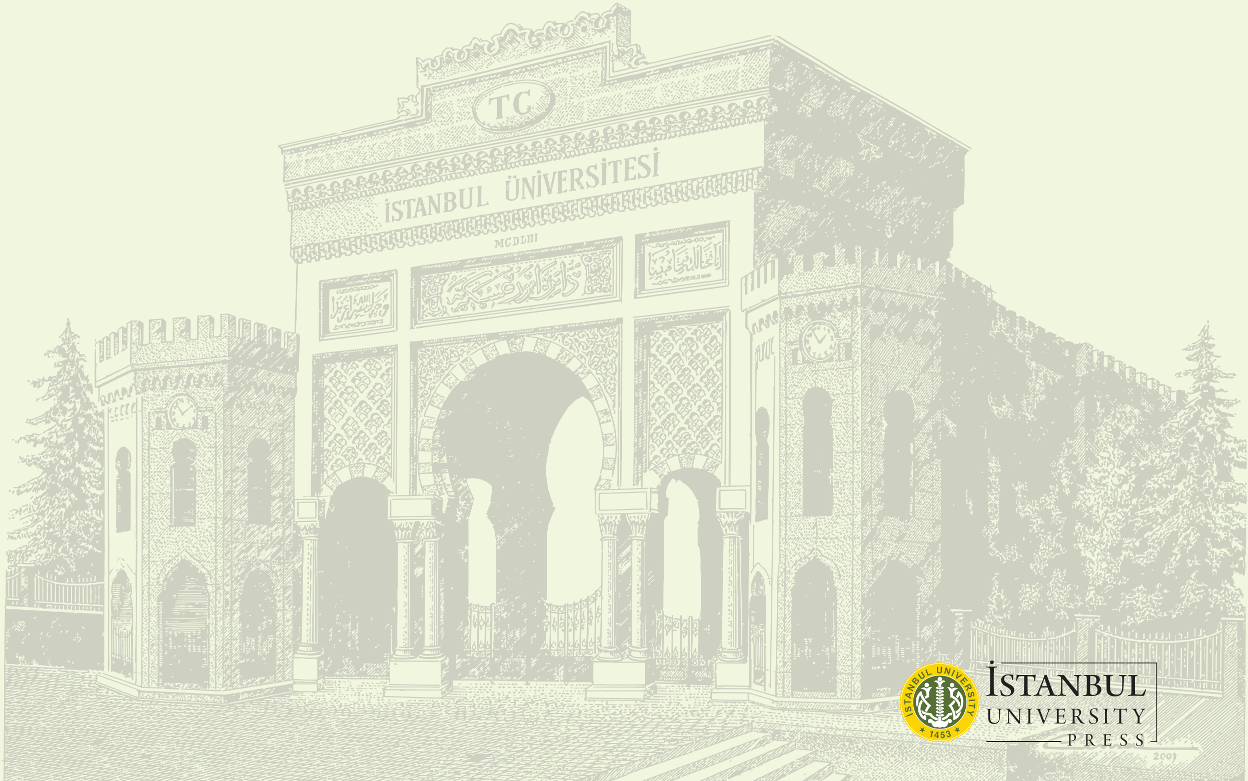

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RESEARCH ARTICLE

Investigation of Connectedness Effects in the Euro Region: The Case of the Real Estate Prices Index

Öznur TAŞDÖKEN[1], Hakan KAHYAOĞLU[2]

ABSTRACT

Shocks occurring in the housing market among countries using the common currency in the European Union also cause fluctuations in real estate market prices. Therefore, the analysis of the spread and mutual influence of price fluctuations in the real estate market on the economies of countries becomes essential in the implementation of macroeconomic and common monetary policies. In terms of the social and economic impact of the housing market, this information has become the most important source for understanding countries' investment preferences and price dynamics. Consequently, what initially begins as country-specific shocks in housing markets often evolves into a structure in which these shocks affect housing markets in other countries. Within this framework, the primary objective of this study is to present findings regarding the estimation of parameters related to the interconnectedness of shocks occurring in the housing markets of countries using the single currency of the European Union with other countries' housing markets.Otherwise, it explores the macroeconomic impacts of countries' housing markets in the Eurozone due to the mutual interdependence among these countries.The main findings obtained from the study indicate that shocks in the left tail (τ = 0.05) and right tail (τ = 0.95) have a greater impact on connectivity than shocks obtained from median predictions. This demonstrates that relying solely on median-based predictors is not appropriate for examining return transmissions associated with extreme positive/negative events. This is because shocks in the housing market propagate more strongly in the right and left tails than in the median.

Keywords: European Union, Housing Market Shocks, Interconnectedness, Quantile İnterconnectedness Approach, Eurozone house price index
JEL Clasification: G51, H31, E27, F15, E00

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1. Introduction

Interest rates, as an economic variable that discounts the future values of asset prices to the present in an economy, play a decisive role in intertemporal asset prices. Therefore, when interest rates decrease, a valuation emerges today based on the potential future values of assets. This situation is the most significant factor in increasing housing demand in the current period. In practise, the fundamental relationship underlying the decrease in financing costs and the subsequent increase in housing demand due to lower interest rates is present. One of the key determining variables is the income level of the decision-making unit undertaking borrowing. The expectation that the future income stream may be higher in return for the investment in the asset within the framework of the current income levels of the decision units is also stated in economic theory as a second determinant for the purchase in question. In general, the real channel of the monetary transmission mechanism operates within this framework.

A change in the interest rate leads households to purchase real estate through mortgage loans as a housing or wealth element. Consequently, it affects the value of real estate, particularly housing. This is because a low interest rate by reducing financing costs, increases housing demand while also tending to raise housing prices. An increase in the interest rate decreases house prices as it increases financing costs and reduces aggregate demand. The effect of interest rate changes on household housing demand and the alteration of housing preferences also reveal the presence of asymmetric pricing flexibility in housing markets (Tsai and Chen, 2009; Fan, 2022), which contributes to volatility in housing prices and causes macroeconomic cyclical fluctuations (Demary, 2010). Based on the insights derived from Tsai and Chen (2009), Fan (2022), and Demary (2010), Tsai (2013) established that the impact of interest rates on housing demand depends on their effect on household income, thereby demonstrating the effectiveness of monetary policy on the real estate market (Tsai, 2013).

At the core of household borrowing lies the objective to finance the adverse effects of changes in consumption expenditures resulting from fluctuations in income or to maintain the consumption level within a given time frame (Taşdöken and Kahyaoğlu, 2022). This situation leads households to utilise housing as collateral for credit, increasing their indebtedness in the short term while smoothing consumption over the long term. In other words, the high value of the house makes it easier for households to use collateral loans and also creates a substitution effect on their savings, acting as a different channel through which the value of the house is transferred to consumption expenditures over different periods.Consequently, the wealth effect arising from changes in housing value has been demonstrated to move in tandem with consumption expenditure patterns (Ortalo-Magné and Sven, 2006; Lustig and Nieuwerburgh, 2010).

The decrease in the value of housing and the unexpected and persistent nature of this price change lead to alterations in household borrowing and spending capacities in housing investments. This situation, by causing a decline in the value of credit collateral, triggers changes in savings preferences, increases consumption sensitivity to income, and reduces consumption expenditures. This interplay, contingent on the permanence of changes in the stock size and value of housing wealth, influences households' economic decisions and preferences (Skinner, 1989; Muellbauer and Murphy, 1990; Engelhard, 1994; Case et al., 2005). In other words, within the framework of life-cycle income theory, any change in the value of households' housing, in other words, any change in the total present value of lifetime wealth, will lead to a wealth effect due to changes in households' current and future borrowing preferences, consumption expenditures, and savings decisions.

Household expenditures for the purchase of a dwelling are considered investment expenditures within the total expenditure composition.Therefore, the consequences of changes in these expenditures lead to a real connexion between housing markets and macroeconomic factors through their influence on financial markets (Cochrane, 2005). From this perspective, developments in the housing market find out the "feedback" effect of housing, which is the main product of this market, or more broadly defined as real estate, through its forward and backward linkages with numerous production sectors in the economy, both in real and financial terms (Fratzscher, 2007; Goodhart and Hofmann, 2008; Holinski and Vermeulen, 2009; Attanasio et al., 2009). Particularly, the financialization of housing, with its financing source relying on asset-backed securities (e.g., mortgages), affects the financial soundness of financial institutions through the collateral value of housing.

One of the most significant consequences of the global crisis of 2008-2009 was that the financialization of the housing markets was a source of crisis on a global scale. As indicated, these housing markets have gained paramount importance as a key indicator for national economies (Gupta and Hartley, 2013; Bandt et al., 2010; Claessens et al., 2011). Hence, it can be stated that investigating the interaction between the countries where housing markets are located and the degree of relationship, which is the measure of this interaction, is essential information for the analysis of macroeconomic balances, especially for Eurozone countries that implement a common monetary policy.

The high correlation and interconnectedness among housing markets change one market to spread more rapidly to other markets. This is because, as the link between housing markets and macroeconomic variables strengthens, housing markets across countries become more interconnected and exhibit similar characteristics. Therefore, considering the indicators of the pricing process of financial assets as the determinant effect of information transmission, a common piece of information or policy change has an impact on market expectations (Harvey and Huang, 1991; Ederington and Lee, 1993). In this respect, the mentioned effects of households on housing demand may also be the main reason for the volatility in the markets.

The utilisation of a common currency among Eurozone countries and the increasing degree of economic integration in Europe have concurrently led to higher interconnectedness among financial institutions, housing markets, and macroeconomic variables (Bandt et al., 2010; Yunus and Swanson, 2012; Tsai, 2018). Therefore, high interconnectedness across countries also increases the magnitude and severity of the spillover effect of shocks from one country to another when economic changes occur. In this context, with the growing mutual dependence among housing markets in these countries, fluctuations in housing prices in one country can easily spread to other countries. Therefore, because an economic change in housing markets has a direct impact on GDP, macroeconomic variables, and household decisions both within the country and in other countries, the change can trigger a global crisis. Thus, it can be categorised as a potential crisis risk within financial markets. Hence, evaluating the macroeconomic consequences of fluctuations in housing markets is of essential significance from a global standpoint.

To examine changes in the housing market and the resulting transmissions, this study focuses on the interconnectedness among countries using the Eurozone house price index. The second section of the study reviews the relevant literature of applied research. In the third section, data, econometric methods, and empirical findings are presented. The fourth section interprets the results of the analysis.

2. Literature Review of Applied Studies

We use the method proposed by Diebold and Yilmaz (2014), which uses variance decomposition of the forecast error of vector-lagged distributed (VAR) approaches to measure the link between the time series representing the variables. The literature features a growing body of work applying this approach to various hypotheses and datasets. Using the new approaches developed within the framework of Diebold and Ylmaz (2009, 2012, 2014), studies in the literature on housing markets have yielded different findings. These findings are supported by Vansteenkiste and Hiebert (2011), who show that there are restricted house price spillovers in the Eurozone (Belgium, Germany, Ireland, Spain, France, Italy and the Netherlands). Lee and Lee (2018) investigated volatility interconnectedness between housing markets in the G7 region. Volatility interconnectedness significantly fluctuated over time and exhibited an unprecedented jump during the global crisis, as indicated by the interconnectedness index values. In Antonakakis et al. (2018), the network topology of Areal property yields in the United Kingdom were examined. The transmission of inter-regional property yield shocks is a significant source of regional property yield fluctuations.

According to the findings of the three studies, it is concluded that price volatility is more strongly correlated with price level. However, it was found that geographic proximity plays a role in the heightened interconnectedness due to price levels. Hwang and Suh (2019) investigated the regional housing market interconnectedness among 25 districts in Seoul. The study's outcome reveals that the effect of interconnectedness varies across the entire country after the global crisis. Lee and Lee (2019) identified the housing market in Seoul, South Korea, as the most influential market, with findings indicating that other metropolitan cities only impress neighbouring areas. Zhang and Fan (2019), in their study on housing prices across 70 major cities in China, found that the highest level of interconnectedness within a city group was as high as 85%. In addition, the authors obtained results that support prior research in the literature through their study. In the study by Tsai and Lin (2019), housing price indices of 20 major cities across the United States are utilised. The housing markets on the western coast are the most influential, and this influence is affected by the spatial distribution of the high-interest mortgage crisis. Lee and Lee (2020) examined the interconnectedness of housing prices in China, Japan, and South Korea. The main finding is that interconnectedness precautions increased during the global financial crisis and changed throughout the business cycle. However, international connexions among the three Asian housing markets were found to be quite weak. This demonstrates that economic relationships between countries within the same spatial region are influenced by non-economic variables or factors. For regions exhibiting tendencies towards economic integration, it can be anticipated that the propagation of changes in asset prices may be transmitted through specific regions. Gabauer et al. (2020), who investigated the dynamic connexions of random shocks among 50 US states and the District of Columbia in terms of housing prices, concluded that the propagation of regional random shocks moves from southern states to western states and from the Midwest states to the Northeast states.

Diebold and Ylmaz (2014) developed the interconnectedness approach using the Vector Autoregression (VAR) framework to measure the linkage between different markets or macroeconomic variables.Formun Üstü Considering the studies conducted in the literature on housing markets using the approaches developed within the framework of this methodology, the interconnectedness effect in housing markets increases due to the increase in financial and macroeconomic interconnectedness across countries or regions. The lack of an analysis of the countries using a common currency in the studies conducted in the literature can be considered as a study that provides empirical information. This is because, due to the use of a common currency, interdependence between these countries and the correlation between their markets are expected to be high (Nzama et al., 2022) . In other words, the effect of the preference for housing as an asset in household portfolios on the tendency to integrate spatially and the spillovers of the consequences of macroeconomic policies will be analysed. Hence, investigating the macroeconomic impacts of countries' housing markets is crucial. In this context, housing markets have a significant effect on the macroeconomic structure and transmission mechanism in financial markets, both as indicators of household wealth and as an important part of the financial structure.

3. Data and Methodology

In this section, the dataset used in the study and the econometric methodology are discussed.

3.1. Data Set

In this study, analyses are conducted using the quantile interconnectedness approach developed by Chatziantoniou et al. (2021), based on the Diebold and Ylmaz studies, employing the housing price index data of 12 Eurozone countries for the period between Q1 2006 and Q4 2021. The housing price index data for the Eurozone were obtained from the European Central Bank. Because of the incomplete nature of housing price index data for some Eurozone countries, they are not included in the study. Therefore, the study focuses on 12 Eurozone countries: Belgium, Germany, Estonia, Ireland, Spain, France, Cyprus, Latvia, Lithuania, Malta, Slovakia, and Finland. The housing price index data for these countries are organised as return series in the analysis. The analysis was performed using the R econometric package programme.

Using the Diebold and Ylmaz (2014) method, the impact of housing market interconnectedness has been studied by considering regions or cities on a country basis. In this context, our study differs from the studies in the literature by first investigating the interconnectedness structures in the Eurozone countries using the common currency and the impact of their values, which can be defined as a source of asymmetric effects, defined as time-varying right and left tail effects, on the markets. This research is the first to explore the effect on changes occurring in the median, left, and right tails of the housing market return series for the 12 Eurozone countries. Second, this is the first study to examine quantile VAR-based return transmissions between Eurozone housing price index data and housing markets.

The main aim of this study is to reveal the magnitude of the effect on spillovers, which emerge as country-specific housing market shocks, on the housing markets of other countries and to reveal housing market mobility across countries in the Eurozone. Second, it investigates which countries exert the most influence on the housing market and probes the implications of changes in the housing market from these countries to others. Third, the research aims to identify systematic risks by forecasting correlations among housing markets concerning the research topic. Fourth, it explores the macroeconomic impacts of countries' housing markets in the Eurozone due to mutual interdependence among these countries. Fifth, it delves into the integration of housing markets within the Prozone.

3.2. Econometric Methodology

In this section of the study, the quantile connectedness approach and the Elliot, Rothenberg, Stock's Point Optimum (ERS,1996) Test will be discussed.

3.2.1. Quantile Connectedness Approach

In the traditional least squares method, when making linear predictions, the condition of unrelatedness between changing variance, error terms, and the previous value of the period under consideration is necessary. In particular, when the distributions of the series or data representing the variables used in the estimation have fat tails or outliers, the parameters of these estimation methods lose their effectiveness. To address this issue, Koenker and Bassett (1978) developed the quantile method, which reduces the impact of these tail effects on the efficiency of parameters by using left or right tail and median values. Combining the approach of Koenker and Bassett (1978) with the method developed by Diebold and Ylmaz (2012), the connectivity method was advanced in this framework. With this method, the effect of structural shocks within the network on the volatility of every variable within that network is demonstrated using the variance decomposition of the prediction error. In this method, findings are obtained that give the relationship between the tails at the endpoints of the distribution according to the criteria determined in the range of 0.05–0.95. In the prediction stage of this approach, the characteristics of data representing median ($\tau = 0.50$), left tail ($\tau = 0.05$), and right tail ($\tau = 0.95$) variables were considered (Ando et al., 2022). Thus, this approach provides a more valid and efficient parameter estimator than traditional methods for explaining the effects of shocks to the economy, such as epidemics and crises. These effective parameter values, which are indicators of the degree of interconnectedness, also provide information on the direction and time-varying effects of these shocks within the system.

Based on the studies by Diebold and Ylmaz, the quantile VAR (QVAR) method developed by Chatziantoniou et al. (2022, 2021) integrates the quantile connectivity method with the frequency connectivity method for calculating connectivity evaluation in terms of time, frequency, and quantiles. This is because the original QVAR connectivity method does not consider the effect between frequencies, the frequency connectivity method is sensitive to outliers, and does not consider the effect between quantiles. Hence, this method allows identification of the time-frequency dynamics in both the left and right tails of the distribution and thus provides information on the impact of the left and right tails on the distribution (Chatziantoniou et al., 2022, p. 4). In this context, the quantile connectivity method analyzes whether the powerful co-movement between variables depends on the strength of the shock, considering both extreme positive structural shocks (namely higher quantile values) and extreme negative structural shocks (namely lower quantile values).

Quantile vector autoregression QVAR(p) is estimated using the equation shown in equation 1 to calculate the connectedness metrics.

$$x_t = \mu_t(\tau) + \varphi_1 x_{t-1} + \varphi_2(\tau)x_{t-2} + \ldots + \varphi_p(\tau)x_{t-p} + u_t(\tau) \tag{1}$$

The parameters x_t ve x_{t-i} (i=1,2,...,i) given in Equation 1 represent N×1 dimensional vectors of endogenous variables, where the parameter τ represents the quantile value within [0,1], p denotes the lag length of the QVAR model, $\mu_t(\tau)$ parameter represents the N×1 dimensional conditional mean vector, $\varphi_j(\tau)$ parameter represents the N×N dimensional QVAR coefficient matrix, and $u_t(\tau)$ parameter represents the N×1 dimensional error vector with the variance-covariance matrix Σ(τ). The Wold theorem (Equation 2) is used to transform the QVAR(p) equation into the vector moving average representation QVMA(∞) to express the quantile vector.

$$x_t = \mu(\tau) + \sum_{j=1}^{p} \varphi_j(\tau)x_{t-j} + u_t(\tau) = \mu(\tau) + \sum_{i=0}^{\infty} \gamma_i(\tau)u_{t-i} \tag{2}$$

The Generalised Forecast Error Variance Decomposition (GFEVD) is calculated to forecast the connectivity approach. The values obtained from the GFEVD calculation are interpreted as the effect of a shock in series j on the forecast error variance share for series i. The GFEVD calculation is presented in Equations 3 and 4 below.

$$\theta_{ij}(H) = \frac{\left(\Sigma(\tau)_{jj}^{-1}\right)\sum_{h=0}^{H}\left((\gamma_h \Sigma(\tau))_{ij}\right)^2}{\sum_{h=0}^{H}\left(\gamma_h(\tau)\gamma_h'\right)_{ii}} \tag{3}$$

$$\tilde{\theta}_{ij}(H) = \frac{\theta_{ij}(H)}{\sum_{k=1}^{N}\theta_{ij}(H)} \tag{4}$$

Since the sum of the rows in Equation 4, given by $\tilde{\theta}_{ij}(H)$), is not equal to one, normalisation is required based on the row sum, resulting in the parameter θ_{ij}.

With normalisation applied to the equations, $\sum_{i=1}^{N} \tilde{\theta}_{ij}(H) = 1$ and $\sum_{j=1}^{N} \sum_{i=1}^{N} \tilde{\theta}_{ij}(H) = N$ equations are obtained. In this context, the sum of each row is equal to unity, representing how a shock in the series affects the series itself and all other j series. with these equations, other connectedness values are calculated. In this framework, The (overall) total directional connectedness TO is defined as the extent to which a shock in series i is transmitted to all other series j (see Equation 5).

$$TO_i(H) = \sum_{i=1}^{N} \widetilde{\emptyset}_{ji}(H) \; i \neq j \tag{5}$$

The (overall) total directional connectedness *FROM* measures how much of the shocks in all other j series are received by the i series (See Equation 6).

$$FROM_i(H) = \sum_{i=1}^{N} \widetilde{\emptyset}_{ij}(H) \;\; i \neq j \tag{6}$$

The (overall) NET total directional connectedness represents the difference between the (General) total directional connectivity (TO) and the (General) total directional connectivity(FROM), expressed as the net impact that series i has on the predetermined network (See Equation 7). When series i influences all other series and is considered a net transmitter of shocks. However, when , series i is influenced by other series and is considered to be a net receiver of shocks.

$$NET_i(H) = TO_i(H) - FROM_i(H) \tag{7}$$

The (General) Total Connectivity Index (TCI), which measures the degree of interconnectivity within the network, is calculated using Equation 8.

$$TCI(H) = N^{-1} \sum_{i=1}^{N} TO_i\,(H) = N^{-1} \sum_{i=1}^{N} FROM_i\,(H) \tag{8}$$

The TCI value indicates the mean impact of a shock in one series on the other series. In this context, when the TCI value is very high, market risk increases. Conversely, when the TCI value is low, market risk decreases (Chatziantoniou et al., 2022:4)we propose a novel quantile frequency connectedness approach that enables the investigation of propagation mechanisms by virtue of quantile and frequency. This approach allows for the analysis of connectedness measures considering either different frequencies for a given quantile or different quantiles for a given frequency. We investigate dynamic integration and return transmission among a set of four well-established environmental financial indices, namely the S&P Green Bond Index, MSCI Global Environment, Dow Jones Sustainability Index World, and S&P Global Clean Energy over the period from November 28th, 2008 to January 12th, 2022. S&P Green Bond Index and S&P Global Clean Energy appear to be both short-term and long-term net receivers of shocks while MSCI Global Environment and Dow Jones Sustainability Index World are both short-term and long-term transmitters of shocks. We also find that total connectedness indices (TCIs).

3.2.2. Elliot, Rothenberg, Stock'un Nokta Optimum (ERS,1996) Test

The ERS (1996) test provides more reliable results when the series has an unknown mean and linear trend. The equation for the ERS (1996) test is shown below.

$$P_T = \frac{SSR(\bar{\alpha}) - \bar{\alpha}\, SSR(1)}{f_0} \tag{9}$$

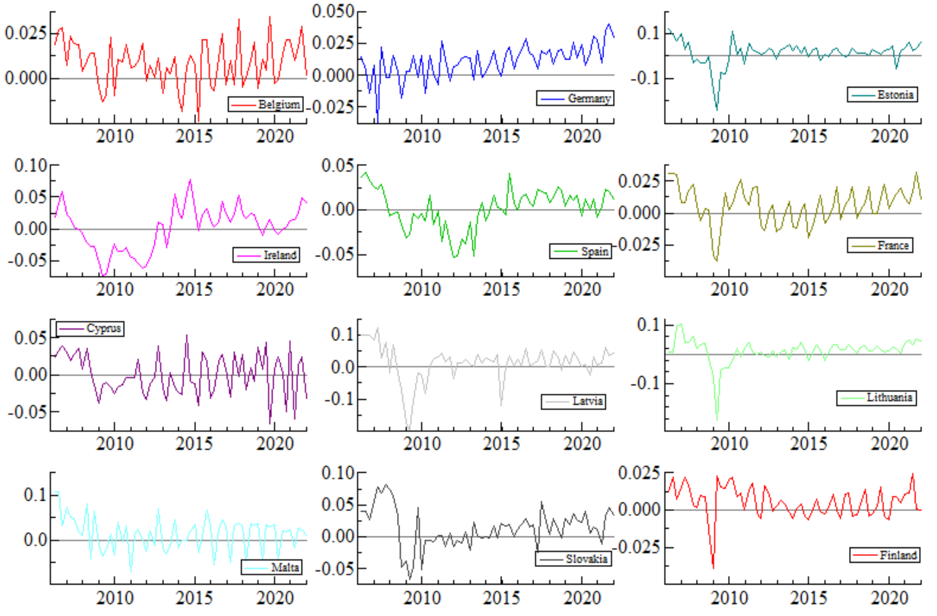
The parameter $\bar{\alpha}$ given in Equation 9 is calculated as $\bar{\alpha} = 1 + \frac{\bar{c}}{T}$. The $\bar{c}$ parameter is chosen to maximise the power of the test, and its values are determined through Monte Carlo experiments. According to the results obtained from the Monte Carlo experiments, when the econometric model includes a constant, $\bar{c} = 7$ is taken as. However, when the econometric model includes both a constant and a trend, $\bar{c} = 13{,}5$ is taken as. The SSR given in Equation 9 is the sum of the squared residuals. In addition, the parameter f_0 is an estimator of the residual spectrum at zero frequency and can be obtained using estimators based on the sum of covariances. In the ERS test, the null hypothesis is expressed as "there is a unit root.'(Çağlayan & Saçaklı, 2006:125-126).

3. Empirical Findings

In this study, we use the quantile mean connectivity approach to estimate the network and impact of the distribution of positive and negative shocks on the housing market associated with the median, right tail, and left tail of the distribution of positive and negative shocks. This study aims to estimate the connectivity network and the effects of both positive and negative shocks that are effective on the housing market using the Quantile Autoregressive Vector (QVAR) approach. Specifically, the distribution of shocks associated with median, right tail, and left tail values is examined to forecast the connectivity network and its effect on shocks in the housing market. In the initial phase of the study, descriptive statistics for the data were obtained, as presented in Figure 1. Pre-tests for descriptive statistics of all series are provided in Table 1, and the correlation matrix illustrating the relationship between variables is presented in Table 2.

The analysis of whether the series has a normal distribution is conducted through the Skewness, Kurtosis, and Jarque-Bera (JB) tests provided in Table 1, which presents the basic statistical values. In these analyses, in the Kurtosis test, a coefficient greater than 3 indicates that the series has heavier tails, whereas a coefficient less than 3 demonstrates a distribution with thinner tails. The Skewness test examines the skewness of the distribution based on whether the coefficient is different from zero and positive; a positive skewness indicates a right-skewed distribution. When the skewness coefficient for the series is negative, it signifies a left-skewed distribution. A skewness coefficient of zero demonstrates a normal distribution for the series. The ERS test is employed for unit root analysis of the series. This test was developed with the aim of enhancing the power of the Dickey–Fuller test. It is particularly acknowledged to be more robust than other tests, even when time series have components with unknown mean and linear trend. In this study, this test was employed against the assumption that the time series representing variables defined as returns have an unknown mean and linear trend (Çağlayan & Saçaklı, 2006:125). The Ljung-Box (Q(20)) test was used to assess the autocorrelation of the return series.

Figure 1: Housing Market Return Series



Note: This study was prepared by the authors using the econometrics software package, with data obtained from the European Central Bank.

The changing returns of all calculated series for each country are shown in Figure 1. As seen in the figure, the time-varying return series exhibits volatility trends across different time periods in all markets.

According to the basic statistics (Table 1), the average return series of the entire housing market in all countries is positive. Moreover, housing prices in Belgium, Germany, Estonia, Ireland, France, Lithuania, Malta, Slovakia, and Finland are statistically significant and coefficients positive, and these return series have a positive mean. Belgium (0.009), Germany (0.011), Estonia (0.014), Lithuania (0.011), Malta (0.014), and Slovakia (0.013) are the countries with the highest average returns. Skewness is negative in all markets except Malta. In this respect, the recurring values of countries with close returns are generally larger than the overall average. Kurtosis is greater than three in Estonia, Lithuania, Latvia, and Finland's housing markets. When examining Jarque-Bera (JB) statistics at a 5% significance level, the

Table 1: Descriptive Statistics

	"Belgium	Germany	Estonia	Ireland	Spain	France	Cyprus	Lithuania	Latvia	Malta	Slovakia	Finland
Mean	0,009***	0,011***	0,014**	0,002	0,001	0,006***	0,000	0,011**	0,012	0,014***	0,013***	0,006***
Prob	0,000	0,000	0,048	0,697	0,603	0,002	0,907	0,038	0,102	0,004	0,001	0,000
Variance	0,000***	0,000***	0,003***	0,001***	0,000***	0,000***	0,001***	0,002***	0,003***	0,001***	0,001***	0,000***
Skewness	-0,195	-0,754**	-1,964***	-0,288	-0,643**	-0,570*	-0,156	-2,666***	-1,504***	0,008	-0,105	-0,922***
Prob	0,489	0,013	0,000	0,310	0,031	0,053	0,580	0,000	0,000	0,979	0,708	0,003
Ex. Kurtosis	-0,393	1,670**	7,460***	-0,465	0,132	0,601	-0,689	13,752***	3,733***	-0,125	0,338	3,317***
Prob	0,642	0,022	0,000	0,512	0,540	0,201	0,174	0,000	0,001	0,886	0,352	0,001
JB	0,817	13,494***	189,545***	1,463	4,453	4,434	1,526	580,126***	61,292***	0,042	0,422	38,399***
Prob	0,665	0,001	0,000	0,481	0,108	0,109	0,466	0,000	0,000	0,979	0,810	0,000
ERS	-1,413	-1,945*	-1,272	-1,980**	-1,334	-2,040**	-1,687*	-3,155***	-1,644*	-0,161	-2,346**	-2,694***
Prob	0,164	0,057	0,209	0,053	0,188	0,046	0,097	0,003	0,106	0,873	0,023	0,009
Q(20)	41,814***	37,886***	43,786***	135,332***	99,547***	56,435***	12,779	46,853***	59,758***	29,923***	43,357***	32,665***
Prob	0,000	0,000	0,000	0,000	0,000	0,000	0,248	0,000	0,000	0,000	0,000	0,000
	34,415***	16,784*	11,824	33,192***	28,646***	18,591**	8,049	3,896	26,850***	12,417	109,691***	16,579*
Prob	0,000	0,064	0,324	0,000	0,000	0,031	0,720	0,987	0,001	0,275	0,000	0,069

Note: The symbols *, **, and *** shown in Table 1 indicate statistical significance at the levels of 10%, 5%, and 1%, respectively.

null hypothesis indicating the normal distribution of return series for Germany, Estonia, Lithuania, Latvia, and Finland is rejected. Therefore, it can be inferred that the return series of these countries' housing markets are not normally distributed. For countries other than those mentioned, the normality null hypothesis cannot be rejected, indicating that the return series for these countries is normally distributed.

The variance value indicates whether the variability of housing market returns in one country explains the variability of returns in another country more weakly or strongly. This situation also reflects the impact of variability dispersion based on the interconnectivity between the two markets. In general, although the variance values are significant, their explanatory power is different.

When examining the ERS[1] values, it is observed that despite using the series of returns for all countries, the housing price series of Belgium, Estonia, Spain, and Malta are not statistically significant. In this context, the non-significant results for these countries' housing market return series indicate the presence of unit roots and demonstrate that shocks still have an effect on their housing markets. Therefore, shocks in these countries' housing markets have a persistent impact. Regarding the autocorrelation of the return series, the results of the Ljung-Box (Q(20)) test reject the null hypothesis of no autocorrelation in all countries except Cyprus. , When considering a lag of 20 periods, it provides information suggesting that variability in the variance is persistent. The probability values for Lithuania, Estonia, Cyprus, and Malta are statistically insignificant. For countries other than these, considering the probability values implies that shocks within the system have a statistically persistent trend, depending on the lag value. In other words, this finding indicates that there is information about volatility having a certain duration effect on the system.

To determine the degree and direction of the relationship among the housing markets of countries, Kendall's rank correlation analysis is employed. This analysis is fundamentally used for the correlation analysis of non-normally distributed variables. The findings obtained from this analysis are presented in Table 2.

[1] For more information see. Elliott et al. (1996)

Table 2: Estimated Kendall's rank correlation coefficients

Kendall	Belgium	Germany	Estonia	Ireland	Spain	France	Cyprus	Lithuania	Latvia	Malta	Slovakia	Finland
Belgium	1,000	-0,028	0,196**	0,202**	0,276***	0,564***	0,204**	0,236***	0,208**	0,322***	0,232***	0,079
Germany	-0,028	1,000	0,093	0,169**	0,225***	0,080	0,144	0,211**	0,112	0,054	0,104	0,052
Estonia	0,196**	0,093	1,000	0,260***	0,185**	0,236***	0,101	0,249***	0,346***	0,210**	0,141	0,113
Ireland	0,202**	0,169**	0,260***	1,000	0,448***	0,179**	0,202**	0,297***	0,263***	0,278***	0,216**	-0,177**
Spain	0,276***	0,225***	0,185**	0,448***	1,000	0,344***	0,268***	0,361***	0,341***	0,191**	0,363***	0,127
France	0,564***	0,080	0,236***	0,179**	0,344***	1,000	0,217**	0,263***	0,274***	0,262***	0,243***	0,147
Cyprus	0,204**	0,144	0,101	0,202**	0,268***	0,217**	1,000	0,349***	0,259***	0,330***	0,343***	0,163
Lithuania	0,236***	0,211**	0,249***	0,297***	0,361***	0,263***	0,349***	1,000	0,408***	0,068	0,402***	0,107
Latvia	0,208**	0,112	0,346***	0,263***	0,341***	0,274***	0,259***	0,408***	1,000	0,205**	0,373***	0,192**
Malta	0,322***	0,054	0,210**	0,278***	0,191**	0,262***	0,330***	0,068	0,205**	1,000	0,229***	0,014
Slovakia	0,232***	0,104	0,141	0,216**	0,363***	0,243***	0,343***	0,402***	0,373***	0,229***	1,000	0,099
Finland	0,079	0,052	0,113	-0,177**	0,127	0,147	0,163	0,107	0,192**	0,014	0,099	1,000

Note: The symbols *, **, and *** shown in Table 2 indicate statistical significance at the levels of 10%, 5%, and 1%, respectively.

According to Table 2, some countries have positively correlated return series, whereas others have negatively correlated series. Overall, there is a correlation between these countries. In general, there is a statistically significant correlation between these countries. The correlation relationships in the markets of Belgium-France, Spain-Ireland, and Latvia-Lithuania are observed to be stronger compared to Belgium-Germany and Ireland-Finland markets among these countries.In this context, the correlation between housing markets suggests, first, that housing, as an indicator of wealth, is a risky asset and the possibility of hedging against the risk of changes in different markets is reduced, and second, that housing prices tend to spread. Third, the low correlation between the markets of some countries also indicates that country-specific factors such as demographics and tax systems have an impact on the markets of these countries. Fourth, the integration relationship between markets is also low.

This study aims to analyse the quantile connectivity relationship among countries' housing markets by considering median ($\tau = 0.50$), left tail ($\tau = 0.05$), and right tail ($\tau = 0.95$) values for prediction. The findings obtained from the prediction are presented in Tables 3, 4, and 5, which represent median total connectivity estimates (Refer to the appendices for Tables 4 and Table 5). In this study, using the mentioned quantile values, connectivity relationships at the extreme points of the distribution are estimated, providing detailed information about shocks that affect the economy.

When looking at the median average connectivity table(See alsoTable 3), it is observed that Belgium's housing market variance explains 52.68% of its own variance. Belgium's housing market has the highest connectivity impact on Latvia (6.02%) and Slovakia (6.79%) housing markets, whereas the highest connectivity impact on Belgium's housing market comes from Latvia (6.11%) and Slovakia (6.63%) housing markets. In other words, Belgium's housing market not only influences the markets of Latvia and Slovakia but is also influenced by these markets in return. Therefore, there is a mutual interaction among these country markets. While the connectivity impact of other countries on Belgium's housing markets is 47.32%, Belgium's impact on other countries' housing markets is 45.79%.

Table 3: Median Average Connectivity Estimated ($\tau = 0,5$)

	Belgium	Germany	Estonia	Ireland	Spain	France	Cyprus	Latvia	Lithuania	Malta	Slovakia	Finland	FROM
Belgium	52,68	3,99	4,21	2,49	3,72	3,89	2,99	6,02	4,10	4,13	6,79	4,98	47,32
Germany	3,78	48,77	3,57	2,71	3,37	4,86	11,18	2,85	3,67	5,74	4,85	4,64	51,23
Estonia	4,27	3,98	52,34	4,11	4,92	2,31	6,24	3,61	3,92	3,47	9,45	1,39	47,66
Ireland	2,83	3,09	4,65	53,27	4,95	4,77	5,20	1,77	4,03	4,34	8,30	2,78	46,73
Spain	3,36	3,49	4,46	4,43	48,19	8,06	4,04	3,37	7,64	4,30	2,57	6,08	51,81
France	3,68	4,91	2,02	4,33	8,00	44,40	2,09	3,60	4,91	5,25	3,25	13,57	55,60
Cyprus	2,66	11,28	5,69	4,20	3,75	2,49	50,55	6,07	4,33	3,01	4,27	1,70	49,45
Latvia	6,11	2,99	3,39	1,67	3,36	4,24	5,90	50,65	5,58	5,33	6,51	4,27	49,35
Lithuania	3,64	3,74	3,72	3,45	7,62	4,91	4,47	5,31	50,67	5,15	1,65	5,66	49,33
Malta	3,79	6,15	3,53	4,34	4,42	5,46	3,10	5,00	5,10	50,29	3,06	5,75	49,71
Slovakia	6,63	4,68	9,20	7,40	2,63	3,22	4,23	6,25	1,44	2,88	47,65	3,80	52,35
Finland	5,04	4,87	1,25	2,55	5,92	13,69	1,68	4,04	5,29	5,58	3,71	46,37	53,63
TO	45,79	53,18	45,70	41,68	52,66	57,90	51,13	47,90	50,01	49,18	54,42	54,62	604,18
Inc. Own	98,47	101,94	98,04	94,94	100,86	102,30	101,68	98,54	100,68	99,48	102,07	100,99	cTCI/TCI
NET	-1,53	1,94	-1,96	-5,06	0,86	2,30	1,68	-1,46	0,68	-0,52	2,07	0,99	54,93/50,35
NPT	4,00	10,00	2,00	1,00	5,00	9,00	6,00	4,00	5,00	3,00	9,00	8,00	

When we look at the interconnectedness values of the other countries in the table and their effects on other markets, we see that these effects are different in each country, firstly because the population mobility that emerged as a result of the Russian-Ukrainian war affected the labour markets and the migration receiving/receiving countries changed. Second, differing tax policies in countries have led households to respond differently to housing purchases and sales. Third, an increase in inflation rates leads to a widening gap between house prices and rental rates, thereby increasing the demand effect on housing markets, resulting in different housing demand across countries. Fourth, different socio-cultural factors across countries impact households' housing purchase/sale decisions. Therefore, these aforementioned factors are fundamental causes of heterogeneity among Eurozone housing markets.

When looking at the TO values in the table for the median(See alsoTable 3), it indicates the spread effect of a change from one country's market to another country's markets. The highest spread effects are observed in the markets of Germany (%53.18), France (%57.90), Slovakia (%54.42), and Finland (%54.62), while the lowest spread effects originate in Belgium (%45.79), Estonia (%45.70), and Ireland (%41.68) markets. Notably, Germany's strong economic structure within the Prozone, its low impact of monetary policy shocks on household decisions (Demary, 2010), and the use of a common currency have amplified Germany's influence on other housing markets. Therefore, we can conclude that these markets have the most influence on the Eurozone housing market.

When examining the FROM values(See alsoTable 3), they indicate the impact of a change taken by one country's market from another country's market. Consequently, the countries most significantly affected by other country markets are France (%55.60), Slovakia (%52.35), and Finland (%53.63), while the least affected countries are Belgium (%47.32), Ireland (%46.73), and Estonia (%47.66). Considering the results obtained, both the countries that have an effect of other country markets and the countries where other country markets have an impact are the same. Therefore, the fact that these countries are not only affected by other markets but also affect other markets suggests that both the impact of monetary policy are the same in these countries, i.e., households react similarly to changes in interest rates, and housing markets have similar characteristics. Moreover, a slow or high degree of interconnectedness between these markets may cause a change in one market to disappear without spreading to other markets or to spread very quickly.

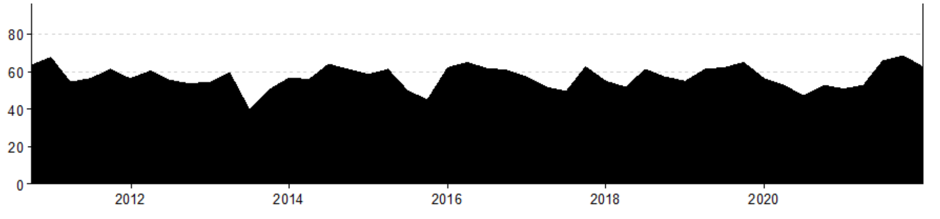
The net spread value reveals the difference between the information/shock transmitted from one country's housing markets to another country's housing markets and the information/shock received. A positive value indicates that the country plays the role of a net transmitter, whereas a negative value indicates that the country acts as a net receiver. In this context, countries such as Germany, Spain, France, Cyprus, Lithuania, Slovakia, France, and Finland being net shock transmitters to other markets implies their significant influence on those markets. In addition, Belgium, Estonia, Ireland, Latvia, and Malta are influenced by changes occurring in other countries' markets. In particular, shocks in the housing markets of France and Slovakia have the highest effect on other markets. This is due to the presence of a contractual savings system (Bauspar) that facilitates mortgage lending in Slovakia, coupled with low transaction costs and high liquidity in the housing market. This situation makes Slovakia's housing market conducive to facilitating arbitrage transactions among other country markets.

When examining the NPT values in the table(See also Table 3), it illustrates the shocks occurring in a country's market. Observing the shock cycles of countries throughout the considered period reveals that these cycles are distinct for each country, with the most shocks observed in the markets of Germany, Cyprus, France, Slovakia, and Finland. This situation demonstrates that shocks originating from a country capable of influencing global factors are not transmitted to all countries worldwide, but only to certain countries. In other words, macroeconomic similarities across markets also impact the propagation of shocks, as they lead to similarities in the housing market cycles of the Prozone. Furthermore, among the findings is that fiscal policies might have negative effects on housing markets in some countries, while being supportive for others. Therefore, the different responses of housing markets to monetary and fiscal policies indicate, first, an asymmetric relationship between markets and, second, heterogeneous characteristics. As a result, it emphasises the need to consider the asymmetry of housing price changes in European Central Bank policies.

Considering the left tail (τ = 0.05) and right tail (τ = 0.95) values, connectivity values for all housing markets have been predicted (See alsoTable 3and Table 4). In this estimation, the distinction between extreme negative shocks and extreme positive shocks, namely shocks that have an impact on the series, allows us to differentiate between the right and left tails of quantile connectivity. In this context, the estimated average connectivity values for different quantile values are presented in Tables 4 and 5, and these tables are presented in the appendices. When examining the findings within this framework, it becomes evident that the spread in both the right and left tails exceeds the median spread. In other words, while the median total connectivity value is 50.35%, the total connectivity index in the left tail (τ = 0.05) is 53.49% and that in the right tail (τ = 0.95) is 53.55%. This result is consistent with the finding that spillover effects defined as "bubble" have the same proportion of price changes as periods defined as stable (Hu, 2022). That is, the observed connectedness values in the tails are both different from and higher than the median value. First, the fact that the right and left tails are higher than the median is an indication of the reason why the spread is asymmetric in both directions. Second, for these countries, the relationships in the right and left tails are stronger. In other words, it signifies that these markets are highly interrelated during events or crises. Consequently, extreme negative/positive shocks have a significant influence on the connectivity system (Bouri et al., 2021)

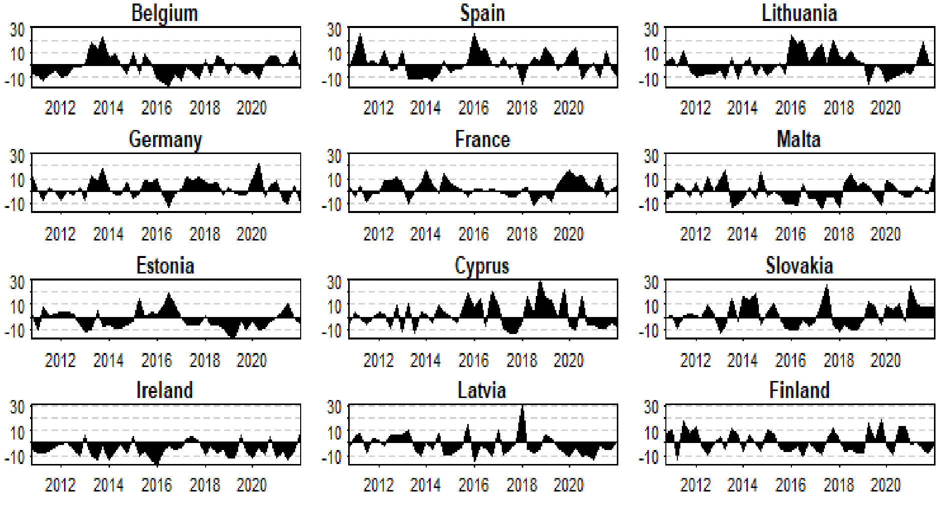
Because certain countries primarily act as net recipients or net transmitters of spread effects in both the right and left tails, the net spread patterns are mixed. Therefore, in the housing market connectivity system, during significant events and crises, the diffusion patterns in the left and right tails are different from the diffusion patterns in the median. Within this framework, the rates at which shocks spread and influence markets vary across different quantile values for countries. These results imply that shocks have a strong effect on the return-spillover system and that the net receivers and transmitters of shock spillovers also change. Hence, when considering the obtained results, it becomes evident that the quantile-VAR approach is more appropriate than the average-VAR approach. In other words, the Quantile VAR approach provides more detailed information regarding the connectivity of shocks within the system.

Figure 2: Dynamic Total Connectivity Estimated



According to the findings obtained from the Dynamic Total Connectivity Estimate using the Quantile VAR approach (See also Figure 2), the median dynamic total connectivity illustrates specific events occurring in certain years and their impact on housing market return series. When observing the TCI (namely the shaded black area), it becomes evident that the housing price market is significantly tied to events (approximately between 60% to 70%) and displays substantial fluctuations over time. In other words, the housing market is greatly influenced Fby factors such as crises, policy decisions, and pandemics. However, these influences do not lead to abrupt changes in the housing market. Considering the time period analysed, it can be said that the housing market crisis that started in the US in the period before 2012, the economic effects of the Covid19 pandemic that affected all countries globally, the increase in uncertainty about the future in the preferences and decisions of households, the high inflation rate all over the world in 2021, and uncertainty shocks also had an impact on the housing market.

Figure 3: Net Total Direct Connectivity Estimated



According to Net Total Direct Connectivity Estimated(See also Figure 3), depicts the general directional connectedness across all countries based on median values (represented by the shaded black region). In addition, a shaded area indicates the net shock transmitter country when it falls into positive values, whereas negative values correspond to net recipient countries. Furthermore, over time, any country's housing market can exhibit both scenarios (namely net transmitter or net recipient). When considering the estimated net total direct connectivity, in 2020, Lithuania, Belgium, Ireland, Malta, and Latvia received shocks from the housing markets of other countries, while Slovakia and France transmitted shocks to the markets of other countries. In each country, in different periods, markets respond low to shocks, whereas in other years, they respond high. Taking these findings into consideration, it can be concluded that all countries alternately act as shock receivers and transmitters at different periods. Hence, for different quantile values, the status of any market as a net taker or net giver changes over time. In this context, net return spreads change over time in all markets. However, no evidence has been found indicating that this variation arises due to geographical proximity in the connectedness effects among markets.

The static connectedness analysis fails to capture changes in the propagation effects of the housing market across all countries over time. In this context, the quantile-based average connectedness estimation demonstrates dynamically changing propagation effects in the housing markets at the median, right tail, and left tail values. In other words, to capture the time variability of the conditional distribution not only at the median but also in the return spreads at the right and left tails, an estimation based on VAR methodology is performed (Chatziantoniou et al., 2022). Within this framework, the obtained predictive results are presented in Figure 4.

Figure 4: Overall Dynamic Total Connectivity over Time and Quantile Values

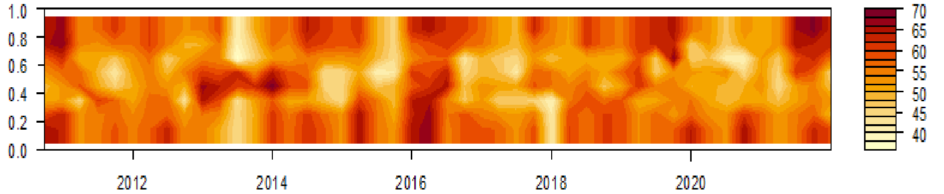


Figure 4 illustrates the overall dynamic total connectedness forecast for all countries included in the analysis. According to the findings of the analysis, darker colours in the figure correspond to higher levels of connectedness. Connectedness is very strong for both very negative housing market changes (below 40%) and positive changes (above 70%). Therefore, there exists a high degree of connectedness between the housing markets of these countries. In these countries, the connectedness effect increased in the years before 2012, 2016, 2018, and 2021.

Figure 7 in the Appendix shows that Germany, France, Finland, and Cyprus have the highest degree of connectedness when the dynamic total degree of connectedness for each country is considered. In other words, a shock in the housing market of these countries exerts an influential effect on the housing markets of other countries because of their elevated degrees of connectedness. Additionally, Belgium, except for the year 2015, Ireland in the period prior to 2016 and post-2020, Malta between 2016 and 2020, Estonia before 2015, and

Latvia in the periods of 2016-2017 and post-2020 act as net recipients of shocks. This implies that a shock occurring in the housing markets of other countries affects these countries' housing markets during the specified years. Therefore, considering the findings from the analysis, the findings from the estimation of overall dynamic aggregate connectedness over time and quantile values support the other findings and provide a more detailed picture of connectedness over time for each country.

4. Conclusion

This study enables us to research the interconnectedness of interaction among housing markets in Eurozone countries within the framework of the quantile VAR model, considering median(τ = 0.50) values in the right tail (τ = 0.95) and left tail (τ = 0.05). Based on the information explained earlier in this study, the interconnectedness between the markets of these countries should be considered as a new channel for both the cause and propagation of new macroeconomic shocks. In other words, shocks in the right and left tails have a greater effect on connectivity than shocks obtained from the median prediction. This situation demonstrates that relying solely on median-based predictors is not appropriate for examining the spread of returns associated with extreme positive/negative events.

The high interdependence of financial systems in the Eurozone leads to higher risks and volatility in the markets. Particularly, with financial institutions in these countries being overseen by the European Central Bank when considering median, left-tail, and right-tail values, it can be argued that both markets and household behaviours react differently to shocks. Therefore, it can be inferred that the varying sensitivities of financial institutions to common shocks, along with the diverse social, economic, and cultural differences in the markets, contribute to the differentiation in household behaviours and preferences.

The fact that the behaviour of households is different for each country under market conditions also implies that their expectations are also different. This is because news related to housing prices can lead households to adjust their expectations about housing prices in other countries. Therefore, despite homogeneous financial markets across countries, there are highly heterogeneous house price spillovers at the country level. This phenomenon also reveals that even with the implementation of the same monetary policies, household decisions have heterogeneous effects on housing markets at the country level. The effects on housing markets are different, given the general trend of monetary union towards increased linkages in trade, financial markets, and general economic conditions. More generally, the effect of financing costs on house prices has been growing over time. In this context, changes in long-term interest rates increase the borrowing costs of households and thus impact housing markets, indicating that monetary policy is also effective in these markets. Therefore, changes in interest rates cause intertemporal preferences of households and liquidity constraints to affect macroeconomic variables through the housing market.

While housing is perceived as a stable long-term investment and a reliable hedge against inflation for households, evidence indicates that during significant events and crises, there is a stronger interdependence among markets compared with normal periods. Therefore, it can be inferred that households are more sensitive to information dissemination during abnormal periods, and markets respond rapidly to this sensitivity. Therefore, we can say that households' sensitivity to information diffusion is also higher than in abnormal periods and that markets react quickly to this sensitivity. In this context, the high impact of both internal and external factors on housing markets increases market volatility. Therefore, it is important for policymakers to take measures to reduce external shocks and the size of spillovers.

The high volatility of housing prices for households can lead to perceptions of housing as a risky investment asset. In this framework, households' perception of housing as a risky asset will affect their consumption and investment decisions. Therefore, this necessitates a detailed analysis of the housing markets for them to be considered a reliable investment instrument. Hence, the varying effects of shocks at different quantile levels indicate that when households are forming their housing portfolios, they should consider not only the median value but also the values in the left and right tails. Economic uncertainty and unexpected events directly or indirectly affect housing market interdependence, and this impact varies across different quantile values. Considering the sector's backward and forward linkages and the macroeconomic effects of new investments to be made, the impact of macroeconomic policies will be asymmetric for the studied countries. In this context, policies addressing issues such as inflation and unemployment should consider the relationships between these housing markets.

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APPENDICES

Table 4: Average Commitment Estimated (τ = 0.05)

	Belgium	Germany	Estonia	Iceland	Spain	France	Cyprus	Latvia	Lithuania	Malta	Slovakia	Finland	FROM
Belgium	53,78	1,84	0,96	4,60	4,27	2,58	6,21	5,18	3,84	5,64	7,67	3,44	46,22
Germany	1,40	41,54	3,44	2,48	4,47	3,51	13,20	4,25	6,26	8,01	5,63	5,79	58,46
Estonia	0,96	4,07	51,24	5,65	2,73	5,07	3,85	6,34	4,48	7,84	5,61	2,16	48,76
Iceland	4,06	2,64	5,31	44,81	5,10	7,32	7,06	4,46	3,98	3,87	9,17	2,23	55,19
Spain	3,94	4,56	2,39	4,82	50,20	9,16	3,82	4,79	1,86	3,25	2,66	8,55	49,80
France	1,96	3,27	4,69	6,69	8,12	40,59	4,14	7,55	4,57	1,82	4,68	11,92	59,41
Cyprus	4,94	12,62	3,38	6,41	3,25	4,12	39,19	4,74	7,02	4,00	6,37	3,94	60,81
Latvia	4,30	3,81	6,57	4,43	4,84	8,23	4,71	45,26	6,87	1,82	5,28	3,87	54,74
Lithuania	3,13	6,62	4,26	3,96	1,48	4,91	8,13	7,13	47,90	1,53	4,12	6,82	52,10
Malta	5,79	8,93	7,46	4,14	3,24	2,06	4,87	2,07	1,84	52,73	5,20	1,67	47,27
Slovakia	7,31	5,65	5,49	8,43	2,65	4,48	6,87	5,20	3,53	4,90	44,05	1,45	55,95
Finland	3,01	6,43	2,07	1,92	7,91	13,16	4,32	3,69	7,60	1,68	1,40	46,80	53,20
TO	40,81	60,43	46,02	53,54	48,06	64,61	67,18	55,41	51,84	44,37	57,81	51,82	641,92
Inc. Own	94,59	101,97	97,26	98,35	98,26	105,19	106,38	100,68	99,74	97,10	101,86	98,62	cTCI/TCI
NET	-5,41	1,97	-2,74	-1,65	-1,74	5,19	6,38	0,68	-0,26	-2,90	1,86	-1,38	58,36/53,49
NPT	2,00	8,00	1,00	3,00	4,00	9,00	10,00	6,00	6,00	3,00	8,00	6,00	

Table 5: Average Commitment Estimated (τ = 0.95)

	Belgium	Germany	Estonia	Ireland	Spain	France	Cyprus	Latvia	Lithuania	Malta	Slovakia	Finland	FROM
Belgium	52,54	2,50	1,15	4,84	4,15	3,46	5,88	3,04	3,13	6,20	8,14	4,98	47,46
Germany	1,9	41,58	3,49	2,77	3,60	2,77	15,52	2,97	7,46	7,82	5,27	4,87	58,42
Estonia	1,22	4,36	56,54	5,72	3,42	6,41	3,24	2,50	4,72	4,44	4,72	2,70	43,46
Ireland	4,51	2,87	5,62	46,77	6,19	5,66	6,85	3,49	1,55	6,27	7,75	2,48	53,23
Spain	3,74	3,14	3,16	6,21	47,21	10,99	2,80	3,36	0,99	3,52	4,14	10,75	52,79
France	2,79	2,71	5,27	5,55	10,32	40,88	3,42	5,06	4,40	2,05	4,53	13,03	59,12
Cyprus	4,33	14,45	2,64	6,06	2,35	3,21	39,54	4,41	6,67	6,00	6,62	3,71	60,46
Latvia	2,97	3,03	2,41	4,14	3,81	6,37	4,72	52,90	8,52	2,62	4,10	4,42	47,10
Lithuania	2,67	8,80	4,31	1,96	1,16	4,70	8,25	7,26	48,55	1,56	2,92	7,87	51,45
Malta	6,44	8,98	3,82	6,41	3,66	2,49	7,18	2,96	1,86	51,35	3,32	1,52	48,65
Slovakia	7,83	5,92	4,64	6,85	4,07	4,66	8,03	3,76	2,51	3,20	47,54	0,99	52,46
Finland	4,24	5,54	2,12	2,32	10,15	13,29	4,32	3,69	7,67	1,66	1,01	44,00	56,00
TO	42,64	62,29	38,63	52,82	52,88	64,00	70,21	42,49	49,48	45,32	52,52	57,32	630,61
Inc. Own	95,18	103,88	95,17	99,59	100,09	104,88	109,75	95,39	98,02	96,67	100,06	101,31	cTCI/TCI
NET	-4,82	3,88	-4,83	-0,41	0,09	4,88	9,75	-4,61	-1,98	-3,33	0,06	1,31	57,33/52,55
NPT	2,00	8,00	0,00	6,00	6,00	10,00	11,00	3,00	4,00	2,00	8,00	6,00	

Figure 5: Net Total Direct Connectivity Estimated (τ = 0.05)

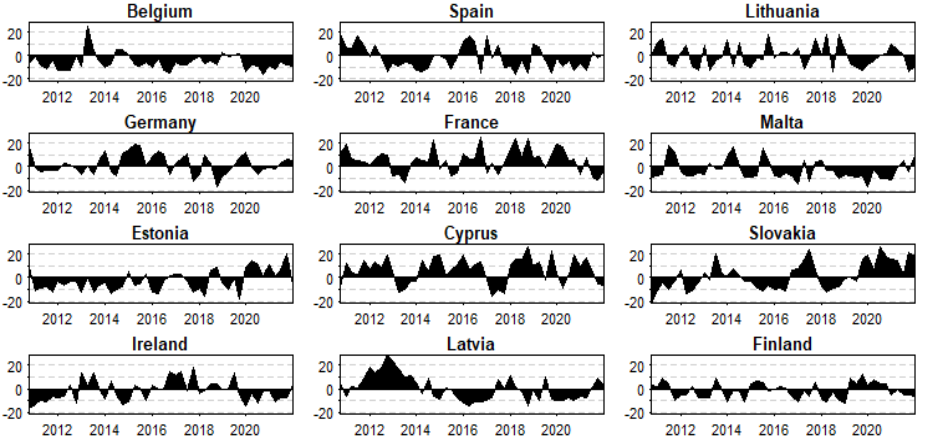


Figure 6: Net Total Direct Connectivity Estimated (τ = 0.95)

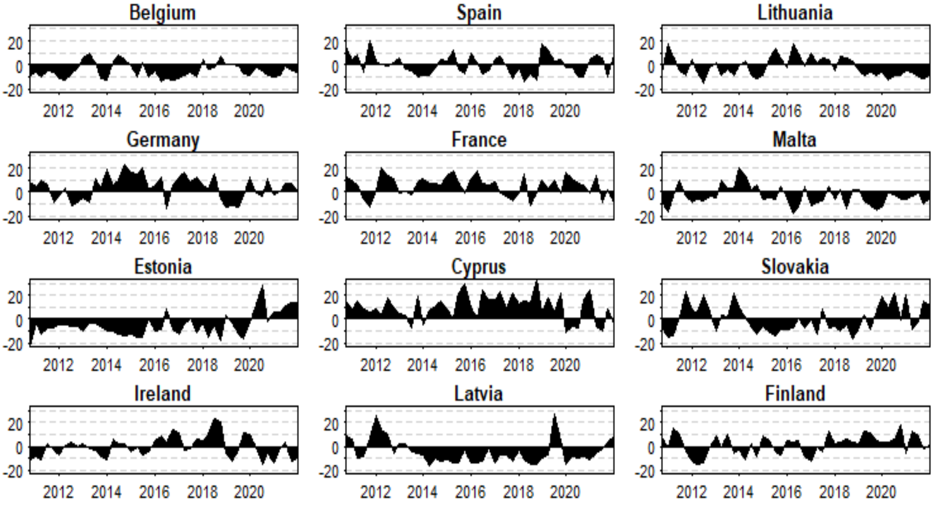
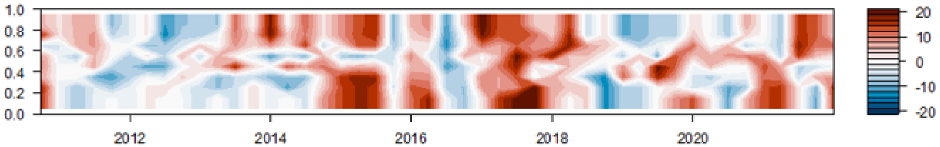
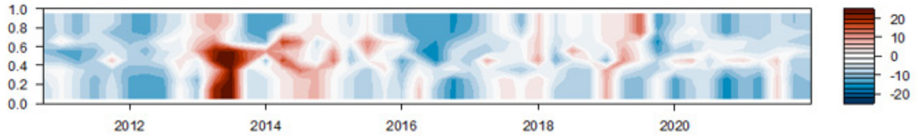


Figure 7: Overall Dynamic Total Connectivity by Country by Time and Quantile

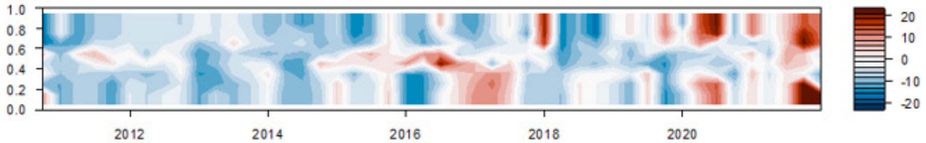
Germany



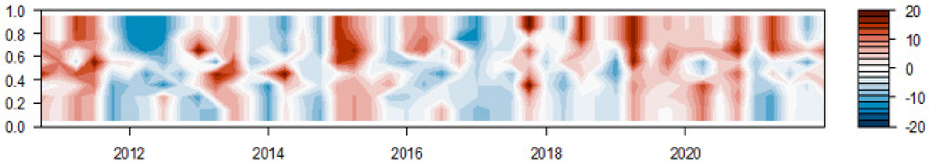
Belgium



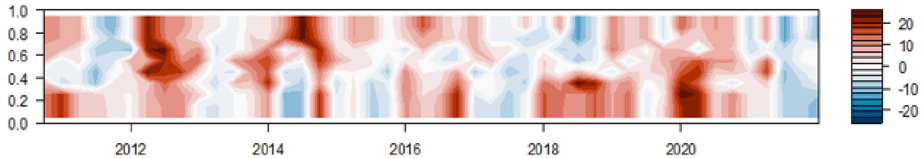
Estonia



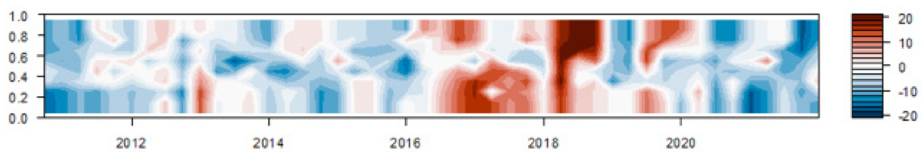
Finland



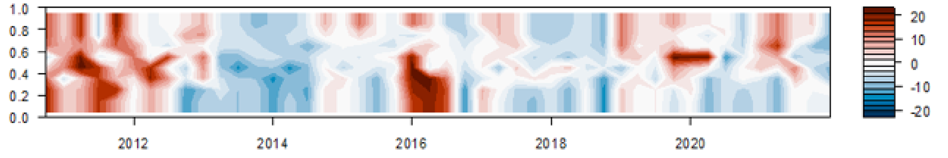
France



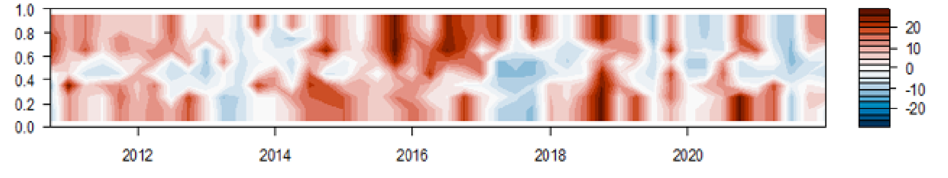
Ireland



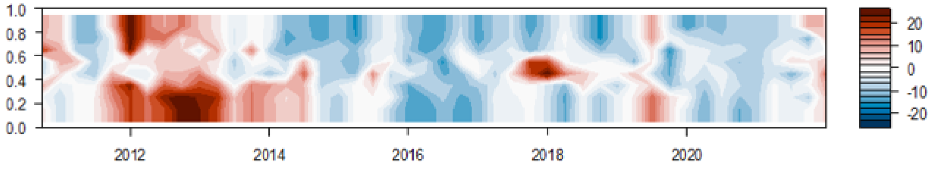
Spain



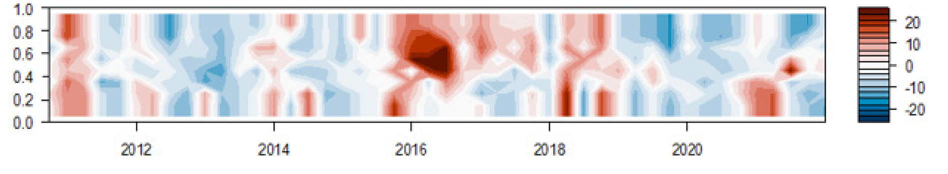
Cyprus



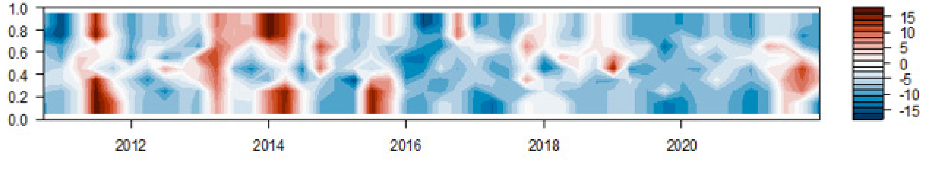
Latvian



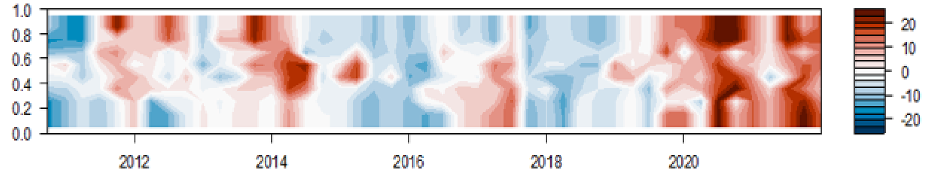
Lithuania



Malta



Slovakia



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RESEARCH ARTICLE

Aspects of Employment in Ottoman Waqfs Examples of Fatih, Yavuz Selim, and Süleymaniye Waqfs

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ABSTRACT

This study examines the role of Ottoman imperial waqfs as employment institutions, focusing on the salary register EV.HMH.1178, prepared for the Fatih, Yavuz Selim, and Süleymaniye waqfs in the early 18th century. By analyzing the administrative and financial oversight documented in this register, the article explores the redistributive functions of these waqfs and their contribution to sustaining long-term social and economic stability. Special attention is given to the intervention of the central office (Sadr-ı Âli Nezareti/Grand Vizier's Office) through an imperial decree and the classification of employee roles by workplace. This research contributes to the literature on waqfs by providing insights into their employment systems and administrative practices.

Keywords: Ottoman Waqfs, Employee, Salary Register, Waqf Account Book

JEL Classification: B11, B15, Z13

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1. Introduction

Ottoman imperial waqfs, established by sultans, their families, and high-ranking state officials, played a central role in social and economic life across both urban and rural areas (Barkan,1963a; Orbay,2017). These waqfs, with their public buildings (hayrat) and revenue-generating properties, significantly contributed to urban social life through complexes (külliye), which were often shaped around a mosque and included facilities such as madrasas and imarets (soup kitchens) and provided a wide range of social services to the public (Barkan, 1993; Gökçen, 1946; İnalcık,1990; Oded, 1992; Singer, 2002; Thys-Şenocak, 2009; Yediyıldız, 2012).

These waqfs generated substantial revenue based on real estate holdings and taxes collected in rural and urban areas. The largest waqfs even had annual revenues that reached millions of silver coins (Arslanboğa, 2015; Barkan, 1963a; Güran, 2006; Orbay, 2011; 2014; 2017; Pantık,2014). This financial power enabled imperial waqfs to play a central role in both economic and social area. Their wealth allowed waqfs to fund essential services and perform a crucial redistributive role, such as paying salaries to hundreds of employees and supporting various beneficiaries (zevâid-horan), including those in need, through their surplus (Barkan, 1993; Faroqhi, 1981; 1988a-b; Güran, 2006; Orbay, 2007a; Shefer-Mossensohn, 2003; Singer, 2002).

Orbay (2017:146) refers to this system as the "waqf economy," a concept crucial for understanding the economic and social dynamics of the Ottoman Empire. One of the best ways to understand the waqf economy is by analysing the official documents of these waqfs. Studies have shown how natural disasters, financial crises, and social uprisings are reflected in waqf documents, particularly waqf account books, demonstrating their usefulness for exploring economic and social history (Barkan, 1975; Faroqhi, 1988a-b; Güran, 2006; Orbay, 2013a; 2018; 2019; Pantık, 2021). The account books and müfredat (detailed) registers of waqfs are particularly valuable in tracing their operations and resilience across centuries (Orbay,2005).

This study examines the role of sultanic waqfs as employment institutions by analysing the accounting records of the Fatih, Yavuz Selim, and Süleymaniye waqfs. It specifically focuses on müfredat (detailed) register EV.HMH.1178, which was prepared as a salary register (defter-i vazifehorân) for these three sultanic waqfs. Let us first describe müfredat registers. These registers were maintained in addition to account books, particularly for major waqfs. Various types of müfredat registers were kept for different purposes. For example, uncollected revenues of waqfs were recorded in arrear registers (defter-i bakâyâ-i mukataat), inventoried goods of storehouses for imarets were documented in storehouse accounts (defter-i muhasebe-i anbâr ve kilâr), and salary payments of waqf employees were detailed in registers (defter-i vazifehorân) (Barkan, 1963a:254; Orbay, 2005; 2013b).

Müfredat register EV.HMH.1178 is a bound salary book (defter-i vazifehorân) containing three separate salary registers for the three sultanic waqfs. It was prepared to audit the employees of these waqfs and is dated 4 February 1702. The register consists of 89 double-sided pages (Karademir,2022:319). Each waqf's salary register began with an introductory paragraph, as is typical in waqf account books, providing details about the waqf (Barkan, 1963b; 1971; Orbay, 2007b; 2013b). Moreover, since these registers were specifically maintained to audit employees, they also included the names of the auditing members. For instance, the Fatih Waqf's salary register begins with the following passage:

"Defter-i yoklama-i vezaifanı…ebu-el Feth Sultan Mehemmed Han tabe serahu der nezaret-i hazreti Sadr-ı Âli ve ma'rifeti veziri mükerrem Osman Paşa kaimmakamı Asitane-i Saadet ve Abdürrahim Efendi Müfettiş-i Evkaf-ı mezbur ve Abdullah Efendi Halife-i muhasebe-i evvel ber muceb-i emr-i âli ve Rikab-ı Hümayunu şevketmakrun tahrir şüd mucebi'l va'ki fi 6 Ramazan 1113".

This paragraph reveals that the registers were prepared under the Sultan's command, where the audit would be conducted under the supervision of the Sadr-ı Âli Nezareti (Grand Vizier's Office) and overseen by Osman Paşa, the kaimmakam (Grand Vizier's Deputy) in Istanbul. Abdurrahim Efendi, as müffettiş-i evkaf (Inspector of the Waqfs), led the inspection, while Abdullah Efendi, as Halife-i muhasebe-i evvel (Chief Accounting Deputy), was responsible for maintaining and verifying the financial records (EVHMH.d.1178:3b).

Following the introductory paragraph, the employees were listed under their respective offices of employment. At the end of each register, there was a summary detailing the total payments for the year 1702. For instance, the Fatih Waqf's salary register was organised into four main categories. The first category included payments allocated according to the waqfiyye (endowment deed), noted as ber muceb-i şart-ı vakıf (in accordance with the condition of the waqfiyye/founder of the waqf). The second category comprised employee payments determined during the tahrir (survey) conducted by the Kadi (judge) of Istanbul, pursuant to the Sultan's decree in 1663 (Hijri 1073). A note at the top of the record stated: *"lüzumu olub muhaddes yekûnu mukarrer olan cemaatlerdir an vacib sene 1073 Dıhki Efendinin tahrir-i şüd ferman-ı âli."* This indicated that several muhdes (newly added) positions, which were outside the scope of the waqfiyye, were evaluated. Under the Sultan's decree, Dıhki Efendi assessed these positions and determined which were necessary for the waqf. Payments in this category were, thus, allocated to the muhdes positions deemed essential during the 1663 survey. The third category included fixed meat payments (baha-i lahm), also allocated in 1663. Finally, the fourth category included payments for muhdes positions recorded in 1702 (EVHMH.d.1178:18a-19b).

This article aims to contribute to the literature on Ottoman waqfs by examining the intervention of the Nezaret in the oversight of waqf employees within the scope of an imperial decree, while analysing the redistributive role of three major sultanic waqfs as both social welfare entities and employment systems. The article also explores the roles of employees within their respective workplaces, such as mosques or imarets, as recorded in the 1702 salary registers.

The Fatih, Yavuz Selim, and Süleymaniye waqfs, as major institutions, have garnered significant academic interest. Ömer L. Barkan (1963b; 1971), in his pioneering works, published the account books of the Fatih Waqf for 1489 and

1490, as well as those of the Süleymaniye Waqf for 1585 and 1586, providing exact transliterations. Kayhan Orbay (2011) expanded on Barkan's work by conducting a financial analysis of the Süleymaniye Waqf in the 16th century, while Tevfik Güran (2006) evaluated the account books of the Süleymaniye Waqf, including those from the 17th and 18th centuries. Fahri Unan (2003) also studied various documents of the Fatih Waqf, including waqfiyyes and account books, spanning a period from 1489 to the early 1900s. Building on these foundational studies, this article offers an examination of the salary registers of the three sultanic waqfs, shedding light on their administrative and financial structures.

2. Employment in Fatih, Yavuz Selim, and Süleymaniye Waqfs

The Fatih, Yavuz Selim, and Süleymaniye waqfs were major institutions of employment in Istanbul, supporting a wide range of public buildings, including mosques, madrasas, imarets, and hospitals. These waqfs managed not only their primary complexes but also additional mülhak (annexed) institutions, thereby expanding their reach and impact. For instance, these waqfs collectively managed twenty-five madrasas and annexed an additional fourteen, supporting a total of thirty-nine madrasas, twenty-five mosques and masjids of varying sizes, five primary schools, and two zaviyas (dervish lodges) (EV.HMH.d.1178, pp. 3a,16a, 17a-b, 18b, 34a, 35b, 50a, 72a-b,74a-b, 75b). Beyond these, they maintained mausoleums, imarets, dârüşşifâs (hospitals), tâbhanes, libraries, muvakkithânes (clock rooms), caravanserais, and bathhouses (hammams), employing personnel in nearly ninety facilities.

By 1702, the three sultanic waqfs collectively employed individuals across 2,148 duties and provided stipends to 156 zevâid-horan (beneficiaries). However, the salary registers leave certain details unspecified. For example, Fatih's Sahn-ı Seman madrasas and the Yavuz Selim madrasa only recorded total payments without specifying the number of individuals employed. Earlier records provide some insight: two accounting books from 1489 and 1490 for the Fatih Waqf show that 160 individuals, including 120 students, received payments from eight madrasas (Barkan, 1963-b). Similarly, the Yavuz Selim Waqf's account book for

1628–1630 lists 24 individuals employed in its madrasa (MAD.d.4914, p.2a). Additionally, the salary registers mostly do not specify the number of personnel employed in mülhak (annexed) madrasas and mosques, suggesting that the actual number of employees was likely higher than the records indicate.

The daily payments to personnel in the three sultanic waqfs amounted a total of 15,601 akçe, equivalent to an annual sum of 5,616,360 akçe. The Fatih Waqf distributed 3,949 akçe daily, the Yavuz Selim Waqf allocated 4,767 akçe, and the Süleymaniye Waqf provided 6,885 akçe[1]. These payments covered the salaries of regular personnel assigned according to the waqfiyye, as well as additional payments for muhdes (newly added) positions, which were created outside the scope of the waqfiyye (EV.HMH.d.18-b,49b,89b).

As shown in Table 1, muhdes positions were recorded in both 1663 and 1702 in the Fatih and Süleymaniye waqfs. While the specific reasons for these additions remain unclear, the icmal (synoptic) registers of the Fatih Waqf indicate that the waqf employees were audited by the Sultan's decree under the supervision of the Kadi of Istanbul, and the necessary positions were identified in 1663. Consequently, the Fatih Waqf continued to allocate 474 akçe daily, and the Süleymaniye Waqf allocated 887.5 akçe daily for the remaining muhdes positions. However, it is uncertain which positions were deemed unnecessary for the waqfs.

Table 1: Daily Salaries in Fatih, Yavuz Selim, and Süleymaniye Waqfs in 1702

	Fatih Waqf	Yavuz Selim Waqf	Süleymaniye Waqf
Waqfiyye	1,867	1,429	3,071
Muhdes/1663	474	-	887.5
Muhdes/Add. Pay.	1,059	433	842
Muhdes/1702	549	2,905	2,084.5
Total payment	3,949	4,767	6,885

Source: BOA EV.HMH.1178 p. 18a, 49b, 89b – **Currency**- Akçe

[1] When the daily salaries of the offices in the Süleymaniye Waqf were calculated individually, the total came to 6,875.5 akçe, which is 9.5 akçe less than the amount stated in the original document (Karademir,2022:322).

Additionally, the employees of the Fatih Waqf were entitled to an in-kind allowance of 240 vukiyye (equivalent to nearly 308 kg)[2] of meat, as specified in the waqfiyye. In 1663, the Kadi of Istanbul set this allowance at 1,059 akçe and distributed it among the madrasas and waqf employees. Similarly, the Süleymaniye Waqf's lahmiyye (meat allowance) was valued at 842 akçe and allocated accordingly (Karademir, 2022:322).

Eventually, these decisions continued until 1702. Nonetheless, it is evident from the salary registers that between 1663 and 1702, additional muhdes positions were created. Furthermore, it is noted that the meat allowances caused disagreements among the Fatih waqf employees due to the increasing number of personnel in 1663. The originally statement was as follows:

"…vakfiyye-i mâmul behada mastur ve suhtegân ve sâir hüddamanın şurayalarının vaz olunmak üzere iki yüz kırk vukiyye lâhm tâyin olunub lâkin mûrür-ı eyyamiyle cami-i şerifin vezâif-i muhdesatı ziyâde olub ve suhtegân ve hüddam-ı mezkûrların şurayalarında vaz' olunan iki yüz kırk vukiyye lahm için mezkûrların beynlerinde menâzi vâki olmağlar…" (EV.HMH.d. 19-b).

As a result, by the Sultan's decree, it was decided to audit the employees in the Fatih, Yavuz Selim, and Süleymaniye waqfs under the supervision of the Sadr-ı Âli Nezareti.

Research on the imperial waqfs reveals that increases in the number of employees or granting imaret rights to individuals out of the waqfiyye were not uncommon (Barkan, 1993:260; Eroğlu-Memiş, 2020:123; Oded, 1992:176; Pantık, 2021). Such changes were often accompanied by interventions via sultanic decrees issued by the central office (Oded, 1992; Pantık, 2021:75-76). Notwithstanding, the exact reasons for these increases remain unclear.

Barkan (1993:260) suggests that the rise in employee numbers may have been driven by the unemployment pressures of the 17th century. In the Fatih, Yavuz

[2] 1 vukiyye (okka)= 1,282 kg (İnalcık,2004:446)

Selim, and Süleymaniye waqfs, these increases could also have been attributed to the expansion of the waqfs through the addition of madrasas, mosques, and masjids annexed as mülhak properties. Another factor may have been the creation of muhdes (newly added) positions to address the evolving waqf services, such as appointing dersiâm or mevlevihan in mosques during the 17th century. Regardless of the reasons, these changes clearly led to disagreements among waqf employees over the distribution of the meat allowance in the Fatih Waqf 1663.

After providing an overview of the salary registers of the Fatih, Yavuz Selim, and Süleymaniye waqfs, we can now examine the detailed records in the register in the following section. In this study, the waqf personnel in the salary registers are analyzed under six categories: personnel in office of management, theological schools (madrasas), mosques, imaret (soup-kitchens), dârüşşifâs (hospitals), and zevâid-horan (beneficiaries from waqf income surplus).

2.1. Office of Management (Cemaat-i Zabitan) in the Salary Registers

The waqfs were managed by a mütevelli (Öztürk,2006). In the Süleymaniye waqfiyye, the mütevelli is described as the person responsible for managing the waqf's income, overseeing public buildings, arranging repairs when needed, and ensuring that waqf employees performed their duties (Kürkçüoğlu,1962:37). Particularly, in imperial waqfs, serving as a mütevelli was considered a privilege. Those who gained experience in these roles were often promoted to the management positions of larger and more prestigious waqfs (Orbay, 2017:144).

The primary responsibility of a mütevelli in imperial waqfs was to ensure compliance with the rules outlined in the waqfiyye. These waqfs were closely supervised by central offices, including the offices of the Sadrazam (Grand Vizier), Şeyhülislam (the head of the Ottoman religious-legal hierarchy), and most commonly, the Darüssaade Ağası (chief black eunuch). Financial decisions, such as renting real estate or authorising major repairs to waqf buildings, were made by these central offices (Orbay, 2013b:45; 2017:145; Pantık, 2021:55).

The waqfs of Fatih, Yavuz Selim, and Süleymaniye were supervised and audited by the office of the Sadr-ı Âli Nezareti (the office of Grand Vizierate).[3] This practice was initiated by Fatih Sultan Mehmed (Mehmed II), who placed the management of his waqf under the supervision of his grand viziers—a model later adopted by subsequent rulers. This marked the establishment of the Sadr-ı Âli Nezareti. (Öztürk, 1995:46; Kahraman, 2006:2). The mütevelli did not manage waqfs alone but worked alongside offices listed in waqf accounting books. The kâtib (scribe) played a crucial role, regularly keeping official records. In imperial waqfs, which had diverse income sources and numerous public buildings (hayrat), specialised kâtibs were assigned responsibilities at institutions like imarets and darüşşifas (Barkan, 1963a:280-282). Additionally, offices such as the câbiyan (revenue collectors) and kâtiban, meremmetis (repairmen), and rah-ı ab (water canal repairmen) ensured that waqf services continued without interruption.

In 1702, the mütevelli of the Süleymaniye Waqf received a daily salary of 100 akçe, the highest among the three waqfs addressed in this article. Hüseyin Ağa, the mütevelli of the Fatih Waqf, earned a daily salary of 50 akçe with an additional fixed payment of 2 akçe. Meanwhile, El Hac Ahmed, the mütevelli of the Yavuz Selim Waqf, earned 85 akçe daily, with 70 akçe recorded as kadim (previously established) remaining notes, as muhdes, which meant detected outside the waqfiyye in the records (EV.HMH.d.1178:3a,20b).

The salary register of the Süleymaniye Waqf listed six kâtibs. The kâtib-i evvel (head scribe) received 20 akçe per day, with an additional 2 akçe payment, while other specialised kâtibs, such as the kâtib-i anbar (warehouse scribe) and kâtib-i meremmat (repair scribe), earned between 4 and 10 akçe. These roles were categorised under the office of zabitan (office of management) (EV. HMH.d.1178:51a-b). In comparison, the kâtib-i evkafs of the Fatih and Yavuz Selim waqfs received a daily salary of 10 akçe each (EV.HMH.d.1178:3a,20b).

[3] According to an account book of the Sadr-ı Âli Nezareti, which was prepared shortly before the establishment of Evkaf-ı Hümayun Nezareti (the Ministry of Waqfs), there were 200 waqfs registered within the office. Among these, three were the Fatih waqf (Fatih Külliyesi Vakfı), Yavuz Selim waqf (the Sultan Selim-i Kadim Vakfı), and Süleymaniye waqf (Süleymaniye Külliyesi Vakfı) (Pantık,2021:53-footnote 101).

The salary registers of the three sultanic waqfs also detailed the large offices of câbiyan and kâtibân. These offices included 63 individuals in the Yavuz Selim Waqf (33 managing revenues in Rumelia and 30 managing those in Anatolia), 30 in the Süleymaniye Waqf, and 20 in the Fatih Waqf[4] (EV.HMH.d.1178:39a,81a).

2.2. Theological Schools (Madrasas) in the Salary Registers

A madrasa was an educational institution in the Islamic world, often associated with religious learning but offering a broad curriculum, especially in the Ottoman Empire. Throughout Ottoman history, these institutions served as essential educational centres with a profound impact on both the state and society (İpşirli, 2003). The Ottoman ulema (scholar) class was trained in madrasas and could later be appointed as müderris within the madrasas, or in religious roles such as hatib (preacher) in mosques, kadis (local judges) in courts, or kâtibs in state institutions (Baltacı, 1976:19). Additionally, madrasas played a crucial role in preparing future high-ranking state officials. For instance, research on the Sahn-ı Seman madrasas reveals that between the late 15th and mid-16th centuries, out of 105 müderris, 28 went on to become kadis (judges), 7 advanced to the rank of Şeyhülislam (chief jurist), 5 became sanjak müftis, and one rose to the position of the Grand Vizier (Unan, 1999:90).

Sahn-ı Seman madrasas established by Fatih Sultan Mehmed after the conquest of Istanbul were among the most prominent, and these included eight schools, four located on each side of the Sultan's Mosque within the Fatih Complex. Each madrasa contained nineteen rooms: two for muids (assistants to the müderris), fifteen for students, and two for servants. Behind the Sahn-ı Seman madrasas, the Fatih Complex included an additional eight madrasas known as tetimme madrasas, which prepared students for the Sahn schools (Baltacı,1976:23; Unan, 2003:63-66). Records indicate a stipend of 6 akçe for a hafız'ül-küttab (librarian) and 4 akçe for the kâtib, suggesting the presence of a library in the tetimme madrasas

[4] In the Fatih Waqf's salary register it was named as the office of câbiyan ve mutemedan and included only one kâtib.

(TSMA.d.3882:2a, 3b).[5] Both positions were recorded under the office of mosque (cemaat-i müteferrika-i camii şerif) in the accounting book of the waqf (EV. HMH.d.1178:4b). Some scholars concluded that books initially located in madrasas may have been moved to the mosque during the reign of Sultan Bayezid II. (Erünsal, 2018:84-85; Unan, 2003:71)

Fatih's waqfiyye stipulated that each müderris in eight madrasas would receive a daily salary of 50 akçe, each muid would receive 5 akçe, each student would receive 2 akçe, and two servants in each madrasa would also receive 2 akçe (TSMA.d.5882:2a). On the other hand, the 1489 and 1490 accounting books for the Fatih Waqf indicate that two müderris received an increased daily salary of 80 akçe marked as zevâid, meaning their salaries exceeded the waqfiyye's stipulated amount by 30 akçe- while another müderris received 60 akçe, also noted as zevâid (Barkan, 1963b).

Until the mid-16th century, the Sahn-ı Seman madrasas were the most prestigious (Ünver,1942), accommodating 120 students at a time. According to the salary register, the staff and students in each madrasa received a total of 103 akçe with an additional supplementary payment of 116,5 akçe. Additionally, the suhtegân madrasa paid a daily sum of 33 akçe, noted as lahmiyye (meat payment) (EV.HMH.d.1178:3a-b).

When Sultan Süleyman built his complex, he followed a similar approach to that of Fatih Sultan Mehmed, constructing six madrasas around the mosque. Of these, four were dedicated to theological education, one focused on the study of Hadith (Dârül-hadis), and one served as a medical school (medrese-i tıb). In Süleymaniye's waqfiyye, the müderris in the four theological schools were allocated a daily salary of 60 akçe each, those in the hadith school were allocated 50 akçe, and the müderris in the medical school were allocated 20 akçe. Similar to the Sahn-ı Seman madrasas, each madrasa was expected to educate 15 students,

[5] The date of this this waqfiyye, first published by Süheyl Ünver, is unknown. Ünver (1938:39) suggested that this waqfiyye might belong to the 17th century.

each receiving a daily stipend of 2 akçe, while the medical school accommodated eight students, also with a daily stipend of 2 akçe for each (Kürkçüoğlu, 1962). Together, these madrasas collectively accommodated 83 students. Additionally, Sultan Süleyman built a madrasa in honour of his father, Yavuz Sultan Selim, in 1548-49, and it was part of the Yavuz Selim Complex (Baltacı, 1976:537; Yüksel,2009).

In the salary register, müderris and student payments in the Süleymaniye Waqf matched the waqfiyye's specifications. In addition to this, for Darülhadis and four madrasas, a daily baha-i taam (fixed food payment) of 117 akçe was provided, while the medical school received 58,5 akçe (EV.HMH.d.1178:50a-b).

According to the salary register, the Yavuz Selim Waqf paid 112 akçe for müderris and students, with an additional 97 akçe noted as lahm-ı madrasa (meat payment) (EV.HMH. d.1178:20a,49b). In 1628, the number of madrasa staff was 24, and they were paid 111 akçe according to the account book (MAD.d.4914:2a).

In the salary registers of three sultanic waqfs, additional madrasas were funded by these waqfs outside the provisions outlined in the waqfiyyes. The Fatih waqf supported three madrasas: Kalenderhane with 17 students, and Efdalzade and Molla Gürani, each with 10 students madrasas (EV.HMH.d.1178:3a; Unan, 2003:148). Kalenderhane was reportedly one of the eight churches converted by Fatih Sultan Mehmed into a mosque or madrasa (Baltacı, 1976:267; Unan, 2003:148-149), although there is no record of it in the accounting books of 1489 and 1490.

Additionally, the Yavuz Selim Waqf funded six mülhak (annexed) madrasas: İbrahim Kethüda, Kirmasti, Mehmed Ağa, Tahtakadı, Üçbaş, and Yarhisar. Finally, the Süleymaniye Waqf provided salaries for five madrasas: the Fatma Sultan, Hafıziyye, Hakaniyye, Süleyman Subaşı, and Şeyhülharem madrasas (EV.HMH. d.1178: 35a-b, 50a).

The salary registers of the three sultanic waqfs indicate that they collectively funded 39 madrasas, including preparatory schools (medrese-i suhtegân) in the

Yavuz Selim and Süleymaniye waqfs, provisions, with a total payment of 1,352,760 akçe including supplementary payments in 1702 (EV.HMH.d.1178:48b,76b).

2.3. Mosque Personnel in the Salary Registers

In the Ottoman Empire, mosques, sibyan mektebi (primary schools), and tekke/zaviyas (dervish lodges) served not only as places of worship but also as centers for religious services and public education. Mosques held particular significance in social life, acting as central gathering spaces for Muslim neighbourhoods (Önkal-Bozkurt,1993). This role become even more pronounced when a mosque was constructed by an Ottoman sultan, as it came to symbolise the sultan's authority and presence within the community.

In the salary registers of the three sultanic waqfs, individuals serving in the sultanic mosques were categorised under the office of the mosque staff in a manner similar to the classification found in waqf accounting books, depending on their specific duties (Barkan, 1993; Faroqhi, 1988b; Orbay, 2013b). These duties were broadly classified into subcategories such as personnel performing religious services and supporting mosque functions (cemaat-i müteferrika-i camii şerif), staff responsible for the upkeep and maintenance of the mosques, and duagûs (jûz/surah reciters).

The most important roles in religious services were held by hatibs and vaizs (preachers), both of whom addressed the congregation during the Friday prayers. The primary distinction between them lied in the hutbe (the sermon delivered by the hatib), which is a compulsory part of the Friday prayer and was traditionally conducted in Arabic in Ottoman mosques, whereas the vaiz's sermon was not mandatory (Baktır, 1998; Zengin, 2008:379-380). In the Süleymaniye Mosque, this new role of vaiz, following Hanafi teachings, was authorised to deliver sermons during the Friday prayers, religious holidays, and holy nights (Necipoğlu-Kafadar, 1985:98). According to the 1702 salary registers, the hatib in the Fatih Mosque received 30 akçe, while the vaiz received 50 akçe (EV.HMH. d 1178:3a). In the Yavuz Selim Mosque, the hatib earned 25 akçe, and the vaiz earned 35 akçe (EV.

HMH. d.1178:20b). In the Süleymaniye Mosque, the hatib was paid 45 akçe, and the vaiz was paid 40 akçe (EV.HMH. d.1178:50a). Additionally, the office of müezzins (cemaat-i müezzinan), who called the faithful to prayer, included 12 müezzins in the Fatih Mosque and 24 in the Süleymaniye Mosque (EV. HMH.d.1178:5b,52b).

The salary registers for the three sultanic waqfs also list the şeyh (scholar) of the dârülkurrâs under cemaat-i müteferrika-i camii şerif. The dârülkurrâs were often established around sultanic mosques and served as places for teaching the recitation of the Quran (Bozkurt, 1993). Abdullah Efendi, the şeyh of dârülkurrâ in the Fatih Waqf, received 10 akçe, while Hafız Ahmed Efendi received 15 akçe in the Yavuz Selim Waqf. The Süleymaniye Waqf, by contrast, had a separate building for the dârülkurrâ within the complex, where the şeyh, Hüseyin Efendi, was paid 25 akçe including 10 akçe designated for student support (EV. HMH.d.1178:4b, 20a, 51b).

Another significant role in religious services was the dersiâm, a position that emerged in the mid-17th century. The dersiâm taught madrasa students and held public lectures (İpşirli, 1994a), while the Mesnevi-hân (Mesnevi reader) also became recognised as a religious position in Ottoman mosques. In the Yavuz Selim Waqf, a dersiâm received a daily salary of 10 akçe, while in the Süleymaniye Waqf, a dersiâm earned 30 akçe, and a mesnevi-hân earned 20 akçe. All records in the register were written down as muhdes since they were assigned outside the scope of the waqfiyye (EV.HMH.d.1178:6a, 20a, 51b). The importance of these positions laid in their direct contact with the public. Not only did they provide essential religious services, but they also shaped social life.

Beyond these primary roles, there were various other positions within cemaat-i müteferrika-i camii şerif that supported mosque functions, including the muvakkit (timekeeper), hâfız-ı kütüb (librarian), kâtib-i kütüb (library scribe), and mücellid (bookbinder). Staff members in these roles in the three sultanic mosques received a daily wage of 5 to 10 akçe, as noted in the salary registers (EV.HMH.d.1178:4b, 20a, 50a).

Furthermore, additional staff members were tasked with maintaining in the mosques, lighting candles, sweeping floors, and opening and closing the doors of waqf buildings (cemaat-i kayyıman, siraciyan, bevvaban). In the salary registers of the three sultanic waqfs, these roles were typically recorded under separate offices, with daily salaries ranging from 3 to 5 akçe. Within the Fatih Mosque, there were 11 individuals in these roles in total, while there were 16 in the Yavuz Selim Mosque and 31 in the Süleymaniye Mosque (EV.HMH.d.1178: 5a, 21a, 53b).

Finally, the office of duagûs in the mosques deserves mention. Given that the majority of mausoleum personnel were duagûs, they are best evaluated together under the same title, as duagûs largely performed similar roles across both mosques and mausoleums.

Office of Duagûs in the Mosques and Mausoleums

In the Ottoman Empire, duagûs held the responsibility for conducting prayers and Quranic recitations, especially within the framework of waqfs (İpşirli, 1994b). These duagûs were often organised into sizable groups, either explicitly specified in the waqfiyyes or designated at a later stage. They were notably active within the mosques and mausoleums affiliated with the Fatih, Yavuz Selim, and Süleymaniye waqfs, where the salary registers reveal that these groups operated as distinct duagû communities. Their primary duties included reciting Quranic verses (devirhân, eczahân, mustahfız), specific surahs (Enamhan, Yasinhan, Tebarekehan), and counting rosary beads with designated holy phrases (müsebbih, salavati). Additionally, they prayed for the souls of the waqf founders (musalli) within their respective communities.

The presence of large duagû groups in Ottoman waqfs can be traced back to the 15th century, as evidenced by Fatih Sultan Mehmed's 1470 waqfiyye (Beyatlı, 2013). The Süleymaniye waqfiyye reveals that duagûs congregated in mosques and mausoleums, where they conducted collective prayer sessions (Kürkçüoğlu, 1962). The stipends received by duagûs in the three waqfs were generally consistent. For instance, hafızes (individuals who memorised the Quran) within the devirhan groups received daily stipends ranging from 3 to 5 akçe. Musallis and those responsible for reciting specific surahs from the Quran, such as Enamhân, received daily stipends between 5 and 7 akçe, while others typically received a daily stipend of 2 akçe. The titles of duagûs in the registers included efendi, şeyh, seyyid, halife, and hafiz although some duagûs were mentioned by name alone. According to the salary registers, there were a total of 83 duagûs in the Fatih Waqf, 458 in the Yavuz Selim Waqf, and 524 in the Süleymaniye Waqf (including duagûs in the zaviya and Cihangir Mosque). They worked in the mosques, mausoleums, and the Hakim Çelebi zaviya. The presence of eczahans played a significant role in the expansion of the number of duagûs within the waqfs. For example, the salary registers for the Fatih Waqf reveal a relatively small number of eczahans. Although the waqfiyye for the mausoleum of Fatih Sultan Mehmed initially specified 90 eczahans (TSMA.d.3882:3b), the salary registers listed only 22 individuals (EV.HMH.d.1178:10a-b,11b). Additionally, an examination for the accounting registers of the Fatih Waqf for 1489 and 1490 reveals 36 eczahans with a stipend of 1,5 akçe, organised into three groups within the mausoleum (Barkan, 1963b). Furthermore, 20 eczahans assigned to the Fatih Mosque in the waqfiyye did not appear in the records (TSMA.d.3882:2b).

In contrast, the situation differed in the Yavuz Selim Mosque, where 96 eczahans were documented, and in the Süleymaniye Mosque, where 124 eczahans were present. This pattern also extended to the mausoleums. In the Yavuz Selim Complex, there were 126 eczahans for the mausoleums of Yavuz Sultan Selim, Hafsa Sultan, and Şezadegân, along with 65 mustahfız who not only recited the Quran but also served as guardians. In the mausoleums of Kanuni Sultan Süleyman and Hürrem Sultan, a total of 258 eczahans and mustahfız were recorded.[6] The eczahans in Ottoman waqfs contributed not only through Quranic recitation but also by creating a vibrant and spiritual atmosphere in these buildings.

Many of the duagûs were originally appointed through waqfiyyes, although some were later assigned as muhdes, or newly appointed beyond the scope of

[6] EV-HMH-d,1178, vr. 23b,24a-b, 25a-b,27a,28a-b,29a-b,30a,31a-b,32a-b,33a-b,34a-b,62a, 63a-b,64a-b,65a-b,66a-b67a-b,68a-b,69a-b,70a-b,71a

the original waqfiyye. For example, the registers indicate a group known as cemaat-i musalliyan ve Enam ve Yasin ve Fetih ve İhlas-hân-ı muhdesat-ı mezkûreyn, which included 82 newly designated duagûs in the Yavuz Selim Waqf. However, individuals with identical responsibilities were also present.

Finally, 39 individuals in the Fatih Waqf and 162 individuals in the Süleymaniye Waqf, including women, were recorded under the duagû offices (cemaat-i vaizan ve duagûyan/duagûyan-ı evkaf-ı muhdesat). Most of them received salaries ranging from 5 to 20 akçe, with only one individual in the Fatih Waqf, Abuzer Çelebi, noted as receiving 100 akçe. None of these individuals were assigned to specific duagû positions, and in the Fatih Waqf, they were listed under mahlûl (vacant) positions (EV.HMH.d1178:6b,82b).

2.4. İmaret (Soup Kitchen) Personnel in the Salary Registers

The term imaret in Ottoman waqfs generally refers to the section of a waqf dedicated to food distribution (Ergin, 1945; Tarım-Ertuğ, 2000). The central component of an imaret was the aşhane (kitchen), where meals were prepared. Additional facilities such as tabhanes (guesthouses), caravanserais, or even stables were often included as integral parts of the imaret (Unan, 2003). While the specifics varied depending on the waqfiyye, food from the imaret kitchen was generally served twice a day to variety of individuals, including guests, madrasa students, waqf employees, and those in need (Tarım-Ertuğ, 2000). This practice symbolised the Ottoman Empire's generosity and administrative strength (Singer, 2002).

The Fatih, Yavuz Selim, and Süleymaniye waqfs each had an imaret; however, it remains unclear whether the Yavuz Selim Waqf's imaret included a caravanserai, as this was not mentioned in its waqfiyye (Yüksel, 2009:515). Nevertheless, the salary register for the waqf lists two individuals identified as ahuri (stable servants), suggesting the presence of a stable (EV.HMH.d.1178:38a).

Each imaret was administered by a şeyh (head), who worked closely with the mütevellis to manage all aspects of food production and distribution. The şeyh was responsible for procuring kitchen materials, supervising meal preparation, hosting visitors, and ensuring efficient operation (Kürkçüoğlu, 1962). In the Fatih imaret, the şeyh was titled seyyid/efendi, while he was referred to as halife in the Yavuz Selim imaret and hacı/efendi in the Süleymaniye imaret. The şeyh received a daily stipend of 20 akçe (EV.HMH.d.1178:11a, 35b, 75a).

Under the şeyh's supervision, kitchen operations followed four main stages. Procurement was managed by the vekilharc, who purchased the necessary supplies with the help of a kâtib and delivered them to a kilari (storekeeper). The vekilharc received a daily salary of 10 akçe in the Fatih Waqf, 6 akçe in the Yavuz Selim Waqf, and 5 akçe in the Süleymaniye Waqf. While some kâtibs were specifically appointed in the waqfiyyes, new positions such as kâtib-i kilâri (storehouse scribe) and kâtib-i taam (supply scribe) emerged over time to meet the operational demands of the imaret.

Food preparation involved a well-organised team of workers with distinct roles, often outlined in the waqfiyye. Sorting wheat and rice was assigned to the nakkad-ı kendüm/erz, while grinding them into flour was the responsibility of the kendüm kûb. The tabbah (cook) prepared meals, and bread-making was carried out by the habbaz. Serving bread and meat fell to the nâkib-i nân and nâkib-i gûşt, respectively. Cleaning and collecting utensils were the duties of the kâse-keş and kâse şuy. Salaries for food preparation workers ranged between 4 and 6 akçe daily, while service and cleaning personnel earned 1–2 akçe.

Maintenance work formed another aspect of imaret operations. The Fatih imaret employed 15 maintenance workers, the Yavuz Selim imaret employed 27 maintenance workers, and the Süleymaniye imaret and tabhane (guest house) employed 14 maintenance workers. These workers, tasked with maintaining and cleaning the facilities, received a daily wage of 2-5 akçe, For ensuring that the facilities remained functional and clean.

In total, the salary registers of the three sultanic waqfs list 125 employees dedicated to various roles in the imaret kitchens and 56 maintenance workers.[7]

2.5. Dârüşşifâ (Hospital) Personnel in the Salary Registers

Dârüşşifâs were integral components of waqf complexes, with both the Fatih and Süleymaniye waqfs including their own facilities. Historical sources, such as those by D'ohsson, suggest that the Fatih Dârüşşifâ was exclusively for men (Ünver, 1942). However, Kunter (1961:144) cites the phrase, *"…Dârüşşifâyı âmme-i ehl-i İslam belki kâffe-i ibâd- Rabbü'l enâm için vakfeyledim"* from the waqfiyye, interpreting it to mean that the hospital served all individuals in need, regardless of religion. In contrast, Shefer-Mossensohn (2003:131) notes that while the Fatih waqfiyye explicitly mentions Muslims, it does not clarify whether non-Muslims were treated there.

The salary registers reveal that the Fatih Dârüşşifâ employed nine healthcare staff, including two tabibs (doctors), each earning 20 akçe daily (EV. HMH.d.1178:14b). However, the 1489 accounting book of the Fatih Waqf documents a Ser-e-tıbba Muhiddin, who earned 30 akçe daily, alongside six tabibs, earning between 5 and 15 akçe, though the reason for this increase in medical staff remains unclear (Barkan, 1963b:317).

The Süleymaniye Dârüşşifâ employed eight healthcare staff members, with Ser-e-tibba Ahmed Efendi earning 40 akçe daily. Two other tabibs were specified as tabib-i sani (second doctor), earning 15 akçe, and tabib-i selase (third doctor) earning 10 akçe (EV.HMH.d.1178:77a).

In addition to tabibs, both the Fatih and Süleymaniye dârüşşifâs employed two kehhals (eye doctors) and two cerrahs (surgeons), whose daily salaries ranged from 3 to 6 akçe. The preparation of medicines was managed by the aşşab, who procured the ingredients, and the edviye-kûb, who prepared the medicines.

[7] EV.HMH.d.1178: 11a, 12-b, 13a-b, 35a-b, 36a-b, 37a-b, 38a-b, 75a-b, 76a-b, 77a-b

These personnel earned salaries between 2 and 4 akçe (EV.HMH.d.1178:14a, 77a, 78b).

Patients rested in tabhanes during their recovery period, and supporting patient care required additional staff, including the came-şûy, responsible for washing the clothes of patients, the ser-tıraşi (barber), who provided shaving services, and the âbrizî, who supplied water. These positions received daily wages of 3 to 4 akçe (EV.HMH.d.1178: 14a, 15a-b, 77a, 78a-b). Furthermore, the dârüşşifâs had kitchen and masjid for patients, necessitating additional staff for food preparation and maintenance. A total 26 personnel were assigned to these duties in the Fatih Waqf, and 33 personnel in the Süleymaniye Waqf, including maintenance positions.

The dârüşşifâs also functioned as educational institutions, providing medical students with practical experience alongside theoretical studies (Zorlu, 2002). Although the Fatih Waqf did not have a dedicated medical school, it contributed to medical education by employing şakird (students) within the hospital (Ünver, 1942). According to the Fatih Waqf salary register, a group referred to as şakirdan-ı ve tabiban-ı dârüşşifâ ma'mure received a daily salary of 6 akçe (EV. HMH.d.1178:18b).

2.6. Zevâid-horan (Beneficiaries) in the Salary Registers

Within Ottoman waqf institutions, a category known as zevâid-horan (beneficiaries) consisted of individuals who received allowances from the surplus income generated by the waqfs. These payments, separate from those specified by waqfiyyes, functioned as a form of social welfare within the waqf system. Various groups receiving benefits under the title of zevâid-horan included retired waqf employees, retired state officials, widows, clergy, and those in need (Barkan, 1971). According to the tevcih and mühimme registers, individuals facing poverty, disability, or personal difficulty could petition for support through waqf mütevellis (Aslanmirza, 2017:41).

In the 1702 salary registers, only the Yavuz Selim Waqf recorded a group identified as cemaat-i duâgûyan ve zevâidhoran-ı muhdesat-ı mezkûreyn. This group included 156 individuals, though it was unclear who among them were duagûs and who were zevâidhor. The account records included only the names, and if present, titles such as şeyh, seyyid, halife, efendi, halife, and çelebi. The highest individual payment of 35 akçe went to a certain Abdürrezzak b. Mehmed (EV.HMH.d.1178:46a).

In contrast, in 1628-1630, the account book of the Yavuz Selim Waqf listed zevâid-horan in three categories, with the highest payment, daily 130 akçe, was allocated to Abdullah Efendi in the first group, cemaat-i mevali-i'izam ve mevali-zâdegân. The term mevali-zâdegan was used to refer to children of high-ranking judges and scholars (İpşirli, 1988). The second group, meşayih-i kiram, consisted of 44 individuals who received daily stipends ranging from 5 to 10 akçe. The last group, cemaat-i havâtîn included 101 women, most of whom received a stipend of 10 akçe (MAD,d. 4924, p.3a-b, 4a-b).

On the other hand, neither the Fatih nor the Süleymaniye waqfs recorded any zevâid-horan in their salary registers, without any explanation of this absence. However, in the 1489-1490 account books of Fatih waqf, "cemaat-i müteferrika ve zevâid-horan" (the office of various duties and beneficiaries) listed beneficiaries in this group (Barkan,1963b:318-319). Similarly, in the 1585-1586 accounting books of the Süleymaniye waqf, 188 zevâid-horan were recorded in four different groups (Barkan,1971:149).

Conclusion

This study highlights the crucial role of Ottoman imperial waqfs as both employment institutions and social welfare entities, with a particular focus on the Fatih, Yavuz Selim, and Süleymaniye waqfs. Established by Ottoman sultans, these waqfs not only provided public services but also acted as significant redistributors of wealth and providers of employment opportunities. The analysis of the 1702 salary register reveals the extensive administrative and financial operations of these waqfs, showcasing their ability to adapt to evolving socio-economic needs through the creation of muhdes (newly added) positions beyond the provisions of their original waqfiyyes.

Employing individuals over 2,148 duties and allocating funds to 156 zevâid-horan (beneficiaries), these waqfs demonstrated substantial economic and social influence. The findings indicate that these three sultanic waqfs, established in the 15th and 16th centuries, expanded over time through the addition of mülhak (annexed) public buildings such as madrasas and mosques. Furthermore, the involvement of the central administration in auditing and overseeing waqf employees through the Nezaret underscores the balance between managerial flexibility and the necessity for accountability.

Beyond their social services, the salary registers also detail the expenditures of these waqfs on salaries for employees of mosques, mektebs (primary schools), imarets, and darüşşifas (hospitals). Notably, the support of thirty-nine madrasas—both primary and annexed—that educated hundreds of madrasa students highlights the significant contributions of the waqfs to education, a point that warrants particular emphasis.

This study also contributes to our understanding of the "waqf economy," emphasising how waqfs not only sustained public welfare but also reflected broader economic, social, and political dynamics within the Ottoman Empire. By analysing the müfredat register alongside previous studies, it extends our knowledge of the functioning of imperial waqfs, shedding light on their capacity to address both institutional needs and community welfare across centuries.

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RESEARCH ARTICLE

Determinants of Air Transport in the BRICS-T Countries: Findings from Panel Data Analysis

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ABSTRACT

This paper examines the factors that determine air transport in the BRICS countries, which account for approximately 42% of the world's population and occupy an important position among developing countries in terms of economic size. In more detail, in this study, air transport examines two different models, passenger and freight transport. The research is carried out for the period 1996-2020. Panel data methods were used as analysis methods. According to the results of the analysis, both air passenger transport and air freight transport act together with their macroeconomic and socioeconomic determinants in the long term. Income is positive and significant in the air passenger transportation model, while income is insignificant in the freight transportation model. In addition, inflation, exchange rate, industrialisation and urbanisation on a country basis are important determinants of both air passenger transport and air freight transport for BRICS-T.

Keywords: Airway transportation, Panel data analysis, BRICS-T
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1. Introduction

Recently, the developing air transport sector has positioned itself in an important position for the world economy. Determining the dynamics of air transport and conducting policy analyses are important for the economies of the countries. Considering the position of air transport, it is crucial to know the dynamics of this sector to move it forward. Determining the dynamics of the sector is also expected to shed light on the future of the sector. When we look at the economies of developed countries today, these countries have a say in the sector with the air transportation they have made. Developing countries, on the other hand, have become an important centre after investments in air transport in recent years.

The development of air transportation contributes to economic growth by creating employment and increasing trade (Law et al., 2022). The airline industry is intertwined with tourism, accommodation, and the back-and-forth related sectors (Tirtha, Bhowmik, and Eluru, 2023). Parallel to the economic growth, a rise is observed in the field of air transport. The reasons behind the increase in air transport are mainly population growth and economic activities (Goetz, 1992). Therefore, the recovery in this sector is expected to create a multiplier effect on the economy in general.

BRIC (Brazil, Russia, India, and China) countries, a concept introduced by the US investment bank Goldman Sachs in 2001, have an important place in the global economy. With the participation of South Africa in 2010 among these countries, which first came together in 2006, its name was changed to BRICS. Because of mentioning Türkiye, which has similar economic performance with the BRICS countries, with this group, it is expressed as the BRICS-T classification in the literature. It is thought that these countries will become one of the most important countries in the world because of their economic performance, location, area and population power.

With the beginning of the 21st century, BRICS-T countries have started to gain an important place in the world population and economy. In 2020, the BRICS-T countries accounted for 42.29% of the world's population and had a per capita income of $14,841, which is higher than the world average of $10,489. In terms of population and economic growth, these countries have an important position in air transport. The population power of BRISC-T countries, increasing economic growth and their share in world exports are also significant in air transport. The increase in the national income of these countries and their significant rural population among developing countries are another point that brings the countries examined to the fore.

There may be several reasons why it is desirable to relate air transport to macroeconomic and socio-economic variables. Increasing business volumes and international trade between countries increase air passenger and freight transport. As incomes rise, the propensity of individuals to travel increases (Hakim and Merkert, 2019). The effect of the inflation rate is negative. The mechanism here is that high inflation rates increase uncertainty in the economy and lead to an erosion of consumer confidence, causing them to avoid spending and postpone their travel needs (Adeniran and Adeniran, 2017). An increase in the exchange rate may increase passenger demand as it becomes cheaper for foreign tourists to travel to the country (Pacheco and Fernandes, 2017). The effect of industrialisation can increase production and trade, which can increase the demand for air freight. Finally, increasing urbanisation can increase the demand for airlines as people travel more. In short, air passenger and freight transport interact with many macro- and socio-economic variables such as income, inflation rate, exchange rate, industrialisation and urbanisation (Hakim and Merkert, 2019). Therefore, understanding these relationships helps shape economic policy by making better predictions about the future of the sector. Furthermore, modelling the impact of these variables on air transport can help to better understand the sector. This model allows us to make predictions about the future of the sector by analysing in more detail the impact of macroeconomic and socio-economic variables on air transport. It is an important guide for the sector and policy makers, in particular by predicting how air passenger and freight transport may change in parallel with economic changes in the BRICS-T countries.

As shown in Table 1, the population richness in BRICS-T countries has an advantage in terms of air transport. In China and India in particular, the population of more than 1 billion is eye-catching. The average economic growth rate of this group of countries in 2023 is 4.6%, which is higher than the world average of 2.71%, and a high economic growth rate compared to developed countries is also a remarkable indicator. In terms of annual inflation rates, it can also be said that these countries, which have single-digit inflation rates except Türkiye, have price stability.

Table 1: Indicators of BRICS-T Countries

Countries	Population (Person)	GDP Growth Rate (Annual, %)	Inflation (Annual, %)
Brazil	216 million	2,91	4,59
Russia	143 million	3,60	7,40
India	1,4 billion	7,58	5,64
China	1,4 billion	5,20	0,23
South Africa	60 million	0,60	6,07
Türkiye	85 million	4,52	53,85

Note: The values in the table are data for 2023. The data were taken from the world bank database.

The study examines the BRICS-T countries and uses data on macroeconomic and socio-economic indicators such as air passenger and freight traffic, GDP per capita, inflation rate, exchange rate, industrialisation and urbanisation for the period 1996-2020. The model provides a simple framework for understanding the factors affecting air transport. The study, which uses panel data econometrics, is expected to contribute to the literature in terms of the sample analysed, the model and the methodology used.

The empirical literature on air transportation appears to focus on high- and middle-income countries. However, as far as we know, there is no research focusing on BRICS-T countries. This study provides the literature by examining the determinants of air transport in BRICS-T countries.
The rest of the work is planned as follows: In the 2nd chapter, a literature review on air transport is made, in the 3rd chapter the methodology is summarised and in the 4th chapter the empirical findings are shared. Chapter 5 contains the conclusions and policy recommendations.

2. Literature

To plan and develop sound policies, it is important to identify the dynamics of air transport. The study of the factors that determine air traffic can also be used to improve the efficiency of those involved in the air travel sector. The WB (2021) states that air transportation contributes to economic recovery by promoting tourism, global trade, and job opportunities. According to an IATA (2023) study, air transportation creates an effect parallel to economic growth. In this context, this section provides a summary of the studies on air transport.

Goetz (1992) found a positive connection between economic growth and passenger demand. Chou (1993) argues that air transport is associated with both economic and population growth. Poore (1993) supports that in addition to income, population is also a factor that determines air transportation. Dargay and Hanly (2001) show that air ticket increases are negative for airline transportation and positive for economic growth. Zhang and Zhang (2002) found that global airline cargo growth is associated with business and economic growth. Castelli, Ukovich, and Pesenti (2003) shows that many variables such as population, per capita income, distance, and flight frequency are factors that determine air transport. Fu, Oum, and Zhang (2010) predicted that economic growth is the driving force for air transport. Dobruszkes, Lennert, and Van Hamme (2011) showed that besides national income, distance also significantly affects air transport. Yao and Yang (2012) indicate a positive relationship between economic growth, industrial structure, population density and air transport in China. The sensitivity of air passenger and freight traffic to economic growth is the subject of a paper by Chi and Baek (2013). Hu et al. (2015) provided support for a long-term link between economic growth and domestic air passenger traffic in their study, which was conducted in 29 provinces in China. Examining the air transport industry for China and India, Zhang and Zhang (2017) evaluated the efficiency performances of airlines by comparing them in their study. Because of the evaluation, they found that Indian companies are more efficient. Chsherbakov and Gerasimov (2019), who aim to analyse Russian air transport for the period 2007-2016, state that air transport is an important sector for Russia's gross domestic product. Balsalobre-Lorente et al. (2020) showed that air transport, urbanisation and social globalisation have a positive effect on economic growth. Empirically examining the relationship between air transport and economic growth for six sub-Saharan African countries between 1981 and 2018, Tolcha, Bråthen, and Holmgren (2020) established a unidirectional causality from economic growth to air transport for South Africa in the long run. Zhang and Graham (2020) discovered that air transportation is more likely to be relevant in underdeveloped economies. Gudmundsson, Cattaneo, and Redondi (2021) predicted the relationship between the magnitude of economic shocks and the temporal recovery in the global air transportation sector. Law et al. (2022) found a bidirectional causal relationship between air passenger traffic and economic growth. Ali, Bakhsh, and Yasin (2023) identified unidirectional long-term causality from air passengers and air transportation to economic growth in BRICS countries. Franciscone, Zou, and Fernandes (2024) emphasise the significant role of international air transportation in stimulating global trade, revitalising tourism, supporting people-to-people exchanges, and improving supply chain efficiency.

3. Model, Data, and Methodology

3.1. Model

Potential variables affecting air passenger transport and freight transport in BRICS-T countries are determined by following the study of Hakim and Merkert (2019). The basic models used in this study are as follows:

$$PAX = f(INC, INF, EXCR, IND, URB) \tag{1}$$

$$FREIGHT = f(INC, INF, EXCR, IND, URB) \tag{2}$$

PAX represents the total number of airline passengers, FREIGHT represents air freight, INC represents real GDP per capita, INF represents the percentage increase in the general level of prices, EXCR represents the price of each country's local currency in US dollars, IND represents the industrialisation level of each country, and URB represents urban population growth. The effects of income, industrialisation and urbanisation variables on air transport are examined by considering the studies of Hakim and Merkert (2019). In addition, in order not to ignore the macroeconomic effects on air transportation in different dimensions, the inflation variable is included following Adeniran and Adeniran (2017) and the exchange rate variable is implemented according to Pacheco and Fernandes (2017) in the model. In this respect, in the empirical analysis, airline passenger and freight transportation in BRICS-T countries are associated with macroeconomic and socio-economic variables in various dimensions. As the income level of economic decision units increases, the tendency to travel is expected to increase across the income coefficient, which is theoretically expected to be positive. Theoretically, the effect of the inflation rate on air transportation and its coefficient are expected to be negative. This theoretical expectation about inflation is based on the contraction in the expenditures of decision-makers for travel and freight transportation in an environment of price instability. If increases in the exchange rate make the destination country cheaper for foreign tourists, passenger demand is expected to increase, but if it makes it more expensive, travel is expected to decrease. On the other hand, there are two different situations because of the depreciation of the country's currency. First, the demand for foreign goods and imports decreases; therefore, there will be a decrease in air freight transportation. On the contrary, in the second case, the export of the home nation increases due to depreciation for currency. Therefore, when the export volume is greater than the import volume, the exchange rate coefficient is expected to be positive, and in the opposite case is negative. Hence, there is no definite theoretical expectation about the exchange rate coefficient in our models. Theoretically, the effect of industrialisation is expected to generate an upturn in both output and trade, pushing up the demand for air transport of passengers and freight. Thus, the coefficient of industrialisation indicator will be estimated as positive. It is expected that increasing urbanisation will rise the demand for airlines as a conclusion of the development of mobility of economic decision-making units and urbanisation designed to augment the need for goods subject to international trade. In this context, theoretically, the coefficient of urbanisation is expected to be positive in our models. In brief, development business volumes and international trade between countries increase air passenger and freight transport. In this respect, the economic and demographic dynamics of the two main indicators of air transportation in BRICS-T economies are not neglected in our models.

Due to the scale differences between the variables, we used by taking their natural logarithms, except for URB. Since the URB variable takes negative values, it is not possible to take logarithms. Finally, writing Equations 1 and 2 in linear form is as shown below:

$$lnPAX_{it} = \alpha_{1it} + \beta_1 lnINC_{it} + \beta_2 lnINF_{it} + \beta_3 lnEXCR_{it} + \beta_4 lnIND_{it} + \beta_5 URB_{it} + \varepsilon_{it} \quad (1.1)$$

$$lnFREIGHT_{it} = \alpha_{2it} + \beta_6 lnINC_{it} + \beta_7 lnINF_{it} + \beta_8 lnEXCR_{it} + \beta_9 lnIND_{it} + \beta_{10} URB_{it} + e_{it} \quad (2.1)$$

where $i = 1,2,3 \ldots, N$ represents the cross-sectional dimension and $t = 1,2,3 \ldots, T$ represents the time dimension. α_{1it} and α_{2it} represent constant terms. $\beta_1, \cdots, \beta_{10}$ are regression parameters to be estimated. ε_{it} and e_{it} are error terms.

3.2. Data

Using panel data econometric techniques, this study examines the determinants of air passenger and freight transport for the BRICS-T countries. The analysis is carried out for the period 1996-2020. Data descriptions are shown in Table 2.

Table 2: Definition of the variables

Label	Long Defination	Measurement	Source
PAX	Passengers carried on domestic and international flights by air transport companies incorporated in the country.	Person	WDI (2023)
FREIGHT	Express and diplomatic baggage moved on each leg of the flight, calculated in metric tons multiplied by the number of kilometres travelled.	Million ton-km	
INC	Gross domestic product in relation to the mid-year population.	constant 2015 US$	
EXCR	The price of each country's local currency in US dollars.	LCU per US$, period average	
INF	Consumer price index (2010 = 100)	%	
IND	This covers value added in the extractive, manufacturing, building and electricity/water/gas sectors.	% of GDP	
URB	The urban population refers to people living in urban areas.	annual %	

The descriptive statistics are presented in Table 3 below.

Table 3: Descriptive statistics

Variables/ Countries	Brazil		Russia		India		China		S. Africa		Türkiye	
	M	SS	M	SS	M	SS	M	SS	M	SS	M	SS
lnPAX	17.79	0.54	17.46	0.61	17.61	0.83	19.03	0.87	16.33	0.42	17.20	0.95
lnFREIGHT	7.34	0.11	7.71	0.78	6.95	0.57	9.13	0.83	6.59	0.51	6.86	1.17
lnINC	8.96	0.12	8.92	0.28	7.01	0.36	8.39	0.61	8.62	0.12	9.03	0.25
lnINF	4.49	0.45	4.21	0.89	4.47	0.48	4.58	0.17	4.50	0.38	4.10	1.23
lnEXCR	0.82	0.40	3.39	0.67	3.92	0.21	1.99	0.12	2.14	0.36	0.30	1.05
lnIND	3.07	0.10	3.43	0.07	3.34	0.07	3.79	0.07	3.25	0.08	3.30	0.07
URB	1.52	0.47	-0.04	0.28	2.57	0.18	3.37	0.61	2.01	0.30	2.21	0.33

Notes: Descriptive statistics are calculated using logarithmic data except for the URB. M represents the mean; SD represents the standard deviation of the series.

According to Table 3, the country with the highest average for both passenger and freight transport over the period is China. The lowest average occurs in South Africa. The country with the highest average income is Türkiye, and the lowest is India. China had a high inflation rate compared to other countries on average in this period, while Türkiye, on the contrary, had a low inflation process. In terms of the exchange rate, the highest is India and the lowest is Türkiye. China is the country with the highest average in industrialisation and urbanisation. Brazil lags behind in industrialisation compared to other countries. On the other hand, Russia has a negative growth in urbanisation. Türkiye is the country with the highest standard deviation in air passenger transportation, inflation, and exchange rate. In freight transport, income and urbanisation China is the country with the highest standard deviation. South Africa (and Brazil) in passenger transportation and income, Brazil in freight transportation, China in inflation and exchange rate, and India in urbanisation are the countries with the lowest standard deviations. Lastly, all countries have similar standard deviations in the industrialisation variable.

3.3. Methodology

We are using a panel data testing framework for the empirical application. Panel data methods provide more accurate inferences about the model parameters. This is because, unlike both cross-sectional and time series data, it contains more degrees of freedom. Time series and cross-sectional studies do not control for heterogeneity (variability). Therefore, they carry the risk of slanted results. Panel data methods, on the other hand, increase the efficiency of the estimations by considering the heterogeneity. It contains more information than cross-section and time series data types to detect complex human behaviours. It keeps the effects of excluded or forgotten variables under control (Baltagi, 2008). In the unit root and co-integration methods to be applied in studies using panel data, preliminary information about the data plays a role in determining the test to be used. In this context, first, the homogeneity and the cross-sectional dependence of the panel data are examined. Homogeneity analysis is used to determine whether the cross-sections in the panel data have a similar structure, and cross-sectional dependence is used to determine whether a shock occurring in one cross-section affected the other cross-sections. In the case of a dependency between the cross-sections, ignoring this dependency may lead to inconsistent and biased results (Chudik and Pesaran, 2015). The results obtained from the cross-section dependency and homogeneity analysis affect the determination of the unit root test to be used in the stationarity analysis. In the absence of cross-sectional dependence, the panel unit root tests are used for the first and second generations. 1st and 2nd generation tests are divided into two groups for the homogeneous and heterogeneous panels. In this context, the stationarity test is performed by determining the unit root test suitable for the structure of the dataset. Then, in line with the findings obtained from the preliminary tests, the co-integration test that best explains the dataset is selected.

In this section, the methodology for the tests to be used in cross-sectional dependence, homogeneity, stationarity, co-integration, and long-term coefficient analysis will be explained.

3.3.1. Test of Homogeneity

The Swamy-S (1970) test is used to determine homogeneity. It is used when T>N. The formulation for the Swamy-S test is as follows:

$$\hat{S} = \sum_{i=1}^{N} \left(\hat{\beta}_i - \hat{\beta}_{WFE}\right)' \frac{X_i' M_\tau X_i}{\hat{\sigma}_i^2} \left(\hat{\beta}_i - \hat{\beta}_{WFE}\right) \sim \chi^2_{k(N-1)} \tag{3}$$

$$M_\tau = I_T - \tau_T (\tau_T' \tau_T)^{-1} \tau_T' \tag{3.1}$$

$$\hat{\sigma}_i^2 = \frac{(Y_i - X_i \hat{\beta}_i)' M_\tau (Y_i - X_i \hat{\beta}_i)}{(T - k - 1)} \tag{3.2}$$

$$\hat{\beta}_{WFE} = \left(\sum_{i=1}^{N} \frac{X_i' M_\tau X_i}{\hat{\sigma}_i^2} \right)^{-1} \sum_{i=1}^{N} \frac{X_i' M_\tau Y_i}{\hat{\sigma}_i^2} \tag{3.3}$$

where I_T is the unit matrix. $\hat{\beta}_{WFE}$ represents the slope coefficient. The hypotheses regarding the Swamy-S test are as shown below:

$H_o: \beta_i = \beta$ (Panel Data is Homogeneous)
$H_A: \beta_i \neq \beta$ (Panel Data Is Heterogeneous)

The null hypothesis is rejected if the test statistic obtained from equation 3 is greater than the critical value.

3.3.2. Test of Cross-Section Dependency

The CD_{LM} test proposed by Pesaran (2004) is used to test the cross-sectional dependence. The formulation for the test is as shown in Equation 4:

$$CD_{LM} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=j}^{N-1} \sum_{j=i+1}^{N} (T\hat{\rho}_{ij}^2 - 1) \sim N(0,1) \tag{4}$$

$$\hat{\rho}_{ij} = \hat{\rho}_{ji} = \frac{\sum_{t=1}^{T} \varepsilon_{it}\varepsilon_{jt}}{\left(\sum_{t=1}^{T} \varepsilon_{it}^2\right)^{1/2} \left(\sum_{t=1}^{T} \varepsilon_{jt}^2\right)^{1/2}} \tag{4.1}$$

where $\hat{\rho}_{ij}$ is the number of correlations between the residuals. ε_{it} is the estimated residuals from each unit. The CD_{LM} test gives stronger results when T>N. The hypotheses for the test are as shown below:

$H_o: \rho_{ij} = \rho_{ji} = 0$ (for i$\neq j$) (No cross-section dependency) $(i = 1, \dots, N)$, $(j = 1, \dots, N)$
$H_A: \rho_{ij} = \rho_{ji} \neq 0$ (for i$\neq j$) (Cross-section dependency)

if the CD_{LM} statistic obtained from Equation 4 is greater than the critical value, the null hypothesis is rejected.

3.3.3. Test of the Unit Root

In order to test for stationarity, the CADF test recommended by Pesaran (2007) is used. The CADF test can give results at the same time for each country and for all panel. For the overall panel, Crooss-Sectionally Im, Pesaran and Shin (CIPS) statistics are used. The CIPS test can be used in the presence of cross-sectional dependence and regardless of whether the panel data is homogeneous or heterogeneous. It can give strong results in both N>T and T>N situations.
The formulation for the CIPS statistic is as shown in Equation 5:

$$CIPS = \frac{\sum_{i=1}^{N} CADF_i}{N} \tag{5}$$

where $CADF_i$ is a cross-sectional statistic that examines the existence of a unit root for each cross-section. By taking the average of the $CADF_i$ statistics, the CIPS statistics are obtained. The hypotheses regarding the CIPS statistic are as shown below:

$H_o: \beta_i = 0$ (For all cross-sections) (Unit root)
$H_A: \beta_i < 0$ $(i = 1, 2, 3, \dots, N_1;\ \beta_i = 0, i = N_1 + 1, N_1 + 2, \dots, N)$ (Stationary)

The H_o hypothesis is rejected if the CIPS statistic is greater than the critical values given in Pesaran (2007).

3.3.4. Test of Co-integration

To test the co-integration relationship, the LM bootstrap panel co-integration test on offer by Westerlund and Edgerton (2007) is used. In the presence of cross-sectional dependence, the LM test can be used. The LM test offers advantages such as heteroskedasticity, serial correlation, being robust to possible endogeneity problems and giving consistent results in small samples. The formulation for the LM Bootstrap panel co-integration test under the assumption of cross-sectional dependency is as shown in Equation 6:

$$LM_N^+ = \frac{1}{NT^2}\sum_{t=1}^{N}\sum_{t=1}^{T}\widehat{w}_i^{-2}S_{it}^2 \tag{6}$$

$$w_{it} = \sum_{j=0}^{\infty} a_{ij}e_{it-j} \tag{6.1}$$

where e_{it} are errors with i.i.d over time and has a zero mean. Since a_{ij} varies between all cross-sections, this model allows for a heterogeneous correlation structure. S_{it} is the partial sum of the error terms. The hypotheses regarding the LM test are as shown below:

$H_o\colon \sigma_i^2 = 0$ (For all cross-sections) (Co-integration)
$H_A\colon \sigma_i^2 > 0$ (For some cross-sections) (No co-integration)

The LM statistics and probability values obtained from Equation 6 are calculated using bootstrap. If the obtained bootstrap probability value is greater than 0.1, the H_o hypothesis cannot be rejected.

3.3.5. Estimating the Long-Run Coefficient in the Co-integration Analysis

If, as an outcome of co-integration analysis, there is a long-run relationship used in the model, co-integration estimators are used to provide information on the direction and magnitude of the relationship. At this point, the augmented mean group (AMG) derived by Eberhard and Bond (2009) and Eberhardt and Teal (2010) is used. The AMG estimator considers cross-sectional dependence. It is an estimator that is robust to the possible endogeneity problem. It can also be applied if the integration degrees of the series are different (Eberhardt, 2012: 64). The process of AMG coefficient estimation consists of 3 stages.

First, the coefficient estimates are obtained with the help of Equation 7 using the first-difference ordinary least square (FD-OLS) method.

$$\Delta Y_{it} = b'\Delta X_{it} + \sum_{t=2}^{T} c_t \Delta D_t + e_{it}\,, \hat{c}_t \equiv \hat{\mu}_t^* \tag{7}$$

Model estimation is then conducted by including   in the regressions for each unit.

$$Y_{it} = a_i + b_i' X_{it} + c_i t + d_i \hat{\mu}_t^* + e_{it} \tag{8}$$

Finally, with the mean group (MG) approach proposed by Pesaran and Smith (1995), the AMG coefficient estimate is obtained by averaging the coefficients of each country in the panel.

$$\hat{b}_{AMG} = N^{-1} \sum_{i} \hat{b}_i \tag{9}$$

4. Empirical Results

By the current literature on panel data methods, specification tests must be applied for both series and models in the panel analysed in order to choose the right analysis methods. In this direction, the Swamy-S homogeneity test and cross-section dependence tests were used. Table 4 shows the results of these specifications below.

Table 4: Preliminary Tests

Panel A: Results for the Variables	**Homogeneity: Swamy-S (1970)**		**Cross-Section Dependence: (2004)**	
	Statistic	**p-val.**	**Statistic**	**p-val.**
lnPAX	1580.35	0.000***	4.163	0.000***
lnFREIGHT	1435.75	0.000***	4.115	0.000***
lnINC	773.51	0.000***	5.028	0.000***
lnINF	862.51	0.000***	4.120	0.000***
lnEXCR	460.93	0.000***	2.413	0.008***
lnIND	227.34	0.000***	1.683	0.046**
URB	153.15	0.000***	12.034	0.000***
Panel B: Results for the Models				
Model-1	369.51	0.000***	19.203	0.000***
Model-2	274.65	0.000***	5.103	0.000***

Notes: *** (1%), ** (5%), and * (10%).

According to the outcomes of the homogeneity and cross-sectional dependence tests outlined in Table 4, the variables and models are heterogeneous and have cross-sectional dependence. Therefore, unit root and co-integration tests and co-integration estimators that take heterogeneity and cross-section dependency into account should be used to continue the analysis.

For the empirical analysis, the CIPS panel unit root test procedure, which takes heterogeneity and cross-section dependence into account, was used to test whether the series had a unit root procedure. The results in Table 5 indicate that the variables exhibit a unit root at levels and are stationary in the first differences following the CIPS test. In this respect, it is possible to say that the series has an I (1) process.

Table 5: Results of the Panel Unit Root Test

Variables	**Level: Constant Model**	**Level: Constant & Trend Model**
lnPAX	-1.998	-2.630
lnFREIGHT	-2.329*	-2.411
lnINC	-1.538	-1.355
lnINF	-1.276	-2.067
lnEXCR	-1.850	-2.794*
lnIND	-1.355	-1.114
URB	-1.400	-2.011

	First Difference: Constant Model	First Difference: Constant & Trend Model
lnPAX	-4.307***	-4.440***
lnFREIGHT	-4.437***	-4.844***
lnINC	-2.357**	-2.590
lnINF	-2.955***	-2.909**
lnEXCR	-3.626***	-3.764***
lnIND	-3.364***	-3.806***
URB	-3.176***	-3.306***
Critical Values (N=10, T=30)	%1 ➔ -2.58 %5 ➔ -2.33 %10 ➔ -2.21	%1 ➔ -3.12 %5 ➔ -2.87 %10 ➔ -2.73

Notes: The maximum lag length is determined as 2 due to the annual data. The appropriate lag length is chosen according to the t-statistic information criterion. *** (1%), ** (5%), and * (10%).

Table 6 displays the outcomes of the panel co-integration test. The bootstrap values in the last column of Table 6 decide on the presence or absence of a co-integration relationship. As a result, the null hypothesis that the two models are co-integrated is not rejected. This implies that the series are co-integrated.

Table 6: Results of the Panel Co-integration Test

Model		Statistic	Asymptotic p-val.	Bootstrap p-val.
Model 1	Constant	7.339	0.000***	0.972
	Constant & Trend	13.347	0.000***	0.988
Model 2	Constant	7.663	0.000***	0.991
	Constant & Trend	14.216	0.000***	0.954

Notes: Bootstrap p-values are obtained with 5000 replication numbers. p-values <0.1, 0.5 and 0.01 indicate 1%(***), 5%(**) and 10%(*) significance levels, respectively. If the p-value > 0.1, the hypothesis cannot be rejected.

After determining the co-integration for both models, the long-term co-integration coefficient is estimated to determine the size and sign of this relationship between the variables. The results of estimating the AMG coefficients for Model 1 and Model 2 are indicated in Table 7 and Table 8 orderly. In accordance with the panel results of Model 1 in Table 7, the income variable has a significant effect on air passenger transport in the BRICS-T countries. Accordingly, a 1% increase in income leads to a 1.83% increase in air passenger transport. When the country-basis results are analysed, different results are observed for each country. However, as a result of the panel result, inflation, exchange rate and industrialisation lead to a change of 0.272%, 0.177%, and 0.145%, respectively, on airline passenger transport as a result of a 1% change, but there was no significant effect. Moreover, a 1-unit change in urbanisation creates an insignificant change of 4.9% in airline passenger transportation. Air passenger transport in Brazil is affected positively by income and exchange rate and negatively by the inflation rate. In Brazil, industrialisation and urbanisation have an adverse but not a significant effect on air transport. For Russia, only urbanisation has a positive and significant effect on the air transport of passengers, but the other variables have an insignificant effect. In India, income affects air passenger transportation positively and significantly, whereas inflation and urbanisation have negative and significant effect. Furthermore, in air passenger transportation, the exchange rate has negative, and industrialisation has positive effect but insignificant. When we are looking at China, all the independent variables have a positive and significant effect on air passenger transportation. Income and inflation affect, respectively, positive and negative air passenger transport in South Africa significantly. In contrast, industrialisation and urbanisation have negative and insignificant effects but exchange rate-positive on-air passenger transportation. For Türkiye, income and urbanisation display a direct linkage and significant influence on the air transport of passengers. Besides, industrialisation and exchange rate have negative and insignificant effects, but inflation has a positive impact on-air passenger transportation. In summary, when we look at the variables affecting air passenger transport in BRICS-T countries, income is at the forefront. Looking at the country-based results, income has a positive and significant effect in all countries except Russia. This means that income-increasing policies in these countries will increase the number of airline passengers carried.

Table 7: Results for Panel Co-integration Estimator (AMG)-Model 1

Countries/Variables	lnINC	lnINF	lnEXCR	lnIND	URB
Brazil	3.087*** (0.000)	-0.976*** (0.000)	0.241** (0.046)	-0.525 (0.214)	-0.300 (0.114)
Russia	1.048 (0.459)	-0.271 (0.721)	0.307 (0.480)	0.861 (0.283)	0.638** (0.045)
India	2.576*** (0.000)	-0.724** (0.018)	-0.416 (0.209)	0.603 (0.111)	-0.326* (0.065)
China	1.243*** (0.000)	0.848* (0.061)	1.015*** (0.000)	0.941*** (0.000)	0.156** (0.016)
South Africa	1.385*** (0.000)	-0.633** (0.015)	0.024 (0.850)	-0.956 (0.191)	-0.075 (0.166)
Türkiye	1.646*** (0.002)	0.123 (0.461)	-0.105 (0.362)	-0.050 (0.957)	0.203** (0.020)
Panel	1.831*** (0.000)	-0.272 (0.319)	0.177 (0.370)	0.145 (0.648)	0.049 (0.740)

Notes: Values in parentheses give p-values. *** (1%), ** (5%), and * (10%).

The results of Model 2 are reported in Table 8. As a conclusion of the panel result, income, inflation, exchange rate and industrialisation lead to a change of 2.209%, 1.407%, 0.299% and 1.420%, respectively, on freight transportation because of a 1% change, but there was no significant effect. Besides, a 1-unit change in urbanisation creates an insignificant change of 17.4% in freight transportation. However, the country-based results differ, except for Brazil. In Brazil, similar to the panel-based results, there is no variable with a statistically significant effect on freight transportation. The increase in income and inflation indicators, respectively, in Russia affect freight transport significantly positively and negatively. On the other hand, the exchange rate, industrialisation and urbanisation have a negative and insignificant impact on freight transportation. In India, only income has a positive and significant effect on freight transport. In contrast, inflation, industrialisation and urbanisation variables have positive and insignificant effects on freight transport, but the exchange rate has a negative impact. In China, all independent variables except income have a significant effect on freight transportation. Inflation, industrialisation, and urbanisation affect freight transportation positively but the exchange rate negatively in China. In South Africa, income and exchange rate affect freight transport significantly and positively, whereas inflation and industrialisation variables affect freight transport negatively. In addition, the impact of urbanisation on freight transport in South Africa is negative but insignificant. When the results for Türkiye are examined, the increases in income and exchange rates affect freight transportation significantly and positively, in contrast the increases in inflation rates affect negatively. However, the effects of industrialisation (negatively) and urbanisation (positively) on freight transport in Türkiye are insignificant. The increases in income in Türkiye are more dominant in freight transportation compared to the exchange rate. On the contrary, rising in inflation rate has a negative effect on freight transportation, so when price stability cannot be achieved, there is a decrease in air freight transportation.

Table 8: Results for Panel Co-integration Estimator (AMG)-Model 2

Countries/Variables	lnINC	lnINF	lnEXCR	lnIND	URB
Brazil	-0.803 (0.332)	0.033 (0.927)	-0.132 (0.434)	-0.627 (0.303)	-0.157 (0.564)
Russia	2.513*** (0.000)	-4.788*** (0.000)	-0.012 (0.978)	-0.066 (0.899)	-0.133 (0.297)
India	1.767*** (0.000)	0.133 (0.675)	-0.522 (0.132)	0.575 (0.144)	0.049 (0.790)
China	-2.335 (0.198)	1.785* (0.062)	-0.574 (0.305)	2.470*** (0.004)	1.215*** (0.000)
South Africa	5.838*** (0.000)	-4.190*** (0.000)	1.678*** (0.000)	-7.455*** (0.000)	-0.069 (0.641)
Türkiye	6.273*** (0.000)	-1.421*** (0.002)	1.359*** (0.000)	-3.418 (0.156)	0.141 (0.523)
Panel	2.209 (0.117)	-1.407 (0.185)	0.299 (0.452)	-1.420 (0.323)	0.174 (0.414)

Notes: Values in parentheses give p-values. *** (1%), ** (5%), and * (10%).

5. Conclusion

This study uses panel data econometrics to measure air passenger and freight transport in the BRICS-T countries. The data span the period 1996-2020. The model, which uses national income per capita, inflation, exchange rate, industrialisation and urbanisation as independent variables, examines how these variables affect air transport. In the model, income is expected to have a positive effect, and an increase in income leads people to travel more and companies to buy and sell more goods. An increase in inflation, on the other hand, is expected to reduce the demand for air travel as it increases economic uncertainty and reduces consumer confidence. In the case of an increase in the exchange rate, the effect is more complex. While the depreciation of the national currency will increase the demand for air travel by making it more attractive to foreign tourists, the opposite will be true for residents. In terms of trade in goods, the depreciation of the national currency is expected to increase exports and thus have a positive impact on freight transport. Industrialisation is expected to increase the demand for air travel as production and trade increase. Finally, urbanisation is expected to increase passenger demand as people travel more between cities and countries. As a result of the empirical analysis, both passenger and freight traffic move together with macroeconomic and socio-economic determinants in the long run. In the empirical model, income is important in both models, and this finding is similar to the existing literature (Goetz, 1992; Hakim and Merkert, 2019). In line with the literature, increases in income have a positive effect on passenger and freight traffic.

The empirical results differ between the cross sections in the BRICS-T countries analysed. For the BRICS-T countries, increases in national income per capita increase passenger transport, in line with theoretical expectations, except Russia. Brazil stands out with the highest coefficient. A 1% increase in the Brazilian national income leads to a 3.08% increase in air passenger transport. Inflation, which is one of the macroeconomic determinants of passenger transport, has a negative effect in Brazil, India, Russia and South Africa, in line with the theoretical expectation. The largest effect is observed in Brazil, where a 1% increase in the inflation rate leads to a 0.97% decrease in passenger transport. Rising inflation rates lead to higher living costs and have a significant impact on air passenger numbers. Looking at the socio-economic determinants of passenger traffic, industrialisation has a positive effect in line with the huge Chinese economy. A 1% increase in industrialisation is associated with a 0.94% increase in passenger traffic in China. Urbanisation, another socio-economic determinant, increases passenger transport in China, Russia and Türkiye but, contrary to expectations, reduces it in India.

Model 2, where air freight is the dependent variable, shows that increases in GDP per capita have a positive and statistically significant effect for all countries except Brazil and China. Another striking result is that the coefficients are higher than those for passenger transport. In other words, the national income per capita has a greater impact on freight transport than on passenger demand. An increase in the inflation rate has a negative and statistically significant effect on freight transport in all countries except Brazil and India. As a result of this finding, inflation has a negative impact on both freight and passenger transport. Exchange rate increases have a positive effect on freight transport in South Africa and Brazil. In this case, the depreciation of national currencies in these two countries could stimulate international trade by encouraging foreign trade. Increasing industrialisation leads to an increase in both freight and passenger transport in China. Contrary to the expected result, it reduces freight transport in South Africa. Increasing urbanisation has a positive effect on freight transport in China. A 1% increase in urbanisation in China increases freight transport by 1.21%. Looking at the results in general, passenger and freight transport is influenced by socio-economic and macro-economic variables, with income playing an important role. The change in national income per capita plays an important role in increasing the demand for air transport. Therefore, policy makers who want to develop the aviation industry should implement policies to increase income. Future studies can contribute to the literature by focusing on different determinants of air transport in different groups of countries.

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RESEARCH ARTICLE

Determinants of Ecological Footprint in Türkiye: Evidence from the Fourier ARDL Bounds Test Approach

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ABSTRACT

Ecological footprint calculations evaluate sustainability by examining natural resources. The ecological footprint obtained by calculating the number of natural resources per person provides information about the amount of waste produced as well as the natural resources consumed and examines the sustainability of living conditions in the world in this respect. The ecological footprint is one of the frequently encountered topics in the literature in terms of the analysis of environmental impacts. This study examines the factors influencing the Ecological Footprint in Turkey. Using annual data between 1980 and 2018, the relationship of renewable energy consumption, human capital and urbanization variables to the Ecological Footprint is examined. The Fractional Fourier Augmented Dickey Fuller Unit Root Test and the Fourier Autoregressive Distributed Lag Bound Test is used in the study. There is a statistically significant relationship between the renewable energy, human capital and urbanization variables and the Ecological Footprint. When the outputs obtained in the study are examined, it is seen that the variables affect the ecological footprint. The increased value of these variables can be used to explain why the Ecological Footprint increased. Increasing industrial activities due to globalization and technological developments, increasing vehicle traffic in cities due to population growth, unplanned urbanization and destruction of green areas due to the sheltering needs of the increasing population, inability of recycling facilities to adapt to the increasing population and unplanned waste management, etc. factors can increase the ecological footprint. However, as urbanization increases, if a correct plan is drawn by taking these factors into consideration, the negative correlation between the ecological footprint and urbanization can be explained. Within the determined plan; Wastewater management, protection of green areas, prevention of unplanned urbanization and efficient use of resources are explanatory at this point. The empirical findings have important policy implications. According to these policy implications, to offset the effects on the ecological footprint, educational activities to raise environmental awareness and adopt energy-efficient lifestyles should be given due importance, various incentives and supports should be implemented and a green-based lifestyle.

Keywords: Fourier ARDL, Ecological footprint, Renewable energy consumption

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1. Introduction

The term ecological footprint (EF) has become the subject of many academic studies on the impact of globalization and the importance of environmental sustainability. The variable of EF investigates the efficient use of natural resources by determining the natural resources with the aim of ensuring environmental sustainability. Because of the research, the natural resource consumption per capita is evaluated. The calculations obtained because of this evaluation also provide statistical data for the studies carried out for the effective use of resources. In determining the EF, not only the resources consumed but also the amount of waste released into the environment per capita is evaluated. From this viewpoint, it can be stated that EF provides output on environmental sustainability by evaluating the relationship between per capita natural resource consumption and waste generation. When the beginnings of EF studies, which are frequently included in the literature, are examined, the research of Rees (1990) and Wackernagel (1994) evaluated the importance of EF, which is one of the most important issues of today.

Although several different variables are used in EF studies in the literature, intensity is observed in the studies on certain variables. Among these variables, renewable energy and fossil fuel consumption have an important place. The impact of renewable energy consumption (REC) on reducing the EF and fossil fuel consumption on increasing the EF is explained. While almost all studies include related variables, this study examines the concepts of trade openness and economic growth as well as urbanization (URB).

Among the studies examining the variables in question, Amin, Song & Shabbir(2022) study, in which G-11 countries were evaluated between 1991 and 2018 and the URB variable was also examined, can be given as an example. The study finds that URB, economic expansion and trade have an impact on environmental problems, while the increase in REC has a mitigating impact on overall environmental degradation. In addition to this study, studies examining the nuclear energy variable are found in the literature. Ahmed, et al. (2022)

examined the countries of the Asia-Pacific region with panel data analysis, Sadiq, et al. (2022) examined 16 OECD countries with both panel data analysis and ARDL, while Jin and Kim (2018) used the nuclear energy variable while examining 30 OECD countries. In fact, research is establishing the link between nuclear energy and pollution and the EF. This study examines the relationship among 4 dependent variables and 1 independent variable.

When the studies within the literature are analyzed, it is seen that there is a high level of similarity between the variables and these variables are repeated in the studies. Although this is the case in terms of variables, it has been determined that traditional analysis methods are widely used in the tests applied. This study was carried out using the Fourier ARDL test, which is the most current version of the ARDL test and takes structural breaks into account.

Pesaran, Shin & Smith (2001) introduced the ARDL cointegration test. The fact that the analysis method detects the cointegration relationship between variables has enabled the study to form the basis of academic research since 1995. The analysis method developed within the scope of the study investigates the connection between variables by taking long-term lags into account. The research can provide long-term predictions. By analyzing the consistency levels of the coefficients, it can be stated that the ARDL cointegration test has an important place in the literature (Pesaran and Shin, 1995).

While performing the analysis with the ARDL test, it is aimed to minimize the margin of error in the outputs obtained by including F and t statistical values in the analysis. The ARDL test was developed in 2020, and the Fourier version was introduced to the literature and applied as the Fourier ARDL test. The Fourier ARDL test contributes to the analyses in that it is not a prerequisite for stationarity. The use of dummy variables is another difference in methodology (Yılancı, Bozoklu & Gorus 2020).

In this study, the fractional Fourier ADF and Fourier ARDL tests were used to make an analysis for Turkey. This study evaluated the correlation between the EF (dependent variable) and the independent variables of REC, HC, and URB between 1980 and 2018.

The most up-to-date ARDL analysis in the literature is the Fourier ARDL test applied in the study. This stated situation reveals the importance of this study in the literature as it minimizes the margin of error with the current tests. The Fourier ARDL test to be applied within the scope of the study can be expressed as the most up-to-date ARDL analysis in the literature. The test contributes to the literature by minimizing the margin of error. The fact that the study examines Turkey as a sample can be explained by the rapidly increasing population growth of Turkey, which maintains its status as a developing country and is set to continue to increase with its high migration potential, the expansionary orientation in industrialization and industrial activities, increasing HC accumulation and energy transformation. As a matter of fact, the fact that Turkey is under the influence of all these factors strengthens the threat of EF. The study aims to analyze the relationship between HC, EF, use of REC and URB.

The study is completed in 5 sections. Following the introductory part of the study, the literature review section of the study examines and evaluates the work of people who have worked in the field. In the third part of the study, formulas for the analysis methods used in the study are given and information about the applied methods is provided.

The empirical outputs section expresses the outputs obtained by applying the formulas given in the third part of the study to the relevant variables, and the final evaluation is included in the conclusion section of the study.

2. Literature Review

Several studies in the literature have examined the relationship between the Ecological Footprint (EF), Human Capital (HC), Urbanization (URB), and renewable energy consumption (REC). Although quantitative data analysis is generally used in studies, the studies are designed to statistically evaluate the level of relationship

Table 1: Literature Review of Articles

Research Topic	Author(s) (Date)	Investigation Period	Researched Country/ Country Group	Method	Variables	Results
The aim is to examine the convergence of the Ecological Footprint across the countries studied.	Bayraktar et al., (2023)	1992-2017	BRICS-T	Fractional Frequency Fourier ADF	Ecological Footprint	The convergence results of the ecological footprint vary depending on the tests applied.
The value of biomass use as a renewable energy source in sustainable development is examined.	Asghar et al., (2023)	1990-2017	21 Asian Countries	Panel Data Analysis Cointegration Tests	Biomass Energy Consumption Sustainability Development	The results show that using biomass as a renewable energy source has a positive impact on sustainable development.
The objective of this study is to analyze the impact of green finance on carbon intensity.	Gan and Voda. (2023)	2004-2019	30 Provinces of China	Panel Data Analysis	Carbon Emission Green Finance	It is determined that Green Finance can directly lower the intensity of carbon emissions.
The objective of the study is to analyze the impact of environmental regulations on the GTFP.	Jin, Gao & Pan (2023)	2003-2020	Provinces of China	Endogeneity Tests Robustness Tests	HC	It is considered necessary for the government to invest in creating a favorable ecological environment and adjusting environmental regulations for regional sustainable development.

Table 1: Continue

Research Topic	Author(s) (Date)	Investigation Period	Researched Country/ Country Group	Method	Variables	Results
The aim of this study is to analyze the contribution of renewable and non-renewable energy sources to sustainable development.	Islam, et al. (2022)	1980-2018	ASEAN Countries	PMG FMOLS DOLS CCR	Non-Renewable Energy Renewable Energy Sustainable Development	
This study examines trade openness, energy use, urbanization, economic development and environmental impact.	Amin, et al. (2022)	1991-2018	G11 Countries	Panel Cointegration Test Panel Unit Root Test	Urbanization Economic Growth Trade Openness	Urbanization, economic expansion and trade trigger environmental problems. Increased consumption of renewable energy reduces overall environmental damage.
The aim is to determine the relationship between the variables.	Sun et al. (2022)	1997-2017	China	Panel Data Analysis Durbin Model	REC Carbon Emission	REC and CO2 emissions are negatively correlated.
The aim was to examine the correlation between the variables and to assess the effect.	Ahmed et al., (2022)	2001-2019	Asia Pacific Region	Panel Co-Integration	Nuclear Energy Consumption Carbon Footprint Climate Change	There is a bidirectional causality correlation between the variables.

Table 1: Continue

Research Topic	Author(s) (Date)	Investigation Period	Researched Country/ Country Group	Method	Variables	Results
Assessing the relationship between renewable energy and support schemes is the aim of this study.	Boluk and Kaplan (2022)	2000-2018	EU Countries and Turkiye	Panel Data Analysis	REC Sustainability	According to the variables, the impact on the diffusion of renewable energy varies.
Examining the relationship between variables and human development is the aim of this study.	Sadiq, et al. (2022)	1990-2019	16 OECD Countries	Panel Data Analysis ARDL	Nuclear Energy Consumption Trade Globalization Development	The impact on HC varies according to the variables.
This study examines the relationship between the variables.	Hassan et al., (2022)	1990-2020	16 OECD Countries	Empirical Analysis	Carbon Emission Carbon Footprint Income	Energy efficiency, renewable energy, and technological advantages have a positive relationship with environmental quality.
This study examines the relationship between the variables.	Nathaniel, Yalçıner & Bekun (2021)	1992-2016	BRICS Countries	Empirical Analysis	Natural Resources Renewable Energy Human Capital Ecological Footprint Urbanization	Economic growth and increased use of natural resources increase the EF, while renewable energy reduces it.
The aim of this study is to explore the impact of renewable and non-renewable energy, natural resources, human capital (such as education or skills) and globalisation on the ecological footprint of developing countries.	Sahoo, et al. (2021)	1990-2016	36 Developing Countries	FMOLS DOLS	Renewable Energy Non-Renewable Energy Natural Resources Human Capital Globalization	The results show that non-renewable energy, depletion of natural resources and urbanisation increase the ecological footprint of developing countries and degrade the environmental quality.

Table 1: Continue

Research Topic	Author(s) (Date)	Investigation Period	Researched Country/ Country Group	Method	Variables	Results
It examines the environmental consequences of urbanization, trade, and economic expansion.	Nathaniel (2021)	1971-2014	Indonesia	ARDL	Urbanization Economic Growth Trade Ecological Footprint	Trade reduces environmental quality in the short run, but economic expansion, energy use, and urbanization have consistent long-term effects. In addition, urbanization, economic expansion, and energy use increase environmental degradation.
This study is designed to investigate how economic growth, globalization and energy consumption affect CO2 emissions and their environmental impact.	Pata (2021)	1980-2016	USA	EKC Hypothesis	Globalization Renewable Energy Non-Renewable Energy Carbon Emission Ecological Footprint	Globalization and REC are effective in reducing pollution. In addition, the use of non-renewable energy contributes to environmental pressure.
The aim was to examine the relationship between CO2 emissions and REC.	Hsu (2021)	1990-2018	Taiwan	Empirical Analysis	Energy Consumption Economic Growth CO_2 Emission	No relationship could be found between renewable energy and CO_2 emissions.
This study aimed to evaluate the validity of the EKC hypothesis for the ecological footprint, considering the effects of REC.	Destek,and Sinha (2020)	1980-2014	24 OECD Countries	EKC Hypothesis	Ecological Footprint Trade Openness Renewable Energy Non-Renewable Energy Economic Growth	There is a U-shaped relationship between economic development and the environmental footprint. The increase in the use of renewable energy reduces the ecological footprint.

Table 1: Continue

Research Topic	Author(s) (Date)	Investigation Period	Researched Country/ Country Group	Method	Variables	Results
This study examines the relationship between fossil fuel consumption and CO_2 emissions.	Ayompe, Davis & Egoh(2020)	1990-2017	African Countries	Vector Error Correction Model Johansen Co-integration Test	Carbon Dioxide emission Economic Growth	Population growth and the decline in GDP are found to have a negative impact on CO2 emissions.
The aim is to examine the variables that have an impact on carbon emissions.	Jin and Kim (2018)	1990-2014	30 OECD Countries	Panel Co-Integration Analysis Granger Causality	Nuclear Energy Consumption REC Carbon Emission	There is a relationship between the variables. The use of renewable energy positively affects CO_2 emissions.
It is designed to assess the relationship between the variables.	Apergis and Payne (2014)	1980-2011	25 OECD Countries	Panel Data Analysis	Renewable energy consumption Carbon Dioxide emission	It has been determined that there is a feedback relationship between REC and carbon emissions.
This study examines the variables that impact energy efficiency and the ecological footprint in China.	Chen, and Lin (2008)	1953-2006	China	EMD	Ecological Footprint	The study argues that China should prioritise stabilising economic growth, optimising its industrial structure, regulating domestic oil consumption and improving transport efficiency.

between variables. The literature studies selected a large sample from the 1980s to the 2020s and examined the variable relationship between the relevant years.

The table shows the objectives, authors, sample year range, countries/country groups, empirical tests applied, variables used and results obtained in some of the studies conducted in the literature on the related subject. The studies in the table are compiled by considering the current research published between 2008 and 2023. The high number of publications in the relevant years also provides information about the importance and timeliness of the subject.

When examining the studies that express the relationship between the variables; Jin and Kim (2018) examined 30 OECD countries, Ayompe, Davis & Egoh (2020) African countries, Hsu (2021) Taiwan, Hassan, et al. (2022), Sadiq, et al. (2022) 16 OECD countries, Boluk and Kaplan (2022) EU In the study between countries and Turkiye, Ahmed (2022) Asia, Sun, et al. (2022) China and Amin (2022) determined the correlation between the different variables included in the study in which he studied the G11 countries. Although the positive effect is evaluated in studies conducted in developed countries, the effect can be observed as negative in developing and underdeveloped countries. The fact that integration with REC has not yet been fully achieved explains this situation. Failure to achieve full integration may prevent the effect from being positive.

Although the positive effect is evaluated in studies conducted in developed countries, the effect can be observed as negative in developing and underdeveloped countries. This situation can be explained by the fact that integration with REC has not been fully achieved yet, and failure to ensure full integration may prevent the effect from being positive. From this point of view, the variables analyzed in this study and those in the literature are similar. Although the variables are similar, the tests used in the study differ from the tests applied by other studies in the literature.

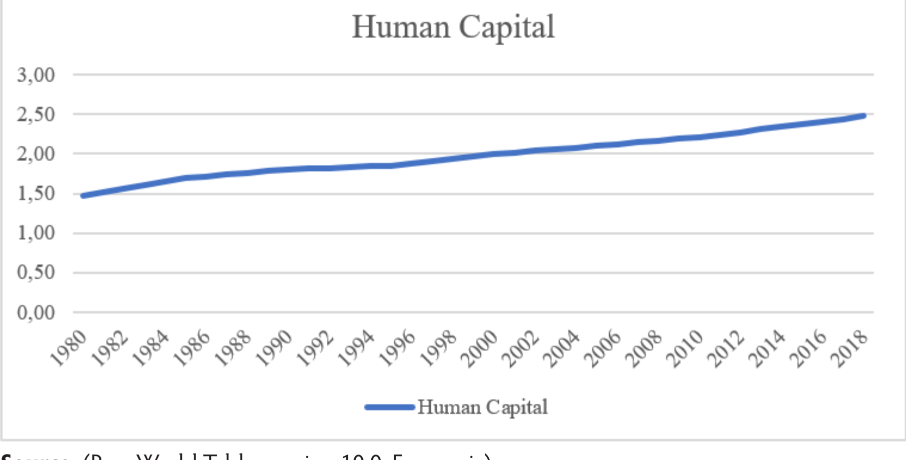
Panel Co-integration Test (Jin and Kim, 2018; Ahmed et al., 2022; Amin et al., 2022), Panel Data Analysis (Apergis and Payne, 2014; Sadiq et al., 2022; Boluk and

Kaplan, 2022; Sun, et al., 2022; Amin, 2022; Asghar, 2023; Gan, 2023), Granger Causality Test (Jin and Kim, 2018), Johansen Co-integration Test (Ayompe,Davis & Egoh 2020), Fractional Frequency Fourier ADF (Bayraktar et al., 2023) and ARDL bounds test (Nathaniel et al., 2021; Sadiq et al., 2022) have been applied in the studies on the subject. However, the Fourier ARDL test was not found in the tests applied in the studies. Fourier analysis is the most up-to-date test in the field and gives the most accurate results in applications with its structure that minimizes the margin of error. In this direction, it is thought that this study will contribute to the literature by applying the Fractional Frequency Fourier ADF and Fourier ARDL.

3. Data and Methodology

Although scholars started discussing the concept of EF in the 1980s, Wackernagel and Rees, (1996) measured the concept. For this reason, the year range of the study starts from 1980, when the subject was first started to be analyzed. Therefore, in this study, we evaluate the data of Turkey between 1980 and 2018. In this section of the study, we express the data of the variables to be analyzed graphically.

Figure 1: Human Capital Ratio by Years (1980-2018)



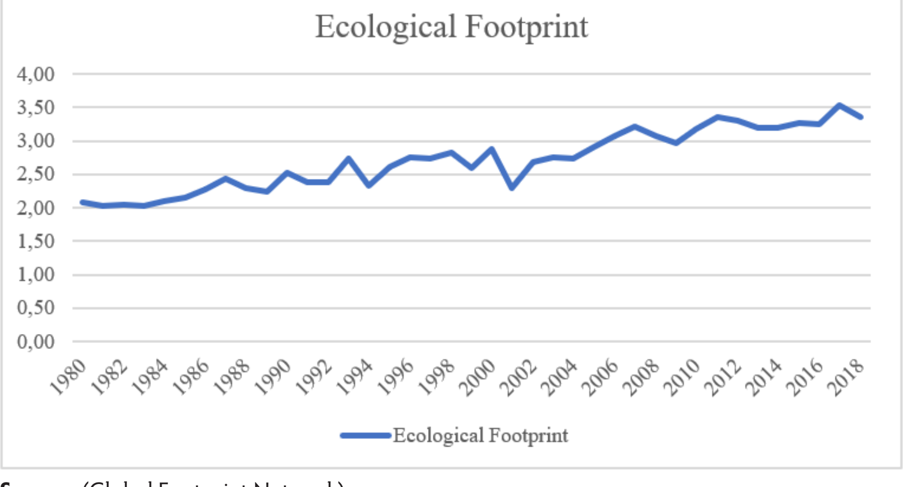
Source: (PennWorld Table, version 10.0. Economic)

The figure shows the values of the HC variable from 1980 to 2018. This variable, which is addressed in many studies in the field, is becoming increasingly important due to the increasing impact of globalization. When the idea of HC is evaluated descriptively, it can be defined as capital that supports knowledge-based development while fulfilling production tasks. The concept, which is a type of knowledge capital, shows an important activity at the point of intellectual development.

Figure 1 shows that HC started to increase with globalization in 1980. When looked at proportionally, the HC ratio, which was 1.46 in 1980, was calculated as 2.47 in 2018. When examined by years, there is no break in the increase. This shows that there is a stable increase.

EF is another issue to be examined in the study. EF data per capita is considered for analysis in the study. Although the increase in the amount of EF can be the result of the inefficient use of natural resources and the high amount of waste, reducing the value can be achieved with a planned environmentalism approach. Figure 2 shows the change in EF (per person) from 1980 to 2018.

Figure 2: Ecological Footprint Ratio per Person by Years (1980-2018)



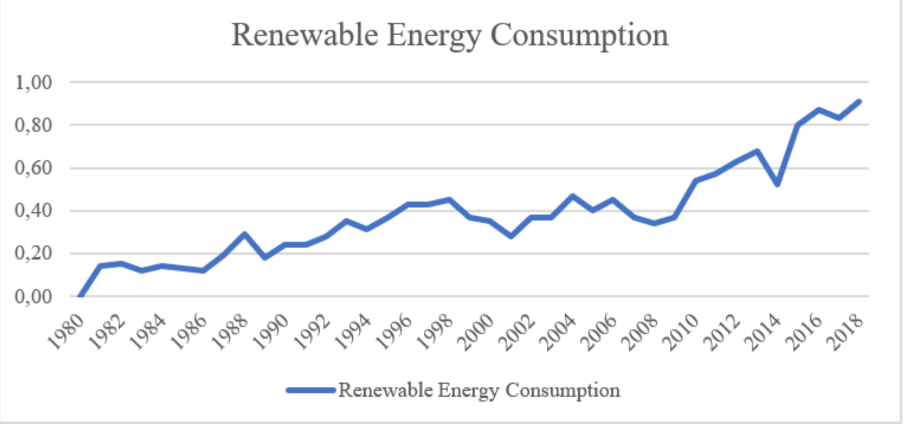
Source: (Global Footprint Network)

The course of the per capita EF value, which is another variable frequently examined in the literature and considered within the scope of the study, between 1980 and 2018 is shown in Figure 2. Although the figure shows that the EF value is between 2.00 and 3.50 on average, it can be interpreted that the value increases from year to year. The reason for this situation is the acceleration of globalization, increasing population, infrastructure problems, deficiencies in environmental planning, etc. multiple factors can be shown.

When the studies in the literature are examined, it is seen that there is more than one study examining the EF. In the study by Mattila (2012) examining sustainability in the relationship between EF and economic growth, the development of eco-efficiency between 2002 and 2005 is mentioned. In addition, the impact of consumption activities on the environment is also included in the scope of the study. In contrast, Chen, Lee & Chen (2022) examined HC and URB as components of the EF in their study.

Another variable to be analyzed is the REC. Besides the fact that energy consumption is at a high rate for countries, energy consumption in Turkey is provided from more than one source. These sources include wind energy, solar energy, geothermal energy, biomass energy, etc. is located. Turkey, a country that not only produces but also consumes energy, is still dependent on foreign sources for energy. Although there are fossil-based types among the energy types that increase the EF, countries tend to reduce their EF rates by not adopting the understanding of environmental sustainability. At this point, it can be stated that the increase in REC has a reducing impact on the EF. In the evaluation made for Turkey, it is determined that REC constituted 11.9% of the total energy consumption in 2018 (World Bank, 2022).

Figure 3: Per Capita Energy Consumption from Renewables (1980-2018)



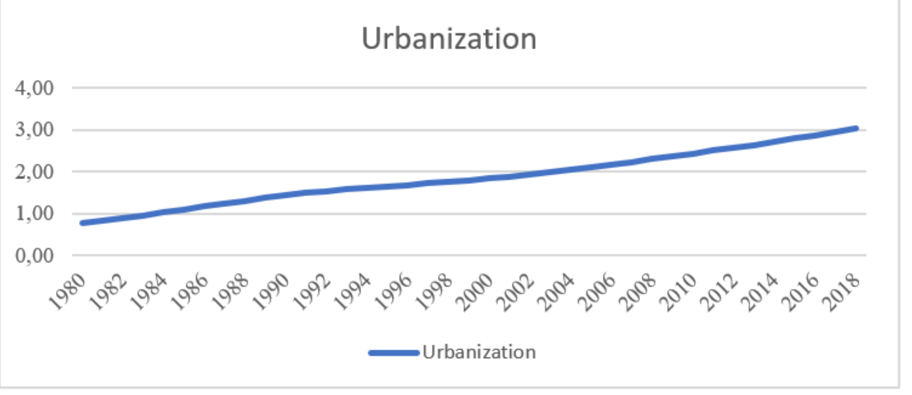
Source: (Our World in Data, 2022)

When Figure 3 is analyzed, it is seen that the data on per capita REC are given for the years 1980-2018. Since high fossil energy has a negative impact on the EF, it is deemed appropriate to evaluate the amount of renewable energy consumed per capita in this study. With this assessment, the impact of increases and decreases in per capita REC on CO_2 emissions should be analyzed.
When the figure is examined, it is seen that the series constantly experiences sudden increases and decreases. The lack of full compliance with the new energy consumption explains this situation

The last variable whose values are expressed in Figure 4 is URB. Because of the increase in unplanned URB, environmental pollution, infrastructure problems, water scarcity, etc. factors can negatively affect the EF.

Based on this idea, URB statistics between 1980 and 2018 are examined within the scope of the study. These variables were obtained from the World Bank database. The values are expressed under the heading of world development indicators and defined as "urban population growth" variable.

Figure 4: Urbanization Ratio by Years (1980-2018)



Source: (World Bank, 2022)

When the URB variable is examined, it can be stated that this variable has shown a more stable increase over the years and has experienced less decline than the EF and REC variables. This situation shows that the URB continues to increase. The ratio, which was between 0.77 and 0.82 in 1980, accelerated with the influence of globalization and experienced periods of decline, but was determined to be 3.02 in 2018.

It is aimed to examine the relationship between HC, EF, REC and URB by considering the data from 1980 to 2018 between the values in the figures and the variables to which the values belong. Fourier ARDL and Fractional Frequency Fourier ADF unit root tests were used to analyze the variables under study. In this study, the Fourier ARDL cointegration test, which is the most advanced version of the ARDL cointegration test, is applied. This test aims to minimize the margin of error.

In addition to applying the Fourier ARDL test in the study, the Fractional Frequency Fourier ADF, which is an improved version of the Fourier ADF, was also among the tests applied. The critical values in the tests included in the study were evaluated considering the data obtained from the Bozoklu, Yılancı and Gorus (2020) study.

Fourier ADF analysis is discussed for the first time in the literature by Enders-Lee (2012). The analysis differs from other studies in the literature in that it adds sine and cosine values to the calculations. Taking the relevant values into consideration is important in minimizing the margin of error in the analysis.

The formulation of the Fourier ADF analysis.

$$\Delta yt \ = \mathrm{c}_0 + \mathrm{c}_1 \sin\left(\frac{2\pi kt}{T}\right) + \mathrm{c}_2 \cos\left(\frac{2\pi kt}{T}\right) + c_3 y_{t-1} + \sum_{i=1}^{p} a_i \Delta y_{t-i} + e_t \qquad (1)$$

The "Fractional Frequency Fourier Augmented Dickey Fuller Unit Root Test" by developing frequency values in the FADF (Bozoklu, Yılancı and Gorus, 2020), which takes into account the sine and cosine values and minimizes the margin of error. The test formulation is shown in equation (2).

$$y_t^* = \alpha_0 1_t^* + \beta_0 t_t^* + \lambda_1 \sin_{1,t}^* + \lambda_2 \cos_{1,t}^* + u_t, \ \ t = 1,2,3, \dots, T \qquad (2)$$

Within the scope of the research, researchers first apply the Fourier ADF test, followed by the Fourier ARDL cointegration test. Pesaran et al. (2001) report the ARDL method in the literature. Although Pesaran, Shin and Smith (2001) introduced the ARDL test, Yılancı, Bozoklu and Gorus (2020) use its Fourier version. To use the test with the smallest margin of error, the series must first be stationary at first order and then the best lag length must be calculated.

The ARDL bounds test developed by Pesaran, Shin and Smith (2001) can be written in error correction notation as in Equation 3.

$$\Delta \mathrm{FP}_t = \beta_0 + \beta_1 FP_{t-1} + \beta_2 EC_{t-1} + \beta_3 FDI_{t-1} + \sum_{i=1}^{p-1} \varphi_i' \Delta \mathrm{FP}_{t-i} + \sum_{i=1}^{p-1} \delta_i' \Delta \mathrm{EC}_{t-i} + \sum_{i=1}^{p-1} \emptyset_i' \Delta \mathrm{FDI}_{t-i} + e_t \qquad (3)$$

The Fourier ARDL test is defined as follows. First, instead of using dummy variables, the following Fourier function was used.

$$d(t) = \sum_{k=1}^{n} a_k sin\left(\frac{2\pi kt}{T}\right) + \sum_{K=1}^{N} b_k \cos\left(\frac{2\pi kt}{T}\right) \tag{4}$$

The study followed Becker, Enders and Lee (2006) and Ludlow and Enders (2000) and allowed a single frequency as follows.

$$d(t) = y_1 sin\left(\frac{2\pi kt}{T}\right) + y_2 \cos\left(\frac{2\pi kt}{T}\right) \tag{5}$$

Yılancı, Bozoklu and Gorus (2020) obtained the following equation (Equation 6) by including the Fourier expansion in Equation 3.

$$\begin{aligned} \Delta \mathrm{FP}_t = \beta_0 + y_1 sin\left(\frac{2\pi kt}{T}\right) + y_2 \cos\left(\frac{2\pi kt}{T}\right) + \beta_1 FP_{t-1} + \beta_2 EC_{t-1} + \beta_3 FDI_{t-1} \\ + \sum_{i=1}^{p-1} \varphi_i' \Delta \mathrm{FP}_{t-i} + \sum_{i=1}^{p-1} \delta_i' \Delta \mathrm{EC}_{t-i} + \sum_{i=1}^{p-1} \emptyset_i' \Delta \mathrm{FDI}_{t-i} + e_t \end{aligned} \tag{6}$$

There are 4 different constraints that need to be examined in the formula. These are expressed in stages (i), (ii), (iii), and (iv), respectively.

(i) If F_A, F_B, and t are substantial, HC, EF, REC, and URB have a co-integration connection.
(ii) There is no co-integration connection between HC, EF, REC and URB if FA, FB and t are meaningless.
(iii) If F_A and F_B are substantial but t is not, the first degenerate condition is observed.
(iv) A second degenerate scenario is encountered if F_A and t are large but F_B is not.

It is considered necessary to arrange the formulas according to the variables to be examined in the tests to be applied.

The empirical findings of the research are stated in the following section of the study using the above formula.

4. Empricial Findings

This part of the study presents the outputs obtained after the application of the analysis methods stated in the third part to the variables within the study. In this section, the outputs are expressed and interpreted in tables.

Table 2: Descriptive Values of the Variables

	Ecological Footprint	Human Capital	Renewable Energy Consumption	Urbanization
	EF	**HC**	**REC**	**URB**
Mean	2.711282	1.979639	0.390825	1.852174
Median	2.730000	1.967192	0.372533	1.795092
Maximum	3.530000	2.479055	0.91456	3.023012
Minimum	2.020000	1.469023	0.121835	0.778726
Std. Dev	0.444357	0.270363	0.213304	0.631002
Skewness	0.028978	0.063024	0.853878	0.117164
Kurtosis	1.786051	2.109632	3.133269	2.056058
Jargue-Bera	2.400177	1.314045	4.768059	1.537147
Proability	0.301168	0.518393	0.092178	0.463674
Sum	1.057400	7.720590	1.524217	7.223480
Sum Sq. Dev	7.503236	2.777655	1.728951	1.513021
Observations	39	39	39	39

The above information includes multiple information such as the minimum and maximum values of variables, probability values, mode and median values. The expressed values are important in terms of being descriptive. Table 3 is important for determining the ADF test results and the degree to which the series is stationary.

Table 3: Fractional Frequency Fourier ADF Test Results

Variables	k	Min KKT	FFADF Test Statistic	Optimal Lag Length	F Test Statistics	FFADF %1 Critical Value	FFADF %5 Critical Value	FFADF %10 Critical Value
EF	0.1	0.726591	3.682082	1	6.440704	-4.87987	-4.26469	-3.95616
ΔEF	3.8	0.954480	7.211575	1	2.026829	-4.32422	-3.65693	-3.31667
HC	0.2	0.001475	-2.663442	6	4.348617	-4.87804	-4.2659	-3.96258
ΔHC	2.4	0.000950	-2.623264	9	4.842245	-4.57925	-3.91711	-3.5715
ΔΔHC	2.4	0.001128	-5.488755	9	1.352868	-4.57925	-3.91711	-3.5715

REC	0.1	0.177583	-1.964921	1	3.103442	-4.87987	-4.26469	-3.95616
ΔREC	5	0.181258	-8.504023	0	2.366425	-4.21133	-3.5507	-3.22669
URB	1.3	0.002067	3.026177	9	3.091448	-4.96172	-4.35584	-4.04304
ΔURB	1.1	0.000927	-6.293324	9	53.93319	-4.98567	-4.36093	-4.05824

Note: Based on the values obtained from the study of Bozoklu, Yılancı and Gorus. (2020), the constraint values of the frequencies at 1%, 5% and 10% significance levels respectively; -4.87987, -4.26469, -3.95616 for 0.1; -4.87804, -4.2659, -3.96258 for 0,2; -4.98567, -4.36093, -4.05824 for 1,1; -4.96172, -4.35584, -4.04304 for 1,3; -4.57925, -3.91711, -3.57015 for 2,4; -4.32422, -3.65693, -3.31667 for 3,8 and -4.21133, -3.5507, -3.22669 for 5.

In the table, the stationarity levels of the variables used in the study are examined and the FFADF test is used for the analysis. In the table, Fractional Frequency Fourier ADF (FFADF) test statistical values and F Test statistical values of EF, HC, REC and URB variables are evaluated and the extent to which they are stationary is determined. In the table, frequency values of 4 variables (k), min. KKT, FFADF test statistic value, optimal lag length, 1%, 5%, and 10% significance levels.

First, when the EF is examined, it is seen that the FFADF test statistic value of the series, 3.682082, is smaller than the values at 1%, 5% and 10% significance levels. Accordingly, the series is non-stationary and contains a unit root. In this case, the series should be different until stationarity is achieved. When the series is differenced at first order, the FFADF test statistic value of 7.211575 is greater than the significance levels of 1%, 5%, and 10%. This indicates that the series has no unit root and is stationary at the first difference.

The HC series with the FFADF test statistic value of -2.663442 is smaller than the reference values. Accordingly, while the series is non-stationary, the FFADF test statistic value is lower than the 1%, 5%, and 10% significance levels when the series is taken at the first difference, indicating that the series is non-stationary at the first degree. When the second difference of the HC series is taken, the FFADF test statistic value is greater than the constraint values, indicating that the series has become stationary.

The other variable to be analyzed is the REC variable. The fact that the FFADF test statistic value of -1,964921 at the level value of the variable is smaller than the indicates levels of significance that the series is not stationary at the level value, while it can be said that the series reaches stationarity when the first degree difference of the series is taken.

The last of the variables is tested as the URB. When the URB variable was analyzed at the level value, the FFADF test statistic value was calculated as 3.026177. When the value is compared considering the significance levels, the value calculated at all three significance levels is found to be smaller than the constraint value. This indicates a unit root in the series and the series is not stationary. When the first difference in the series is taken, the FADF test statistic value of -6.293324 is greater than the 1% significance level. This indicates that the series is stationary at the first difference.

Table 4: Fourier ARDL Test Results

AIC	*FA*	*Bootstrap Critical Values*			*t*	*Bootstrap Critical Values*			*FB*	*Bootstrap Critical Values*		
		%10	*%5*	*%1*		*%10*	*%5*	*%1*		*%10*	*%5*	*%1*
-1.201523	7.198145**	5.517701	6.470723	9.317924	-5.329036***	-4.028064	-4.361360	-5.245762	9.352838**	5.936553	7.184694	10.25311

Note: It is analyzed by considering the constraint values obtained from the study of Yılancı, et al. (2020).

Table 4 shows that the test findings are expressed using the Bootstrap Estimator and the F and t statistical values are evaluated considering the Akaike Information Criterion. When the statistical significance of FA is examined, it is seen that the significance level of 7.198145 is higher than the 5% and 10% significance levels. Additionally, the value is greater than 9.317924 at the 1% significance level. When the t-statistic value of -5.329036 is examined, it can be stated that the value is greater than the significance level.

When the F_B statistical value (9.352838), which is another statistical value, is examined, it is observed that the series is greater than 5.936553 at the 10% significance level and 7.184694% at the 5% significance level, and the same value is less than 10.25311 at the 1% significance level.

Table 5 emerges when the long-term forecast findings are evaluated.

Table 5: Long-Term Forecast Results

Variable	Coefficient	Stnd. Error	t-statistic	Probability
HC	5.823631***	1.802481	3.230898	0.0029
REN	0.746312***	0.258238	2.890019	0.0069
URB	-2.024339**	0.820680	-2.466661	0.0192
C	-5.349208**	2.120874	-3.963105	0.0168

Note: While performing the evaluation, the probability value is compared with the constraint value of 0.05.

When the long-term estimation results are examined, it can be said that the probability value for HC (0.0029), REC (0.0069) and URB (0.0168) is significant on the EF nt. This shows that REC, HC and URB affect the EF. Looking at the long-term coefficients, a 1% increase in human capital leads to a 5.82% increase in EF. In addition, a 1% deviation in REC changes 0.74%. The last variable, a 1% change in URB, has an effect of -2.02% on the EF.

5. Conclusion and Discussion

There has been a significant increase in EF due to increasing globalisation, population growth and inadequate regulation for the growing population. Although the inadequacy of policies towards population is effective in more than one field, it can be expressed within the scope of environmental planning. Regulations that do not progress in integration with the population in terms of adapting to the increasing population have caused population growth to lead to unplanned URB. The increase in migration from rural areas to cities with population growth can also be a reason for this situation.

In addition to the unplanned URB, the failure to plan the resource consumption of the increasing population constitutes another pillar of environmental problems. The increase in the use of vehicles in cities due to population growth leads to infrastructure problems on the basis of traffic problems. Although the aforementioned problems are some factors that cause the EF to increase, more than one variable affecting the EF is examined in the literature. In this study, renewable energy, human HC, and URB variables, which are among the variables affecting the EF, are examined.

Among these, many variables such as URB, openness to trade, economic growth, renewable energy and HC play a crucial role. This study identifies renewable energy, HC, and URB as some variables that influence the EF. Using annual data between 1980 and 2018, the relationship between REC, HC and URB variables and the EF is examined. FFADF tests and FARDL tests are used in this study. When the long-term estimation results of the study are examined, it has been revealed that the probability value of the EF for HC (0.0029), REC (0.0069), and URB (0.0168) is significant. There is also a positive relationship between HC and EF. Looking at the long-term coefficients, a 1% increase in HC causes a 5.82% increase in the EF. These results are very important for policy makers. There is a need to follow various policies to increase the environmental awareness of HC. In this regard, adding issues related to the environment and climate change to the curriculum can support the sustainability of resources at the individual level. HC development should be supported for adopting energy-saving lifestyles such as green technology innovation and environmentally friendly transportation habits. Further efforts should be made to balance the impact of population size on the EF through various incentives and subsidies.

On the other hand, statistically significant relationships were found between REC and EF. A 1% change in REC reduces the EF by 0.74%. The reason for this situation may be that renewable energy does not pollute the environment and has a reducing effect on fossil fuel consumption. In terms of environmental protection, REC can reduce the EF in addition to conventional energy consumption.

Therefore, innovations in renewable energy technologies are effective in reducing the negative impact of energy consumption on the environment. More budget should be allocated to R&D expenditures in renewable energy projects. Turkey is rich in renewable energy resources. For this reason, R&D support should be provided to enterprises in the country that prioritise research in this field. Investments in the field of renewable energy should be increased by giving due importance to resource transfer in order to investigate the potential of renewable energy resources in detail. Private sector and government cooperation should set enforceable mandatory renewable energy targets.

Another result of the study is the existence of a negative relationship between URB and EF. It has been determined that a 1% change in URB has an effect of -2.02% on the EF. It has been determined that the increase in URB has positive effects on the environmental quality. Factors such as the increase in the educated population brought about by URB, the increase in environmental awareness, and the increase in the importance given to green technologies have caused URB to reduce its EF. Therefore, it can be stated that activities such as increasing investments in environmentally friendly technologies, implementing various tax policies and giving due importance to educational activities to raise environmental awareness increase the positive impact of URB on environmental quality. To increase the positive effects of URB, practises that adopt a sustainable lifestyle in many areas such as recycling, smart cities, environmentally friendly food consumption, and the use of renewable energy vehicles should be implemented. Efforts to increase the environmental quality of URB should be continued and even increased.

As a result, when the relationship between EF and REC, HC and URB is considered in general, it is determined that in order to balance the effects of these variables on EF, environmental awareness should be increased, educational activities should be given importance, various incentives and subsidies should be applied and a green-based economy should be targeted with selective taxation procedures. In addition, it is thought that increasing the number of studies examining the impact of EF on the economy will increase awareness in this field.

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RESEARCH ARTICLE

A Monitoring Framework for Progress in Artificial Intelligence Technology: A Research Based on Scientific and Technological Indicators

Fethi ASLAN[1]

ABSTRACT

In the past century, the key technologies that shaped societal and economic transformation were mechanical, electrical, and automation technologies. In the current century, there are strong trends indicating the prominence of artificial intelligence technology. Therefore, artificial intelligence technology has become more important for all countries. The success of countries in artificial intelligence technology is only possible with well-designed artificial intelligence policy tools. It is important to measure the level of technological advancement for the formulation of policies. However, efforts to measure the scientific and technological advancement of artificial intelligence technology are insufficient. Therefore, this study aims to develop a framework to measure the scientific and technological progress of AI technology. The developed framework includes the number of publications and citations, the number of high-impact scientific journals, the number of patent applications, the number of universities ranked in the top thousand in the field of computer science, the number of international high-impact conferences, and the total number of researchers in higher education. Through these criteria, the level of scientific and technological progress of the countries has been analysed in detail. The findings clearly revealed the leading position of the USA in this field. China followed the USA. These two countries are clearly and positively differentiated from the other countries. Other countries with good performance are the UK, the Netherlands and Germany.

Keywords: Artificial intelligence, Technology management, Scientific and technological progress, Entropy, Grey system theory
JEL Clasification: O31, O32, O33

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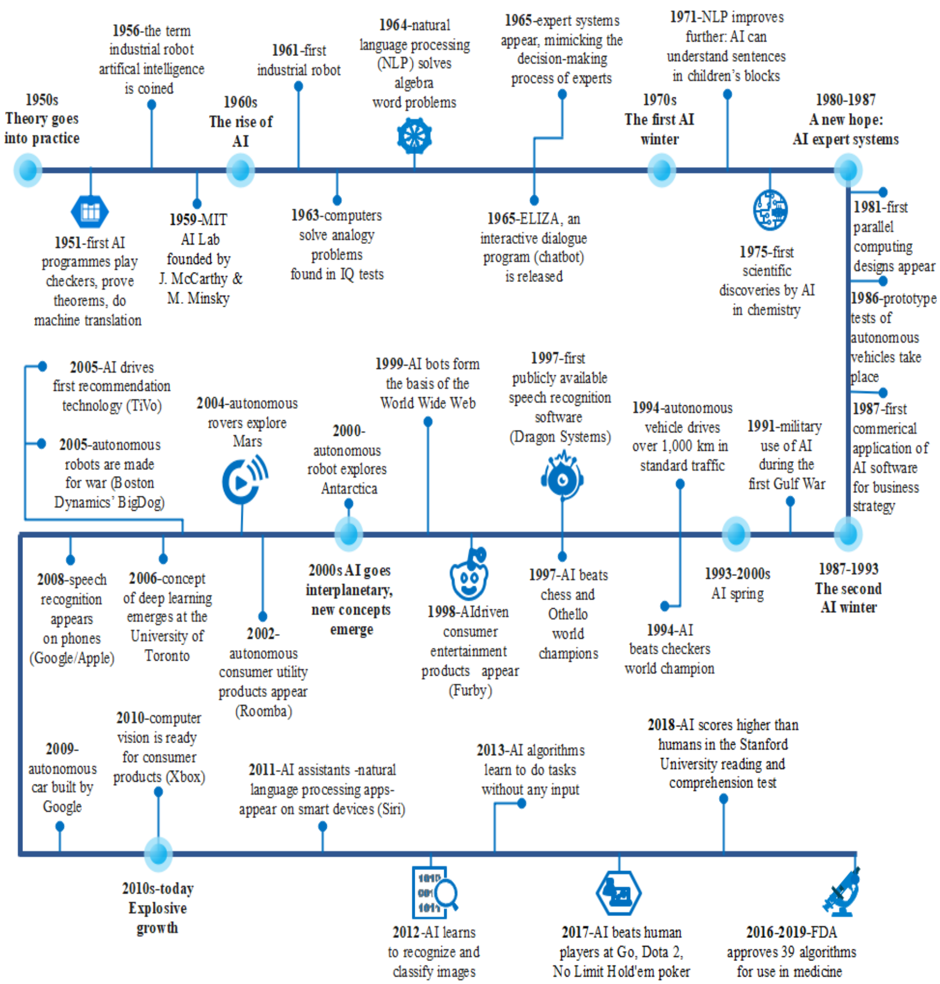
1. Introduction

Disruptive technologies have created significant economic and social impacts. Leading and influential roles in these technologies by countries, industries, and individuals promote positive progress in economic and social effectiveness. According to economic theory, in countries that stand out in terms of technological progress, both positive and negative outcomes can occur simultaneously, and these can balance each other out. However, countries that cannot adapt to technological advancement suffer from its negative consequences (Korinek, Schindler and Stiglitz, 2021, p. 4). Artificial intelligence (AI) is the technology that influences today's world and will create the most significant change in the future. Artificial intelligence has a significant impact on various aspects of life, including healthcare, food, automotive, security, aviation, and pharmaceuticals. Therefore, progress in artificial intelligence technology will place countries in an advantageous position in various ways compared to their competitors. According to predictions, artificial intelligence will contribute approximately 15.7 trillion dollars to the world's GDP by 2030 (World Economic Forum, 2022).

Artificial intelligence refers to information processing-based systems with the ability to learn, interpret, and make decisions based on acquired data. Built upon the foundation of the mathematical sciences, logic, computation, and knowledge constitute the disciplines. The progress in the field of artificial intelligence is depicted in figure 1. As shown in the figure, the origin of artificial intelligence technology is considered to have begun with its conceptual expression at a conference held in the United Kingdom in 1956. In the 1960s, research and studies were conducted in the fields of industrial robots, chatbots, and expert systems. By the 1970s, the first scientific discoveries in natural language processing and artificial intelligence had taken place. However, during the 1960s and 1970s, the desired progress in artificial intelligence could not be achieved. In the 1980s, expert systems emerged as the prominent focus, leading to a decline in interest in artificial intelligence. The 1990s marked the beginning of a period of revolutionary developments in artificial intelligence technology. During this period, an approach based on learning rather than programming artificial intelligence was adopted. The increase in computing power and data volume over the internet were prominent factors in the development of artificial intelligence in the 2000s. The most significant step in the development of artificial intelligence after 2010 has been the deep learning method, which has high prediction capabilities by developing nonlinear models using very large datasets (World Economic Forum, 2022).

Figure 1: Artificial intelligence timeline (World Economic Forum, 2022)



Research and development activities play a decisive role in enabling countries to achieve sustainable growth. These activities also serve as determinants of competition, growth, and industrial progress (Campbell et al., 2015). Global scientific and technological advancement can yield significant benefits on a global scale in terms of goods and services, employment, skill acquisition, and productivity (Bernanke, 2011). Science and technology drove more than half of economic growth in the 20th century (Evans et al., 2021).

Akçiğit & Tok, (2020), emphasised the positive relationship between scientific and technological progress and economic development. Scientific and technological progress encompasses research, development, and technical education activities that span from the creation of scientific and technical knowledge to its use (OECD, 1994). The direction of scientific progress varies. Topics that are popular in certain periods may lose their impact over an extended period. Conversely, areas without progress or obvious potential can evolve and become prominent. Hence, it is essential to determine the direction of scientific progress correctly. Countries can be successful to the extent that they adapt to scientific and technological progress.

Scientific and technological progress refers to the research, development, and technical education activities that occur from the generation of scientific and technical knowledge to its use (OECD, 1994). The direction of scientific progress varies. Popular topics at certain periods can lose their impact over an extended period of time. However, areas where no progress has been made and have no potential can still develop and come to the forefront. Therefore, it is essential to determine the direction of scientific progress correctly. Countries can be successful to the extent that they adapt to scientific and technological progress. Some measurable factors and methods need to be developed to determine the relative positions of countries in this progress. The semantic forms of these factors should be easily understandable and accessible to everyone. Thus, the acquired information can yield meaningful results. The initial studies on measuring progress in scientific and technological research date back to the early 20th century. Hulme conducted one of the earliest studies in this field in 1923. Hulme measured social progress using patent and scientific literature indicators (Okubo, 1997). Throughout the historical process, studies aimed at measuring scientific and technological progress have consistently maintained their importance. The numerical evaluation of scientific and technological indicators assists in the correct formulation of policies in science, technology, economics, society, and the environment (Okubo, 1997). Scientific and technological progress inherently may require a long period and entail high costs. A well-made foresight provides accurate guidance for funding providers, policymakers, and researchers. Efforts aimed at determining the direction of scientific progress can lead to time and cost savings, increase the likelihood of making correct decisions, and establish a balance between effort and impact and results (National Research Council, 2007). In particular, in OECD countries, evaluation activities have become mandatory to ensure the efficient and effective utilisation of resources and to direct research activities towards current developments in science and technology (Moed, 2005).

The aim of this study is to develop a data-driven framework for international comparisons and performance monitoring in order to analyse the levels of scientific and technological expertise in the field of artificial intelligence. The fundamental questions motivating this study are as follows: Which criteria can be used to measure scientific and technological progress in the field of artificial intelligence? Is it possible to create a common framework for measuring the national-level scientific and technological progress in the field of artificial intelligence and for comparing countries? What is the level of scientific and technological progress in the field of artificial intelligence for countries?

2. Literature review

Artificial intelligence is a new technology with significant potential across various industries and disciplines. Therefore, there are limited approaches available for measuring progress in this field. Reviewing previous approaches provides significant contributions to how scientific and technological progress in the field of artificial intelligence should be approached.

One of the first studies aimed at measuring progress in the field of artificial intelligence was conducted by the European Commission's Joint Research Centre

(EC-JRC) in 2018. In this study, patent and scientific publication data were utilised to track developments and contributions in the field of artificial intelligence (Baruffaldi et al., 2020). On the other hand, in another study in the field of artificial intelligence, IBM developed an index methodology to measure the adoption of artificial intelligence in organisations. On the other hand, in another study in the field of artificial intelligence, IBM developed an index methodology to measure the adoption of artificial intelligence in organisations. Similarly, in the study conducted by Baruffaldi et al. (2020), scientific publications, open-source software, and patent data were utilised to measure the progress of AI in the fields of science, technology, and software. This scale was applied to 7,502 businesses worldwide. The evidence obtained indicates that 44% of organisations have undertaken activities to integrate AI into existing applications and processes. The issue of continued bias against artificial intelligence is another significant finding in the study (IBM Corporation, 2022). In another study by Rogerson et al., (2022), an index was developed to measure the level of AI implementation in public services across 182 countries. This index was calculated using criteria such as capacity, frameworks, skills, resources, and infrastructure requirements. The findings have indicated that the United States, Singapore, and the United Kingdom are the countries that use artificial intelligence applications in public services the most. On the other hand, in the study conducted by Nestor et al. (2023), countries have measured their progress in artificial intelligence using factors including research, development, technical advancement, artificial intelligence ethics, economics, education, public administration, policy, diversity, and social participation. Cesareo and White's (2023) study measured countries' capabilities in using artificial intelligence. For this purpose, they used three main factors: the primary factor for AI applications, the innovation factor for measuring progress in technology and methodologies, and the investment factor for financial and procedural commitments to AI. Under these main factors, 111 sub-factors were defined.

3. The conceptual framework for selecting criteria

The comprehensive definition of issues in specific fields and the formulation of appropriate policies rely significantly on the selection of suitable criteria.

Defining the conceptual framework associated with these criteria facilitates the identification of the right criteria. In this context, the criteria employed in the study have been developed on the basis of the definitions of science and technology provided here.

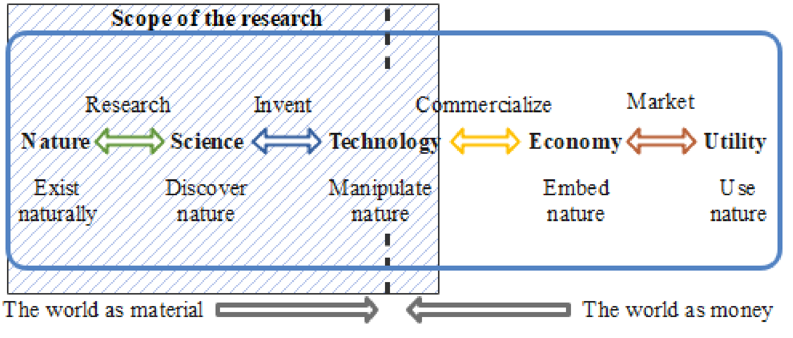
Science is the intellectual activity conducted to explore, verify, and apply the principles and rules of knowledge found in natüre. It is used in the development of technology (National Research Council, 1986). Technology, on the other hand, is defined as tangible outputs that provide both indirect and direct contributions to the production of goods and services from the knowledge found in nature. The transformation of science into technology is achieved through invention. Inventions generate economic benefits, but in some cases, they only gain value as scientific knowledge. The common belief is that technology develops on the basis of science (Eto, 2003).

The criteria used to measure scientific and technological progress can include the number of articles and citations, academic awards, research activities conducted through collaboration, the number of researchers, data related to the research infrastructure of universities, government, and industry, and the financial resources allocated for research (Ministry Of Education, Culture, Sports, Science And Technology Japanese Government, 2005). Furthermore, criteria such as the increase in scientists' efforts in the field, the creation of new courses and programmes and the rise in the number of participants, the expansion of research scope to encompass other scientific domains, the frequency of publication of studies in leading journals, and the growth in academic activities related to scientific events like conferences and symposia, as well as the increase in collaboration across different fields, can be used in measuring scientific and technological progress (National Research Council, 2007).

Measuring the scientific and technological progress in artificial intelligence technology within an international comparative framework is a complex process. One of the most significant reasons for this is the constraints related to data acquisition. There are generally accepted frameworks for data acquisition.

However, countries may be insufficient in implementing fundamental standards for data collection, dissemination, and similar processes (Everaers, 2022). In very few countries, there are studies aimed at monitoring long-term scientific and technical subjects (OECD, 1995). This situation poses a significant challenge in the selection of common criteria and the acquisition of data. Furthermore, the proliferation of artificial intelligence technology across various disciplines, ranging from the arts and social sciences to veterinary medicine, agriculture, engineering, and medical research, brings another significant challenge. The multidisciplinary nature of artificial intelligence makes the determination of boundary complex. This uncertainty complicates the identification of the data needed to develop a common measurement model. Additionally, it is possible to access the data used in the study from different databases. However, in Okubo's (1997) study, it is emphasised that the data to be used in the data collection process should be obtained from databases that best meet the analysis requirements.

Figure 2: Relationship between science, technology, and innovation (Betz, 2011)



Time is a determining factor in measuring the output, results, and impact on scientific and technological progress. Measuring the output factors may require a shorter time, while measuring the result and impact factors may require longer periods. One of the good examples that explains this situation is the studies conducted in the field of magnetism. The knowledge obtained from previous studies in magnetism eventually turned into tangible benefits with the invention of the telegraph after a considerable amount of time (Aslan, 2023, p. 29). The innovation model presented in Figure 2 comprehensively explains the relationship between science, technology, and innovation. This model was used as a reference for criteria selection in the study

Table 1 shows the evaluation framework consisting of the number of citable publications, number of citations, number of high-impact scientific journals, number of patent applications, number of universities, number of top conferences, and number of higher education researchers.

Table 1: Criteria used in the study

Abbreviation	Criteria	Date	Database
C1	Number of citable publications	2022	SJR
C2	Number of citations	2022	SJR
C3	Number of high-impact scientific journals	2022	SJR
C4	Number of patent applications	2022	OECD (USPTO)
C5	Number of top universities	2022	THE
C6	Number of top conferences	2022	Research.com
C7	Number of higher education researchers	2021	OECD

Note: SJR: Scimago Journal & Country Rank, OECD: Organisation for Economic Co-operation and Development, USPTO: United States Patent and Trademark Office, THE: Times Higher Eduction

3.1. Publications and citations

Scientific publications are produced as a result of scientific studies. Scientific publications and citations enable the quantitative monitoring of the outputs of scientific studies. The number of scientific publications refers to the number of research results published in articles, books, journals, etc. produced by individuals, countries or institutions. Number of publications refers to the number of citable research results, such as articles, books, journals, etc., produced by individuals, countries or institutions (Okubo, 1997). Scientific publication and citation counts are used to assess the state of science by linking individuals, research groups, organisational structures and countries (National Research Council, 2007; Okubo, 1997). Scientific publications demonstrate the extent to which researchers contribute to their field of study. These publications also reveal the importance of the relevant field at both national and international levels. Additionally, they reflect the collaboration between individuals and institutions that contribute to scientific developments. (National Research Council, 2007). Technology development activities that are not based on scientific foundations can often lead to higher costs and lengthen the development time (Mansfield, 1991). The connection between R&D activities and scientific publications is stronger in scientifically productive countries (OECD and SCImago Research Group, 2016). The number of scientific publications per capita and per capita gross domestic product (GDP) exhibit a positive and exponential relationship (Akçiğit and Tok, 2020). Especially in the United States and the United Kingdom, most patents in the fields of clinical medicine and biomedicine have been developed significantly based on scientific articles. Additionally, scientific publications play a significant role in patent studies in the fields of chemistry, physics, and engineering (Narin, Hamilton and Olivastro, 1997). The data related to citable scientific publications and citation numbers were obtained from the SCImago database and are presented in figure 3.

Figure 3: Distribution of citable publications among countries

Country	No. Publications	Country	No. Publication
China	42293	Spain	1842
United States	13101	Türkiye	1734
United Kingdom	4816	Netherlands	1276
Germany	4001	Singapore	1209
Japan	3964	Switzerland	951
Italy	2943	Poland	910
Canada	2844	Greece	895
South Korea	2546	Belgium	607
France	2520	Czechia	496
Russia	1914	Slovenia	160
Taiwan	1883		

Note: No: Number of

When new and important topics are addressed in scientific studies, several publications and citations are usually obtained to advance knowledge in this field (Schreiber, 2007). Citation is the act of incorporating information, text or other content used in previous works, while referencing the source, to create new knowledge or present information in a different form. Citation is a determining factor in measuring the significance and impact of information within the research context in a study. Citations provide a supporting foundation for the information presented in the current study (Hellsten, Lambiotte, Scharnhorst, & Ausloos, 2007). It is increasingly important to gain recognition in the academic field, to increase visibility, to emphasise the quality and importance of work, as well as to build wider academic relationships and strengthen collaboration. The level of citation is an indicator of the level of adoption of the study (Hyland, 2003). The relationship between citation analysis and science and technology is shown in Table 2.

However, the contribution of self-citation to the assessment of scholarly impact, creating scientific influence, and measuring ubiquity is a controversial topic. For this reason, self-citations are sometimes not considered in the calculation (Costas, Van Leeuwen and Bordons, 2010). The use of self-citation as a scientific indicator can weaken the proposed argument, especially when self-citation accounts for 20% to 35% of all citations (Aksens, 2003).

Table 2: Relationship between citation and science and technology

Influencing/cited	**Influencing/citing**	
	Science	**Technology**
Science	Contribution of science groups to scientific progress Citations in science papers to other science papers	The science base of technology Citations in patents to scientific literature
Technology	The influence of technology upon scientific development Citation gap	Contribution of technologies to technological progress Citations in patents to other patents

Source: (Moed, 2005)

Figure 4 shows the distribution of citations related to artificial intelligence studies by country.

Figure 4: Distribution of citations among countries

Country	No.Citations	Country	No.Citations
China	7909	Japan	1286
United States	7823	France	1156
United Kingdom	4917	Taiwan	1055
Canada	2299	Netherlands	847
South Korea	2087	Poland	562
Singapore	1937	Belgium	516
Germany	1883	Greece	476
Italy	1857	Russia	404
Spain	1850	Czechia	234
Türkiye	1451	Slovenia	112
Switzerland	1301		

3.2. High-impact scientific journals

Scientific publishing, while determining the scope of knowledge and facilitating its dissemination, also has economic implications (OECD and SCImago Research Group, 2016). Criteria for assessing the quality of scientific publications play a crucial role in measuring the contributions of scientific studies (Moed, 2005). The impact and quality of scientific studies is as important as the impact and quality of the journals in which these studies are published. Each scientific study is not of the same characteristics and quality, just as every scientific journal does not possess the same characteristics and quality. Not every scientific study has the same characteristics and quality, and not every scientific journal has the same characteristics and quality. Therefore, both scientific studies and journals should be evaluated according to objective evaluation criteria (Guerrero-Bote and Moya-Anegón, 2012).

Different performance criteria are used to measure the impact and quality of the journals. The assessment of research quality and impact is typically done using the journal impact factor. This factor is based on the citation impact of scientific studies (Moed, 2005). One of the latest approaches used in measuring journal impact factor is the SJR (Scientific Journal Rankings) indicator. SJR is an assessment framework based on data obtained from the Scopus database, measuring the scientific value of journals (Guerrero-Bote and Moya-Anegón, 2012). The SJR indicator takes into account the number of citations and the impact of the journal in which the cited publication was published. In addition, citations within the journal itself are included in this calculation at a lower rate. A high SJR indicator means that the influence or prestige of the journal is higher than the influence or prestige of the publication (González-Pereira, Guerrero-Bote and Moya-Anegón, 2010).

The distribution of the number of high-impact journals by country is shown in figure 5.

Figure 5: Distribution of the number of high- impact scientific journals by country

Country	No. high-impact scientific journals	Country	No. high-impact scientific journals
United States	50	South Korea	3
Netherlands	48	Spain	3
United Kingdom	44	Canada	2
Switzerland	21	France	2
China	15	Greece	2
Germany	13	Italy	2
Singapore	13	Taiwan	2
Poland	6	Belgium	1
Japan	5	Slovenia	1
Czechia	4	Türkiye	1
Russia	4		

3.3. Patents

Patents are an indicator of the acquisition of a new and applicable technique because of scientific and technological activities. Patents are the result of the technology development process. However, all technologies obtained at the end of the development process can't always be patented (Isaka, 2013).

Patent statistics provide both quantitative and qualitative data about the concrete applications of the developed technology. Patents provide information on the coefficient of inventiveness, technology penetration, the size of the technology market, and the diffusion of technology. Inventive capacity reflects the technological development efforts of inventors within a country, while penetration refers to patent applications originating from foreign sources. The size of the technology market is determined by the total number of patent applications, both domestic and international. Technology diffusion, on the other hand, refers to the efforts to protect domestically developed patents in foreign markets (Okubo, 1997).

Patents and scientific publications are frequently used indicators for analysing technological progress (WIPO, 2019). The relationship between patent data and scientific publications and citation numbers is used as a criterion for investing in the relevant research field (National Research Council, 2007). The success of scientific studies in transitioning into technology is directly proportional to the rate at which publications result in patents. The increased production of scientific publications may result in more patents (Akçiğit and Tok, 2020).

The field of artificial intelligence patents can encompass various areas such as algorithms, robotics, autonomous vehicles, and software. In 2017, the OECD categorised AI-related technologies, such as natural language processing, human interface and cognitive processes, in the information and communication technologies (ICT) patent category (Baruffaldi et al., 2020).

Within this classification framework, the distribution of patents by country occurred as depicted in figure 6.

Figure 6: Distribution of patent applications by country

Country	No. Patent Applications	Country	No. Patent Applications
United States	52361	Singapore	524
Japan	15762	Netherlands	487
China	14886	Belgium	379
South Korea	11834	Russia	371
Taiwan	6401	Spain	214
Germany	3495	Poland	130
United Kingdom	2489	Czechia	87
Canada	2331	Türkiye	56
France	1692	Greece	42
Switzerland	611	Slovenia	15
Italy	573		

3.4. Top-performing universities

The labour market offers better opportunities to individuals with higher education and high skill levels (Samuelson and Sarrico, 2017). Universities play a decisive role in the development of knowledge-based capital. Successful universities produce highly skilled individuals with high-quality research experiences and further research investments (Kaloudis et al., 2019). University rankings are becoming increasingly important as they provide benefits such as improving the functioning of universities, attracting qualified students and staff, developing more research and cooperation, and obtaining more resources (Sobral, 2021). According to Akçiğit and Tok, (2020), countries with the highest number of universities in the top 1000 are also in a leading position in terms of economic development.

Universities around the world are evaluated and ranked by different institutions for different purposes. Different university ranking and evaluation criteria such as The World University Rankings, QS World University Rankings, Academic Ranking of World Universities, and US News Education Rankings are used (Samuelson and Sarrico, 2017). The information related to university rankings in the field of artificial intelligence used in the study is based on the performance data provided by the "Times Higher Education World University Rankings." In this ranking, universities are comprehensively evaluated in terms of teaching, research, and reputation factors. The assessment delves into 5 main factors and 13 sub-factors, including teaching, research, research impact, international outlook, and knowledge transfer (Pavel, 2015; Times Higher Education, 2022).

In the context of these factors, Figure 7 presents the distribution of successful universities in the field of computer science within the top thousand by country.

Figure 7: Distribution of universities in the top 1000 in the field of computer science by country

Country	No. Universities	Country	No. Universities
United States	163	Greece	11
United Kingdom	86	Netherlands	11
China	64	Switzerland	11
Germany	48	Türkiye	11
Italy	47	Belgium	9
Spain	32	Taiwan	9
Canada	31	Czechia	4
France	29	Poland	2
Japan	20	Singapore	2
South Korea	19	Slovenia	1
Russia	18		

3.5. High-impact conferences

Scientific meetings are platforms serving various purposes for scientific studies. It makes important contributions to the advancement of science in many ways, such as access to new ideas and information, sharing research results and findings, transferring experience, funding research, and realising the objectives of improving cooperation and interaction (Parsons, 2015). One of the criteria considered in the evaluation of artificial intelligence research activities is academic conferences (Tsinghua University, 2018).

A study of researchers attending International Marine Conservation Congresses has provided considerable evidence in favour of this view. Participants in the study indicated that 58% supported their research with new ideas, 56% learned new techniques, and 64% gained new skills. Additionally, 91% of participants mentioned communicating with new individuals in their field, while 39% communicated with those providing funding (Oester et al., 2017).

Considering the contributions of scientific meetings, data from high impact international conferences in the field of artificial intelligence can be regarded as a significant criterion in measuring scientific and technological progress. In this context, the Number of high impact conferences in the field of computer science in a country has been used as a measure of scientific and technological progress. The ranking of the high impact conferences in computer science is determined based on the impact score provided in equation (1). The impact score was calculated by considering factors such as the predicted h-index in scientific articles of leading computer scientists and the number of contributing scientists to the study. The index value was calculated using data from the last four years in the Microsoft Academic database.

$$\text{Impact Score} = \frac{\mathrm{H_{index}}\ \text{Value} * \text{Number of Top Scientists}}{2 * \text{Number of Years}} \tag{1}$$

Accordingly, the distribution of the number of international high-impact conferences by country is given in figure 8.

Figure 8: Distribution of the number of high-impact conferences by country

Country	No. Conferences	Country	No. Conferences
United States	54	Switzerland	5
Italy	31	Taiwan	4
Spain	21	Belgium	3
China	19	Czechia	3
France	16	Netherlands	3
Germany	14	South Korea	3
United Kingdom	13	Poland	1
Greece	12	Russia	1
Canada	7	Slovenia	1
Singapore	7	Türkiye	1
Japan	5		

3.6. Researchers in higher education

A researcher is defined as a professionalprofessionals responsible for designing or creating new knowledge in a specific field. Data related to researchers are essential indicators used to measure the performance of research and development activities (OECD, 2017).

Social and economic development is possible through the creation of knowledge-based capital. The driving force behind knowledge-based capital is individuals with scientific and engineering skills (Bernanke, 2011). The most effective way to acquire these skills is through higher education. The higher education system can achieve this in two ways. The first of these is the cultivation of human resources, while the second is the utilisation of research conducted at universities as a source of innovation (Samuelson and Sarrico, 2017).The development of technical and vocational knowledge through higher education enables the enhancement of human resources. Higher education contributes to the development of human resources by increasing technical and vocational knowledge. At the same time, it provides the opportunity to elevate the level of education while enhancing skills. In a specific field, institutions and industries that achieve a certain level of success can contribute to a country's better performance in that area (OECD and SCImago Research Group, 2016). Countries and institutions with a greater number of academic human resources tend to be more successful in R&D activities. This tendency promotes innovation and allows for the improvement of products, processes and services. Furthermore, it provides an opportunity for elevating the education level and the enhancement of skills (Samuelson and Sarrico, 2017). Technological progress is closely related to making long-term R&D investments and accumulating experience. Research conducted at universities serves as a source of innovation (Le et al., 2022).

The distribution of the total number of researchers in higher education by country is illustrated in figure 9.

Figure 9: Distribution of the total number of researchers in higher education by country

Country	No. Researchers	Country	No. Researchers
China	599515	Türkiye	49649
United States^{-1}	175941	South Korea	43772
United Kingdom^{-2}	172489	Taiwan	29022
Japan	137303	Netherlands	26732
Germany	120901	Switzerland	26133
France	91582	Greece	23082
Russia^{-1}	78864	Belgium	22175
Spain	69984	Singapore^{-1}	16848
Canada^{-1}	65340	Czechia	13963
Poland	59457	Slovenia	2431
Italy	57204		

Note: Interpolation has not been applied-$^{1,-2}$

4. Research methodology

In this section, the entropy and grey relational analysis methods used to determine the weights of the criteria, the relationships between the criteria, and the ranking of alternatives based on the criteria are explained in detail.

4.1. Entropy method

The entropy method was developed by Claude Shannon in 1948. This method is an information weight method that allows for an objective evaluation using probability theory. It produces effective and reliable results in the weighting criteria (Dwivedi and Sharma, 2022; Zhu, Tian, and Yan, 2020).

The entropy method begins with the creation of the decision matrix consisting of x_{ij} values. Here, x_{ij} represents the score obtained from the ith alternative for the jth evaluation criterion (Dwivedi and Sharma, 2022).

$$DM = [x_{ij}]_{mn} = \begin{bmatrix} x_1(1) & x_1(2) & \cdots & x_1(n) \\ x_2(1) & x_2(1) & \cdots & x_2(n) \\ \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ x_m(1) & x_m(2) & \cdots & x_m(n) \end{bmatrix} \tag{2}$$

Normalisation process, denoted by $\acute{x}_{ij}$, is carried out to represent data from different scales and intervals on the same scale. It is calculated using the following equation.

$$\acute{x}_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{3}$$

Following the normalisation process, the internal entropy values of the criteria (e_j) are calculated according to equation (4).

$$e_j = -\frac{1}{lnt} \cdot \sum_{j=1}^{n} \acute{x}ij \cdot ln(\acute{x}_{ij}) \tag{4}$$

The differentiation degrees shown in equation (5) are calculated using the obtained entropy (e_j) values.

$$d_j = 1 - e_j \tag{5}$$

In the final step, the weight of each criterion is calculated using equation 6. (Uludağ and Doğan, 2021).

$$w_j = \frac{d}{\sum_{j=1}^{n} d_j} \tag{6}$$

4.2. Grey relational analysis

The grey system theory, which forms the basis of grey relational analysis, was proposed by Julong Deng (Tan, 2005). In real-world applications, there are situations that involve insufficient information and small samples. Many systems such as social, environmental, economic, and human systems can be cited as examples of these situations (Ng, 1994). These systems are often expected to generate useful information by effectively using the existing conditions (Liu et al. , 2020). However, the information generated is unreliable due to the weakness in the current state (Ng, 1994).

Grey relational analysis method, which is one of the important analysis methods of grey system theory, uses the basic principles of grey system theory. Real systems are inherently complex and uncertain. Grey relational analysis aims to reduce uncertainty by focusing on determining the degree of relationship between subsystems and causality. The existence of the relationship is evaluated based on the similarity level of the geometric curves of the data (Peng et al., 2021).

The grey relational analysis method begins by determining the decision alternatives and criteria that will form the decision matrix.

Equation (7) is used to define the values of decision alternatives and criteria. The value of the series to be created is denoted by m.

$$\mathrm{x_i} = \left(\mathrm{x_i(j)}, \ldots, \mathrm{x_i(n)}\right)\ \mathrm{i} = 1,2, \ldots, \mathrm{m}\ ;\ \mathrm{j} = 1,2, \ldots, \mathrm{n} \tag{7}$$

The m series consisting of decision alternatives and criteria is represented by Equation (8).

$$x_{\mathrm{i}}=\begin{bmatrix} x_1(1) & x_1(2) & \cdots & x_1(\mathrm{n}) \\ x_2(1) & x_2(1) & \cdots & \mathrm{x}_2(\mathrm{n}) \\ \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ x_{\mathrm{m}}(1) & x_{\mathrm{m}}(2) & \cdots & x_{\mathrm{m}}(\mathrm{n}) \end{bmatrix} \tag{8}$$

After creating the decision matrix, a reference series is established. The reference series determines the ideal or best value for the criteria in decision alternatives. Thus, a decision matrix can be created to facilitate the comparison of decision alternatives. The value $x_0(j)$ in equation (9) represents the reference series.

$$x_0=\left(x_0(\mathrm{j})\right)\ \mathrm{j}=1{,}2,\dots,\mathrm{n} \tag{9}$$

In the next step, a normalisation and absolute value matrix is created. The normalisation process enables the comparison of criteria that do not have the same value and unit through the same scale. It can be defined as taking the values of the criteria between 0 and 1. The normalised decision matrix is calculated in three ways as benefit, optimal and cost oriented. In cases where all criteria are benefit-oriented, calculations are made according to equation (10).

$$x_i^*=\frac{x_{\mathrm{i}}(\mathrm{j})-\underset{j}{min}\,x_{\mathrm{i}}(\mathrm{j})}{\underset{j}{max}\,x_{\mathrm{i}}(\mathrm{j})-\underset{j}{min}\,x_{\mathrm{i}}(\mathrm{j})} \tag{10}$$

The absolute value matrix is formed by taking the difference in the value in the normalised decision matrix from its normalised value in the reference series.

$$\Delta_{0i}=x_0^*(j)-x_i^*(j) \tag{11}$$

In the next stage, the grey relational coefficient matrix is created. To form the grey relational matrix, the coefficients of each matrix element are calculated using equations (12), (13), (14).

$$\Upsilon_{0i}(j) = \frac{\Delta_{\min} - \zeta \cdot \Delta_{\max}}{\Delta_{0i}(j) - \zeta \cdot \Delta_{\max}} \tag{12}$$

$$\Delta_{\max} = \underset{i}{max} \underset{j}{\max} \Delta_{0i}(j) \tag{13}$$

$$\Delta_{\min} = \underset{i}{min} \underset{i}{min} \Delta_{0i}(j) \tag{14}$$

Grey relational degrees are calculated according to the importance level of the criteria. The grey relational degree is associated with the closeness of a criterion of an alternative to the reference series. In the decision problem, equation (15) is used when the importance levels of the criteria are different. In this equation, $w_i(j)$ is the weight of the j-th criterion.

$$\Gamma_{0i} = \sum_{J=1}^{n} [w_i(j) \cdot \Upsilon_{0i}(j)] \tag{15}$$

5. Findings

To calculate the weight of each criterion using the entropy method, the normalised decision matrix, internal entropy values, and values related to the weights of the criteria are presented in Table 3. The rows in the table represent the alternatives, and the columns represent the normalised values for the specific criteria.

Table 3: Normalised decision matrix, entropy values, and criteria weights

Country	C_1	C_2	C_3	C_4	C_5	C_6	C_7
Belgium	0,0065	0,0123	0,0041	0,0033	0,0143	0,0134	0,0118
Canada	0,0306	0,0548	0,0083	0,0203	0,0494	0,0313	0,0347
China	0,4552	0,1885	0,0620	0,1297	0,1019	0,0848	0,3185
Czech Republic	0,0053	0,0056	0,0165	0,0008	0,0064	0,0134	0,0074
France	0,0271	0,0275	0,0083	0,0147	0,0462	0,0714	0,0487
Germany	0,0431	0,0449	0,0537	0,0305	0,0764	0,0625	0,0642
Greece	0,0096	0,0113	0,0083	0,0004	0,0175	0,0536	0,0123
Italy	0,0317	0,0443	0,0083	0,0050	0,0748	0,1384	0,0304
Japan	0,0427	0,0306	0,0207	0,1374	0,0318	0,0223	0,0729
Netherlands	0,0137	0,0202	0,1983	0,0042	0,0175	0,0134	0,0142
Poland	0,0098	0,0134	0,0248	0,0011	0,0032	0,0045	0,0316

Table 3: Continued

Country	C_1	C_2	C_3	C_4	C_5	C_6	C_7
Russian	0,0206	0,0096	0,0165	0,0032	0,0287	0,0045	0,0419
Singapore	0,0130	0,0462	0,0537	0,0046	0,0032	0,0313	0,0090
Slovenia	0,0017	0,0027	0,0041	0,0001	0,0016	0,0045	0,0013
South Korea	0,0274	0,0497	0,0124	0,1031	0,0303	0,0134	0,0233
Spain	0,0198	0,0441	0,0124	0,0019	0,0510	0,0938	0,0372
Switzerland	0,0102	0,0310	0,0868	0,0053	0,0175	0,0223	0,0139
Taiwan	0,0203	0,0251	0,0083	0,0558	0,0143	0,0179	0,0154
Türkiye	0,0187	0,0346	0,0041	0,0005	0,0175	0,0045	0,0264
United Kingdom	0,0518	0,1172	0,1818	0,0217	0,1369	0,0580	0,0916
United States	0,1410	0,1864	0,2066	0,4563	0,2596	0,2411	0,0935
e_j	0,3084	0,1468	0,2321	0,4108	0,1823	0,1731	0,1895
w_j	0,1877	0,0894	0,1413	0,2500	0,1110	0,1053	0,1153

When the criteria weights (wj) in table 3 are analysed, it is seen that the weights of criteria C_2, C_3, C_5, C_6 and C_7 are low. This indicates that the criteria are largely homogenously distributed. In other words, it can be said that there is a similar performance among countries in these criteria. For the criteria of number of publications (C_1) and number of patent applications (C_4), the criterion weight is higher. This can be interpreted as a more differentiated and varied performance among countries in terms of (C_1) and C_4 criterion.

The results of the grey relational coefficient matrix are presented in table 4. Based on this matrix and the criterion weights obtained from the entropy method, the Grey relational degrees in figure 9 and country rankings were determined. If a country has high coefficients in many criteria in the Grey relational coefficient matrix, it can generally be interpreted as having a high potential for scientific and technological advancement.

Table 4: Grey relational coefficient matrix

Country	C_1	C_2	C_3	C_4	C_5	C_6	C_7
Belgium	0,3357	0,3453	0,3333	0,3349	0,3447	0,3419	0,3408
Canada	0,3481	0,4100	0,3379	0,3435	0,3803	0,3605	0,3585
China	1,0000	1,0000	0,4118	0,4112	0,4500	0,4309	1,0000
Czech Republic	0,3351	0,3368	0,3475	0,3336	0,3375	0,3419	0,3377
France	0,3463	0,3660	0,3379	0,3406	0,3767	0,4109	0,3702

Table 4: Continued

Country	C_1	C_2	C_3	C_4	C_5	C_6	C_7
Germany	0,3549	0,3928	0,3984	0,3488	0,4133	0,3985	0,3841
Greece	0,3373	0,3440	0,3379	0,3334	0,3476	0,3869	0,3412
Italy	0,3487	0,3918	0,3379	0,3357	0,4112	0,5354	0,3550
Japan	0,3547	0,3705	0,3525	0,4170	0,3616	0,3510	0,3924
Netherlands	0,3393	0,3557	0,9245	0,3353	0,3476	0,3419	0,3426
Poland	0,3373	0,3467	0,3577	0,3338	0,3347	0,3333	0,3560
Russian	0,3428	0,3419	0,3475	0,3349	0,3584	0,3333	0,3644
Singapore	0,3390	0,3950	0,3984	0,3355	0,3347	0,3605	0,3388
Slovenia	0,3333	0,3333	0,3333	0,3333	0,3333	0,3333	0,3333
South Korea	0,3464	0,4011	0,3427	0,3924	0,3600	0,3419	0,3495
Spain	0,3424	0,3915	0,3427	0,3342	0,3821	0,4454	0,3605
Switzerland	0,3376	0,3711	0,4579	0,3359	0,3476	0,3510	0,3424
Taiwan	0,3427	0,3626	0,3379	0,3628	0,3447	0,3464	0,3435
Turkey	0,3418	0,3764	0,3333	0,3335	0,3476	0,3333	0,3519
United Kingdom	0,3598	0,5658	0,8033	0,3442	0,5127	0,3926	0,4115
United States	0,4192	0,9784	1,0000	1,0000	1,0000	1,0000	0,4134

In figure 9, the Grey relational degrees provide an indication of the closeness or similarity of each country's performance to the ideal performance. Higher grey relational degrees suggest a closer resemblance to the ideal state, reflecting stronger scientific and technological capabilities.

Figure 10: Grey relational degree and country rankings

Ranking	Country	Γ_{0i}	Ranking	Country	Γ_{0i}
1	United States	0,8214	12	Canada	0,3571
2	China	0,6487	13	Singapore	0,3533
3	United Kingdom	0,4633	14	Taiwan	0,3495
4	Netherlands	0,4240	15	Russian	0,3446
5	Germany	0,3773	16	Greece	0,3438
6	Japan	0,3761	17	Türkiye	0,3426
7	Italy	0,3751	18	Poland	0,3416
8	South Korea	0,3636	19	Belgium	0,3383
9	Spain	0,3621	20	Czechia	0,3379
10	Switzerland	0,3602	21	Slovenia	0,3333
11	France	0,3584			

The country rankings derived from these analyses can be considered an overall evaluation of each country's scientific and technological progress. Countries with higher rankings are deemed to have a more favourable performance across the evaluated criteria. Each indicator has a distinct impact on the scientific and technological progress of each country. Therefore, evaluating these indicators collectively helps us gain a more comprehensive understanding of a country's overall performance in the field of artificial intelligence. The USA is the leader in 4 of the 7 criteria used in the evaluation, while China is the leader in 3 of them. The USA is in a leading position in terms of the number of patents, the number of high-impact scientific journals, conference participation, and the number of universities within the top 1000 in the field of computer science. China is in a leading position in terms of criteria such as scientific publications, citations, and the total number of researchers. China is the leader in terms of scientific publications, citations, and the total number of researchers. Superiority in more criteria and the high weights of these criteria have generally ensured that the United States has a high performance level in scientific and technological progress in the field of artificial intelligence. The US and China have shown a markedly positive divergence from other countries in terms of scientific and technological progress in the field of artificial intelligence. The UK ranks third. The UK has shown a consistent performance in terms of the number of publications, number of citations, number of universities in the computer sciences, number of researchers in higher education, and number of effective scientific journals. This situation suggests that the implemented policies and strategies are consistent and coherent with each other. However, despite ranking in the top three in all these criteria, the discrepancy in performance concerning the number of patents may necessitate a reassessment of the relevant policies and strategies. The Netherlands ranks fourth. It is particularly successful in terms of the criterion of high-impact scientific journals. However, it does not appear within the top 10 in other indicators. In this context, specific research is needed to understand the factors influencing this positive situation in the number of high-impact journals. Germany and Japan are ranked fifth and sixth, respectively. The criterion in which Germany performs best is the number of publications, whereas the criterion in which it shows inadequate performance is the number of citations. Japan, on the other hand, demonstrates its best performance in the criterion of patent applications. This situation supports the notion that in Japan, there is a higher likelihood of scientific studies transforming into innovation. Japan has shown low performance in the number of high-impact conference publications. Japan should put more effort into organising international conferences. Italy ranks second after the USA in terms of the number of high-impact conferences. However, it ranked seventeenth in terms of the number of high-impact journals, showing a poor performance. South Korea, Spain and Switzerland performed similarly, ranking eighth, ninth and tenth. South Korea's best performance in terms of scientific and technological progress criteria is patent applications, and it is ranked 4th in this field. This situation strengthens the idea that scientific studies will increase the possibility of turning into innovation for South Korea. South Korea should take measures to improve its performance in the high-impact conference and journal criteria. Spain performed very well in terms of the number of high-impact conferences. However, it did not perform at the same level in terms of the number of publications and patent applications. Switzerland ranks fourth in terms of the number of high-impact journal publications. However, more effort is needed in terms of the number of scientific publications. The number of citations criterion of South Korea, Spain and Switzerland performed better than the number of scientific publications criterion. This situation can be evaluated by the fact that the scientific studies conducted by researchers in these countries in the field of artificial intelligence are of high quality, effective and citable. France, Canada and Singapore ranked eleven, twelve and thirteenth. France is in a very good position in terms of the number of high-impact conferences and the number of researchers. In addition, France and Canada showed similar performance in terms of scientific publications and patenting activities. The similar performance of both countries in terms of scientific publications and patenting criteria, when other factors are excluded, supports the notion that scientific publications and patenting activities complement each other. Singapore performed well in the criteria of number of high-impact journals and number of citations. The number of citations criteria performed better than the number of scientific publications criteria. Although Singapore performed better in both the number of high-impact journals and the number of citations criteria, the reasons for its second-to-last position in the ranking of universities in the field of computer science should be investigated. Taiwan, Russia, Greece, Turkey, Greece, Turkey and

Poland performed quite close to each other. Taiwan has shown a very high performance in patenting studies like other Asian countries such as China, Japan and South Korea. However, further efforts should be made to improve its performance in terms of the number of high-impact journals and university ranking criteria in the field of computer science. Russia performed very poorly in the criteria of the number of high-impact conferences and the number of citations. However, it ranked among the top 10 countries in terms of the number of publications. When these two situations are evaluated together, it can be thought that the main reason for the insufficient performance in terms of the number of citations is due to language and alphabetic factors. Greece is in a good position in terms of the number of high-impact conference publications. However, it has a low performance in other criteria. Therefore, more policies and strategies should be developed. Turkey is better in terms of the number of scientific publications and citations compared to other factors. However, it ranks last in terms of high-impact conference and journal rankings. Poland is in a better position in terms of the total number of researchers and the number of high-impact journal publications. However, these factors are not sufficient for Poland to make progress in artificial intelligence technology and create economic value. Belgium, Czechia and Slovenia are in the last three places. Although Belgium does not perform well in terms of the number of scientific publications, citations and researchers, it performs better in terms of patenting activities. This situation reinforces the idea that scientific and technological studies are mostly conducted through experimental and applied research. Czechia should develop policies and programmes for criteria other than the number of high-impact conferences and journals, while Slovenia should develop policies and programmes for all criteria.

6. Conclusion

The need to establish a consensus framework for assessing the status and applications of scientific and technological progress in the field of artificial intelligence is the main motivation for this research. This study provides a framework for comparing advances in AI technology at the global level and across countries. The field of artificial intelligence research has a complex and comprehensive nature. There are significant shortcomings in the generation and presentation of the data. Drawing a framework agreed upon by all parties is only possible through the generation and publication of more comprehensive data. There are studies in the grey literature on measuring progress in the field of artificial intelligence. However, there are almost no scientific studies contributing to the research. In this context, the study has provided significant contributions to gathering, understanding, developing the necessary evidence and contemplating potential pathways for measuring scientific and technological progress in the field of AI.

Almost every country provides support for research and development activities. Choosing the right policy tools is crucial for determining how support should be allocated. Therefore, it is crucial to carefully examine the information provided in the findings section regarding the identification of factors that countries need to consider in achieving strategic goals in the field of AI and taking the necessary steps to accomplish these objectives. Strategic issues and policies should be revised based on the findings on which factors countries perform poorly and which factors they perform well in the field of AI. The information obtained allows for making objective and data-driven decisions on which areas of scientific and technological progress require more resource allocation and focus.

According to the obtained data, the driving force in measuring scientific and technological progress is the criteria of scientific publications and patents. Countries with a successful performance in scientific and technological progress in the field of artificial intelligence are generally developed countries. In particular, the efforts of the US to transform its scientific and technological leadership in this field into economic benefits should be carefully monitored. Some countries, despite demonstrating a particularly strong performance in terms of scientific publications, should be closely examined for their weak performance in terms of the number of patents. Some strategic priorities need to be reassessed in these countries, such as the level of cooperation between industry and the scientific community, resource allocation for translating scientific work into applied and experimental research, and the creation of stronger incentives for patenting.

Finally, efforts to measure progress in AI technology are still at a very nascent stage. In particular, the representation of AI by computer science data limits the use of comparable situation-specific data. Moreover, the wide range of AI fields makes data collection and classification difficult. Additional studies on methodological approaches and the presentation of data can obtain better analysis results.

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RESEARCH ARTICLE

Did the February 6-7 Türkiye Earthquake Trigger a Housing Market Bubble? Empirical Insights from Right-tailed Unit-root Tests

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ABSTRACT

This study primarily aims to assess whether the destructive earthquakes of February 6-7, 2023 triggered a potential nationwide housing market bubble. Spanning the period from January 2010 to September 2024, the analysis employs Generalised Supremum Augmented Dickey-Fuller and Backward Supremum Augmented Dickey-Fuller methods to identify bubble formations. The findings reveal significant bubble periods, including January to August 2015, November 2015 to November 2016, May 2018 to January 2019, May to June 2019, and February to December 2023. The latest bubble formation occurred immediately after the earthquake, highlighting a strong link between the disaster and housing market dynamics. While the earthquake's impact—through abrupt housing stock loss, large-scale displacement, and intensified demand for secure housing—was undeniably a crucial trigger for this bubble, other macroeconomic factors, such as inflationary pressures, low interest rates, and the perception of housing as a lucrative investment, also played a reinforcing role. The Türkiye experience enhances the understanding of speculative cycles in seismic regions, demonstrating how non-economic shocks such as earthquakes can rapidly boost demand and strain housing supply, amplifying speculative behaviour. This bubble, which peaked in May 2023 and gradually deflated, completely dissipated by December 2023. This development can be associated with the policies implemented by economic authorities, including interest rate hikes, restrictive credit measures, as well as the normalisation of conditions across the country following the earthquake. This highlights the need for proactive monitoring and intervention by economic authorities through appropriate economic policies and regulations to address supply-demand imbalances and mitigate the risks of future housing bubbles, particularly in response to external shocks. Furthermore, in response to the study's findings on earthquake-triggered bubbles, policymakers should prioritise initiatives aimed at strengthening building infrastructure and implementing urban transformation strategies.

Keywords: Speculative bubbles; Housing market dynamics; Earthquake and housing market; February 2023 Türkiye earthquakes; Right-tailed unit-root tests
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1. Introduction

Türkiye is frequently exposed to earthquakes because of its location in a geologically active region. Earthquakes occur because of sudden movements in the Earth's crust and often lead to significant damage and loss of life. Throughout history, Türkiye has witnessed many major earthquakes, causing both material and spiritual losses. However, the earthquakes that occurred on February 6-7, 2023, are recorded as one of the most devastating disasters in the country's recent history. These earthquakes, with epicentres in the Pazarcık and Elbistan districts of Kahramanmaraş, were recorded as two separate shocks measuring 7.7 and 7.6 magnitudes, respectively. The earthquakes occurred on the fault line known as the Eastern Anatolian Fault Zone or the Dead Sea Fault Zone. These tremors caused extensive destruction along a roughly 550-kilometer line from Hatay to Kahramanmaraş, Adıyaman, Malatya, and Elazığ. The region experienced a significant human tragedy, with more than 50,000 lives lost and substantial material damage in 11 provinces. The total population of the 11 affected provinces accounted for 16.43% of Türkiye's population, constituting approximately 9.8% of the country's 2022 GDP. This devastating disaster, impacting such a vast area, has deeply affected both the region and the country as a whole, leading to various socio-economic consequences.

Table 1: Some Statistical Data on the Effects of the 6-7 February Earthquakes

Province	Pop.*	GDP%	Tot. Hous.*	Destroyed or Damaged	Moderate Damaged	Slight Damage	Displaced Pop.	Deaths
Adana	2.274 (2,67)	2,00	973 (2,42)	2.952 (0,30)	11.768 (1,21)	71.072 (7,31)	52.779 (2,32)	454 (0,02)
Adıyaman	635 (0,74)	0,30	217 (0,54)	56.256 (25,96)	18.715 (1,92)	72.729 (7,48)	307.204 (48,37)	8.387 (1,32)
Diyarbakır	1.804 (2,12)	0,90	563 (1,40)	8.602 (1,53)	11.209 (1,15)	113.223 (11,64)	98.913 (5,48)	414 (0,02)
Elazığ	591 (0,69)	0,50	292 (0,73)	10.156 (3,47)	15.220 (1,56)	31.151 (3,20)	28.090 (4,75)	5 (0,00)
Gaziantep	2.154 (2,53)	2,00	894 (2,22)	29.155 (3,26)	20.251 (2,08)	236.497 (24,32)	252.317 (11,71)	3.897 (0,18)
Hatay	1.686 (1,98)	1,40	847 (2,11)	215.255 (25,40)	25.957 (2,67)	189.317 (19,47)	774.483 (45,93)	23.065 (1,37)

Kahramanmaraş	1.177 (1,38)	0,90	481 (1,20)	99.326 (20,63)	17.887 (1,84)	161.137 (16,57)	489.149 (41,54)	12.622 (1,07)
Kilis	147 (0,17)	0,10	75 (0,19)	2.514 (3,35)	1.303 (0,13)	27.969 (2,88)	13.750 (9,30)	74 (0,05)
Malatya	812 (0,95)	0,50	346 (0,86)	71.519 (20,70)	12.801 (1,32)	107.765 (11,08)	320.100 (39,39)	1.393 (0,17)
Osmaniye	559 (0,66)	0,40	243 (0,61)	16.111 (6,62)	4.122 (0,42)	69.466 (7,14)	69.442 (12,41)	993 (0,18)
Şanlıurfa	2.170 (2,54)	0,80	718 (1,79)	6.163 (0,86)	6.041 (0,62)	199.401 (20,50)	58.895 (2,71)	340 (0,02)
Toplam	14.01 (16,43)	9,80	5.649 (14,05)	518.009 (9,17)	145.274 (14,94)	1.279.727 (3,18)	2.465.122 (17,59)	51.644 (0,37)
Türkiye	85.279 (100)	100,00	40.200 (100)	(1,29)	(0,36)	(3,18)	(2,89)	(0,06)

Notes: Values in parentheses indicate the proportion of the respective data in Türkiye's total. For example, the values in the "Population" column represent the population of the province, while the values in parentheses represent the proportion of the province's population in Türkiye's total population. Similarly, other values in the table indicate the respective data's proportions in Türkiye's total. *Values are in thousands.
Source: TUIK (2022), Presidency of the Republic of Türkiye (2023), Sağıroğlu, Ünsal and Özenci (2023), Wikipedia (2023).

One of the effects of earthquake disasters in the country is the general increase in earthquake fear, which has been felt not only in earthquake-prone areas but also nationwide. This has resulted in many people feeling unsafe in their homes, particularly in regions with high earthquake risks. As a result, many individuals have turned to lower-rise buildings or preferably detached houses. This trend has heightened people's demand for safer housing and caused significant changes in the housing sector.

In particular, the major destruction in the earthquake zone have led to a significant decrease in the housing stock. Before the earthquake, the housing stock in the region was approximately 5 million 649 thousand units, which accounts for approximately 14% of the country's total housing stock, as shown in Table 1. The number of completely destroyed or heavily damaged buildings was recorded as 518 thousand, which is approximately 9.17% of the region's housing stock and 1.29% of the country's total housing stock. Additionally, the number of moderately and slightly damaged houses in the region has also significantly increased. On average, the total number of moderately and slightly damaged houses is approximately 1 million 425 thousand, representing 25.22% of the region's total housing stock and 3.54% of the country's total housing stock. Taking into account the total number of destroyed, heavily damaged, moderately damaged, and slightly damaged buildings, the affected housing units in the region will be approximately 1 million 943 thousand, accounting for 34.39% of the region's total housing stock and 4.832% of the country's total housing stock. These data indicate that the major earthquake disaster in the region has had a significantly adverse effect on the housing stock and has also affected the country's total housing stock. Consequently, there is a high risk of a significant imbalance between supply and demand in the housing market. As it will take time to rebuild the damaged or destroyed buildings, there may be a significant decrease in the housing supply during this process. This situation could disrupt the balance between housing supply and demand and lead to significant changes in the market. Therefore, it is inevitable that the decrease in housing stock due to the earthquake will seriously disrupt the supply-demand balance in the housing market and lead to some market-disturbing effects. In particular, the occurrence of major destruction in the earthquake zone could render the housing supply unable to meet demand, leading to price increases or uncertainties in the housing market. Furthermore, the decrease in housing supply could also affect new housing projects and investments. The economic dimension of these changes in the housing market is also crucial. In particular, the housing shortage in the region after the earthquake directly impacts the construction sector. While there is a significant demand for rebuilding destroyed or heavily damaged buildings, there may also be increases in factors such as materials and labour during this process. This situation could lead to increases in construction costs and, consequently, affect housing prices.

However, the effects of the earthquake are not limited to the residents of the region; people outside the region, especially those living in high-risk earthquake areas, have also deeply felt the fear of earthquakes. This fear has led many individuals to tend to move to safer areas. Additionally, there has been significant migration from the earthquake zone to other regions; as seen in Table 1, approximately 2 million 465 thousand people have had to move to other areas from the region. While some displaced individuals may have done so temporarily, it is highly likely that some of them have permanently settled in the places they moved to. This situation will increase the demand for housing in the target regions from a different perspective. Consequently, due to the deep-seated fear of earthquakes even among those living outside the earthquake zone, the increased demand for secure housing in other regions, as well as the migration from the earthquake zone to other regions, can lead to serious disruptions in the housing supply and demand structure in other regions. The increase in housing demand in migration-receiving areas can adversely affect the housing supply-demand balance, and this situation can lead to imbalances in supply and demand even in regions where there are no earthquakes in Türkiye. This situation can lead to increased uncertainties and price fluctuations in the housing market nationwide. Therefore, we can say that a regional earthquake poses a significant risk of imbalance in supply and demand in both the regional and national housing markets.

Natural disasters like earthquakes can have significant effects on the housing market. The following earthquakes, there can be a substantial decrease in housing stock, changes in the demands of displaced individuals, and overall market uncertainties. This situation can increase the risk of a housing bubble as significant changes in the demand and supply balance can occur. Especially in high earthquake-risk areas like Türkiye, the impacts of earthquakes on the housing market can be even greater. While rebuilding destroyed or heavily damaged buildings takes time, the housing demand from displaced populations can unexpectedly surge. This can lead to sudden and uncertain changes in housing prices and the supply-demand balance. In this context, evaluating the potential formation of a housing bubble in the aftermath of earthquakes is crucial. A balance should be struck between the dynamics of the housing sector and the effects of earthquakes, and economic risks should be minimised. Additionally, identifying and addressing imbalances in the housing market is vital for maintaining overall economic stability. Therefore, careful analyses should be conducted to prevent the formation of a housing bubble or minimise its effects, and appropriate policies should be implemented.

Speculative bubbles are typically characterised by rapid price increases driven by investor behaviour, often fuelled by optimism and the anticipation of future price appreciation, rather than by fundamental values. According to Minsky (1992)who implied that the economy can be best understood by assuming that it is constantly an equilibrium-seeking and sustaining system. The theoretical argument of the FIH emerges from the characterization of the economy as a capitalist economy with extensive capital assets and a sophisticated financial system. In spite of the complexity of financial relations, the key determinant of system behavior remains the level of profits: the FIH incorporates a view in which aggregate demand determines profits. Hence, aggregate profits equal aggregate investment plus the government deficit. The FIH, therefore, considers the impact of debt on system behavior and also includes the manner in which debt is validated. Minsky identifies hedge, speculative, and Ponzi finance as distinct income-debt relations for economic units. He asserts that if hedge financing dominates, then the economy may well be an equilibrium-seeking and containing system: conversely, the greater the weight of speculative and Ponzi finance, the greater the likelihood that the economy is a \"deviation-amplifying\" system. Thus, the FIH suggests that over periods of prolonged prosperity, capitalist economies tend to move from a financial structure dominated by hedge finance (stable's Financial Instability Hypothesis, credit expansion and excessive borrowing can lead to speculative bubbles, emphasising the crucial role of debt and credit cycles in driving asset price volatility. This theory emphasises the role of debt and credit cycles in driving asset price bubbles. Theoretical models suggest that such bubbles arise from a combination of psychological factors, market inefficiencies, and external shocks, which can distort the rational pricing mechanisms typically observed in efficient markets. By also considering the valuable insights in Scherbina (2013)'s study analysing theoretical approaches to speculative bubbles, theoretical approaches to speculative bubbles can be summarised as follows:

1. Psychological Factors:

- Herding Behaviour: Investors tend to follow the crowd, buying assets when prices are rising and selling when prices are falling.
- Overconfidence: Investors may overestimate their ability to predict future price movements, leading to excessive risk-taking.
- Anchoring Bias: Investors may anchor their expectations on past price levels, leading to overvaluation.

2. Market Inefficiencies:

- Short-Sale Constraints: Restrictions on short-selling can limit the downward pressure on prices, allowing bubbles to persist.
- Information Asymmetries: Unequal access to information can lead to mispricing and speculative behaviour.
- Market Frictions: Transaction costs, liquidity constraints, and regulatory barriers can hinder efficient price discovery.

3. External Shocks:

- Monetary Policy: Low-interest rates can stimulate borrowing and investment, fuelling asset price inflation.
- Fiscal Policy: Government spending and tax cuts can increase aggregate demand, leading to higher asset prices.
- Global Economic Conditions: International factors such as global economic growth and financial market volatility can influence domestic housing markets.

4. Theoretical Models:

- Rational Bubble Models: These models assume that investors rationally expect future price increases, even though fundamentals do not justify them.
- Behavioural Finance Models: These models incorporate psychological factors, such as overconfidence and herding behaviour, to explain irrational exuberance and price bubbles.
- Fundamental Value Models: These models focus on the relationship between asset prices and underlying economic fundamentals, such as income and interest rates. Deviations from fundamental values can lead to speculative bubbles.

The formation of housing market bubbles can pose a serious risk to economic and financial stability. Particularly, rapid and continuous increases in housing prices attract speculators and challenge market confidence. Examples like the Mortgage Crisis in the United States have demonstrated that housing market bubbles can lead to collapses. This situation can transform the housing sector from being just a tool for economic growth into an area where financial risks intensify. Similar dynamics shape Türkiye's housing market as well. Factors such as demographic changes, urban transformation projects, low interest rates, income increases, and investment/ speculation demand are significant elements affecting housing demand. These factors can lay the groundwork for imbalances and potential housing market bubbles. In this sense, by understanding the theoretical underpinnings of speculative bubbles, policymakers and regulators can develop effective strategies to mitigate their negative consequences and promote financial stability.

In this context, it is important to examine the potential effects of major earthquake disasters on Türkiye's housing market and analyse the economic dimensions of these effects. This pioneering study aims to contribute significantly to the literature by investigating the impact of earthquakes on the housing market, covering the data period from January 2010 to September 2024, encompassing both pre- and post-earthquake periods. Therefore, the primary goal of this research is to assess whether the most devastating earthquake in recent history, which occurred on February 6-7, 2023, triggered a potential housing market bubble nationwide. The study will delve into whether the risks emerging after the earthquake have heightened housing market imbalances and potentially led to a bubble formation. Consequently, the study will primarily focus on evaluating the risks and effects associated with a potential housing bubble, representing the distinct impact of the earthquake. Throughout the study, the GSADF method was used to analyse potential housing market bubble formations. This method is effective in determining the existence or absence of bubbles. Additionally, the BSADF method has been used to identify the periods during which bubble formations occurred. This method is useful in determining the start and end periods of the bubble formations. The use of these methods has allowed for a more detailed analysis of the potential housing market bubble formations and the timeframes in which these formations occurred.

The subsequent sections will start with a comprehensive literature review focusing on housing market bubbles. Following that, the Data and Methodology section will detail the data sources, variables, and the application of the GSADF and BSADF methods in analysing potential housing market bubbles. The Empirical

Results section presents the findings regarding the existence of housing bubbles before and after the earthquake, along with their economic impacts. Finally, the Conclusion and Discussion section will synthesise the findings, discuss their implications, and suggest policy recommendations for mitigating the risks associated with housing market bubbles triggered by major earthquake disasters.

2. Literature Review

The 2008 Mortgage Crisis served as a pivotal point that sparked increased interest in analysing housing market bubbles across different regions. Researchers have used various econometric methods to explore the presence and impact of housing bubbles in different economic contexts. Empirical studies focusing on housing market bubbles in countries outside Türkiye have played a significant role in understanding the dynamics of these bubbles and their economic implications. For instance, studies conducted by Balcilar, Katzke and Gupta (2018), Phillips and Yu (2011), Kishor and Morley (2015), Mikhed and Zemčík (2009), and Shi (2017) in the United States have identified multiple periods of housing bubbles, notably during the late 1800s, mid-1950s, and mid-2000s. Similarly, research by Chan, Woon and Ali (2016) in Asia-Pacific countries, excluding Japan and Thailand, highlighted housing bubble occurrences before and after significant economic crises such as the 2000s dot-com bubble and the 2008 global financial crisis. Studies focusing on other regions such as Brazil (de Oliveira & Almeida, 2014), China (Hui & Gu, 2009; Liu et al., 2016), Hong Kong (Yiu, Yu, & Jin, 2013), Ireland (Gallagher, Bond, & Ramsey, 2015), Sweden (Asal, 2019), Kenya (Kiarie Njoroge, Aduda, & Mugo, 2018), and many others have also documented the presence of housing bubbles during specific economic periods or events. Additionally, studies utilising panel data from multiple countries have provided insights into synchronised housing bubble behaviours across different regions (Gomez-Gonzalez et al., 2017; Pavlidis et al., 2013). These studies have contributed significantly to the literature by highlighting the interconnectedness of housing market dynamics on a global scale.

The literature on the housing bubble phenomenon in Türkiye encompasses several studies that analyse different aspects of this issue. In this context, Coskun et al. (2020) employed various statistical methods to analyse housing bubble formation in Türkiye during different time frames, concluding that while there were instances of overvaluation, an actual bubble did not form. Abioğlu (2020) examined bubble formation in multiple cities in Türkiye and identified significant bubble formations, particularly in areas excluding Bursa and İzmir, from 2007:06 to 2018:01. In addition, other studies have investigated housing bubbles in Türkiye using various methodologies and analysing different time periods. For example, Bakır Yiğitbaş (2018) discusses the increase in housing prices compared to economic indicators post-2010, indicating potential artificial stimuli in the housing demand. Zeren and Ergüzel (2015) analyse Istanbul, İzmir, and Ankara from January 2010 to June 2014, finding no long-term bubbles but short-term price increases. Karakoyun and Yıldırım (2017) focused on demand-side factors in the real estate sector, showing the significant explanatory power of real interest rates in the long term. Coskun and Jadevicius (2017) assessed Istanbul, İzmir, and Ankara's housing markets from January 2010 to December 2014, finding no support for the existence of a bubble. Berk, Biçen and Seyidova (2017) suggest unsustainable high prices in certain regions. Dogan and Afsar (2018) investigated bubble formations without conclusive evidence. Mandacı and Çağlı (2018) identified bubbles in certain regions from January 2010 to April 2017. Cağlı (2019) explores explosive behaviours in housing prices from January 2010 to December 2017. Using data from January 2010 to August 2019, Gökçe and Güler (2020) identified evidence of housing market bubbles in Ankara. Similarly, Güler and Gökçe (2020) detected bubbles across Turkey during the periods of November 2014 to November 2016 and April 2018 to January 2019. Their study also highlighted the presence of bubbles in Istanbul during March 2013 to December 2013, April 2014 to December 2016, and January 2018 to August 2019, as well as in Antalya from August 2018 to November 2018. Akkuş (2021) confirmed the bubble presence from January 2010 to June 2020. Ayan and Eken (2021) found in their study conducted in the 2007 to 2019 data period that balloon formations in Istanbul's housing market neighbourhoods varied regionally and temporally, with some districts showing disappearing balloons towards the end of 2019 in the first analysis using monthly data, while the second analysis using three-month data suggested more widespread and persistent balloon formations. Kartal (2022) identified housing bubbles in Türkiye from January 2010 to July 2021, revealing 4 bubble periods for Türkiye overall (February 2013 to December 2013, June 2014 to July 2017, February 2018 to October 2019, and June 2020 to August 2020), and emphasised the need for continuous regulatory oversight due to associated macroeconomic risks. Akkaya (2024) identified two speculative housing bubbles (2014-2018 and June 2019-June 2022) in Türkiye from January 2013 to June 2022. Yalçın Kayacan (2022) study examined the presence of housing bubbles in Türkiye and its 26 sub-provinces/regions, including major cities, from January 2010 to March 2022, revealing the presence of inflated bubbles and emphasising the need for continuous regulatory control in both housing and financial markets associated with housing.

Considering the empirical methods used in these studies, it can be seen that housing bubble detection studies employ various econometric methods to identify potential bubble formations in the housing market. In this regard, some of the econometric methods used by researchers are such as Generalised Supremum Augmented Dickey-Fuller (GSADF) developed by Phillips, Shi and Yu (2015) (Akkaya, 2024; Kartal, 2022; Yalçın Kayacan, 2022; Coskun et al., 2020; Abioğlu, 2020; Zeren and Ergüzel, 2015), Backwards Supremum Augmented Dickey Fuller (BSADF) developed by Phillips, Shi and Yu (2015) (Kartal, 2022; Yalçın Kayacan, 2022; Abioğlu, 2020; Zeren and Ergüzel, 2015), Supremum Augmented Dickey-Fuller (SADF) developed by Phillips, Wu and Yu (2011) (Zeren and Ergüzel, 2015), statistical models like Ordinary Least Squares (OLS)/Fully Modified Ordinary Least Squares (FMOLS)/AutoRegressive Integrated Moving Average (ARIMA)/Kalman filters (Coskun et al., 2020), Blanchard-Quah SVAR (Structural Vector Autoregressive) model (Karakoyun and Yıldırım, 2017), and Logit models (Akkuş, 2021), LSTM (Long Short-Term Memory) automatic encoder model (Ayan and Eken, 2021).

The general assessment of the literature on housing market bubbles in Türkiye reveals that most studies focus on the post-2010 period and primarily use statistical tests such as GSADF, BSADF, and SADF. These studies predominantly cover Türkiye as a whole or specific major cities, often providing some evidence of the existence of housing bubbles. However, considering that many of these studies concentrate on older data periods and typically analyse pre-earthquake periods, changes in the housing market post-earthquake and potential bubble formations are not evaluated. In this regard, this study's focus on the post-earthquake period and its use of the most recent data sets for analysis are expected to make it a significant contribution as the first study to investigate the relationship between earthquakes and housing bubbles, filling a gap in the literature. In this context, the results of this study could deepen our understanding of the dynamics of the housing market in Türkiye and establish a stronger foundation for future policy decisions.

3. Data and Methodology

In this study, we investigated the presence of housing bubbles and their formation periods using econometric methods. Our data period spans from January 2010 to September 2024, specifically chosen to cover the period before and after the significant earthquake on February 6-7. We determine whether the earthquake impacted triggering a housing bubble in Türkiye. The Housing Price Index data were obtained from the Central Bank of the Republic of Türkiye (TCMB). Subsequently, we adjusted the Housing Price Index to real terms using the Producer Price Index (PPI) data. This process ensured the accurate representation of the housing market trends and dynamics in our analysis. We employ the Generalised Supremum Augmented Dickey-Fuller (GSADF) method to examine the existence of housing bubbles. Additionally, we use the Backwards Supremum Augmented Dickey Fuller (BSADF) method to accurately identify the periods of bubble formation. By focusing on this particular data period, we aim to contribute to the understanding of how external events such as earthquakes may influence housing market dynamics and potential bubble formations.

In this study, we employed the Generalised Supremum Augmented Dickey Fuller (GSADF) test developed by Phillips, Shi and Yu (2015), which is an extension of the Supremum Augmented Dickey Fuller (SADF) test developed by Phillips, Wu and Yu (2011). The SADF test proposed by Phillips, Wu and Yu (2011) uses recursive regression and right-tailed unit root tests to examine explosive behaviours (i.e., bubbles) in stock prices in the U.S. Nasdaq stock exchange. Unlike left-tailed unit root tests, such tests generally focus on the alternative hypothesis (rather than the unit root hypothesis) due to their interest in possible deviations from fundamentals and the presence of market irrationalities or mispricing (Phillips, Shi, & Yu, 2015: 1047). The SADF test (Equation 1) begins with the least squares estimation of Eq. (1) (Phillips, Wu and Yu, 2011, p. 206).

$$x_t = \mu_x + \delta x_{t-1} + \sum_{j=1}^{j} \phi_j \Delta x_{t-j} + \varepsilon_{x,t},\ \varepsilon_{x,t} \quad \mathrm{NID}(0, \sigma_x^2) \tag{1}$$

Here, j represents the lag value, and NID denotes the normal distribution. The null hypothesis of the unit root H_0:δ= 1, with the right-tailed alternative hypothesis H_1:δ > 1. The SADF test relies on repeated predictions of the ADF model over an expanding sample series and obtains the test as the sup value corresponding to the ADF test series (Phillips et al., 2011, p. 207).

$$\mathrm{ADF}_r \Rightarrow \frac{\int_0^r \tilde{w}\,dw}{\left(\int_0^r \tilde{w}^2\right)^{1/2}}, \text{ and; } \sup_{r\in[r_0,1]} \mathrm{ADF}_r \Rightarrow \sup_{r\in[r_0,1]} \frac{\int_0^r \tilde{w}\,dw}{\left(\int_0^r \tilde{w}^2\right)^{1/2}} \tag{2}$$

The PWY test uses an expanding sample sequence with a window size that increases from r0 to 1. It relies on repeated ADF model estimations and calculates the sup value of the ADF statistic sequence. The starting point of the sample sequence is fixed at 0, and the endpoint varies from r0 to 1. The PWY test statistic, denoted as SADF(r0), is obtained as the supADF value from the forward recursive regression (Phillips et al., 2015, p. 1048):

$$\mathrm{SADF}_{(r_0)} = \sup_{r_2\in[r_0,1]} \mathrm{ADF}_0^{r_2} \tag{3}$$

Following this, Phillips, Shi and Yu (2015) introduced the Generalised Supremum Augmented Dickey Fuller (GSADF) test and Backwards Supremum

Augmented Dickey Fuller (BSADF) dating algorithm to detect multiple bubbles, building upon the SADF test by Phillips, Wu and Yu (2011). The GSADF test expands the coverage significantly by recursively applying ADF test regressions on the data sub-samples based on equation 4.

$$\Delta y_t = \hat{a}_{r_1,r_2} + \hat{\beta}_{r_1,r_2} y_{t-1} + \sum_{i=1}^{k} \hat{\psi}^{i}_{r_1,r_2} \Delta y_{t-i} + \hat{\varepsilon}_t \tag{4}$$

The GSADF test expands on the concept of recursively applying ADF test regressions on data sub-samples (Equation 4). However, unlike the SADF test, the GSADF test uses much broader sub-samples in the recursion. This allows for varying the endpoint of the regression r2 from r0 (the minimum window width) to 1, and also permits the starting point r1 in Equation (4) to vary within a feasible range, specifically from 0 to r2 - r0. The GSADF statistic is defined as the largest ADF statistic obtained through this double recursion across all feasible ranges of r1 and r2, denoted as GSADF (r0).

$$\mathrm{GSADF}(r_0) = \sup_{\substack{r_2 \in [r_0,1] \\ r_1 \in [0, r_2 - r_0]}} \left\{ \frac{\frac{1}{2} r_w \left[W(r_2)^2 - W(r_1)^2 - r_w \right] - \int_{r_1}^{r_2} W(r)dr \left[W(r_2) - W(r_1) \right]}{r_w^{1/2} \left\{ r_w \int_{r_1}^{r_2} W(r)^2 dr - \left[\int_{r_1}^{r_2} W(r)dr \right]^2 \right\}^{1/2}} \right\} \tag{5}$$

Additionally, the GSADF statistic is simply defined as follows in Equation (6) Phillips, Shi and Yu, 2015, p. 1049):

$$\mathrm{GSADF}(r_0) = \sup_{\substack{r_2 \in [r_0,1] \\ r1 \in [0, r_2 - r_0]}} \mathrm{ADF}_{r_1}^{r_2} \tag{6}$$

The Generalised Supremum Augmented Dickey Fuller (GSADF) statistic proposed by Phillips, Shi and Yu (2015) allows for the detection of multiple bubbles, unlike the Supremum Augmented Dickey Fuller (SADF) statistic proposed by Phillips, Wu and Yu (2011), due to its allowance for the window size to vary from 0 to r2 - r0, providing a significant advantage in this regard (Phillips, Shi and Yu, 2015, p. 1048).

Following the GSADF test statistic, Phillips, Shi and Yu (2015) proposed the Backwards Supremum Augmented Dickey Fuller (BSADF) series for determining the start and end dates of bubble formations. This procedure uses a flexible window similar to the one mentioned earlier. Specifically, the backward SADF test conducts a sup ADF test on a backward expanding sample sequence, where each sample's endpoint is fixed at r2 (the sample fraction corresponding to the window's endpoint), while the starting point varies from 0 to r2 - r0 (the sample fraction corresponding to the window's origin). The backward SADF statistic is then defined as the sup value of the ADF statistic sequence over this interval, represented as (Phillips, Shi and Yu , 2015, p. 1051):

$$BSADF_{r2}\left(r_0\right) = \sup_{r_2 \in [0, r_2 - r_0]} \left\{ADF_{r_1}^{r_2}\right\} \tag{7}$$

Consequently, this approach offers greater flexibility in detecting multiple bubbles. PWY (Phillips, Wu and Yu, 2011) proposed comparing ADF_{r2} with the (right-tail) critical values of the standard ADF statistic to identify explosiveness at observation T_{r2}. The point at which the backward SADF sequence first intersects the critical value indicates the onset of bubble formation, the points where the BSADF sequence is above the critical value indicate the region where the bubble is located, and the last point where the BSADF sequence is above the critical value indicates the end of bubble formation. In this context, the BSADF curve can be considered as a representation of "the fair price curve" in the market. This curve serves as a tool for detecting overvaluations within the housing market, illustrating how closely market prices align with their fundamental values. Fair pricing is crucial for understanding the relationship between the true values of assets and their market prices. If the BSADF curve remains below a certain threshold, it may signal excessive overvaluation or the formation of a bubble. Therefore, the BSADF curve can be used as a reference point for determining fair pricing. However, it is essential to assess whether this curve accurately reflects fair prices by considering market conditions, economic indicators, and other relevant factors.

4. Empirical Findings

During the data period from January 2010 to September 2024, an analysis was conducted to identify potential housing bubbles in Türkiye's real estate market. Initially, the Generalised Supremum Augmented Dickey-Fuller (GSADF) test was applied to examine the presence of housing bubble formations. The results indicated the existence of housing bubble formations throughout the data period, highlighting significant trends in the Türkiye housing market. Following the identification of multiple bubble formations, the Backward Supremum Augmented Dickey-Fuller (BSADF) test was used to pinpoint the specific periods of bubble formation. This involved generating the Backward SADF series and critical values, which are presented in Table 1. The combination of the GSADF and BSADF test results offers comprehensive insights into the dynamics of housing bubbles in Türkiye, shedding light on the occurrence and duration of the bubble formation periods.

Table 1: Bubble Formation Periods in the Türkiye Housing Market: Results of the GSADF and BSADF Analysis

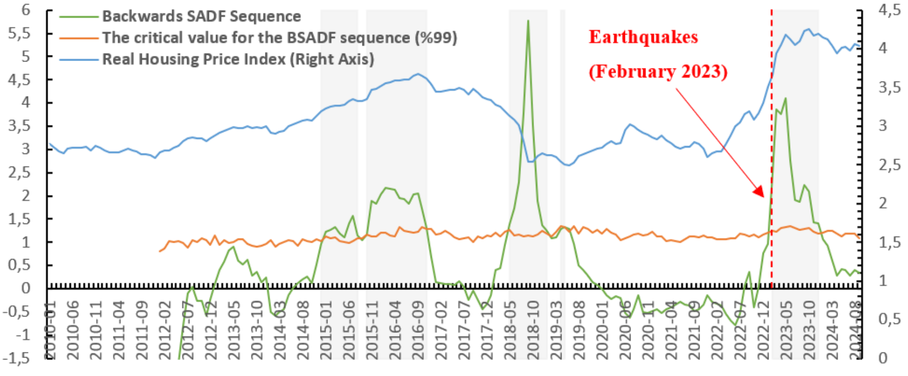
GSADF Statistics	Bubble Period	
5.770***	First Bubble Period	January 2015-August 2015
	Second Bubble Period	November 2015-November 2016
	Third Bubble Period	May 2018-January 2019
	Fourth Bubble Period	May 2019-June 2019
	Fifth Bubble Period	February 2023-December 2023

Note: ***, **, and * indicate the presence of housing bubble formations at the significance levels of 1%, 5%, and 10%, respectively, in the right-tailed tests. The critical values for the GSADF statistic are 1.754, 2.077, and 2.596, respectively. These critical values were obtained through 2000 repeated Monte Carlo simulations with a minimum estimation window size of 24 months for 177 observations. According to the BSADF results, the housing bubble formation periods are indicated at the 1% significance level.

The housing bubble formations observed in Türkiye from January 2010 to September 2024 exhibit considerable diversity. When examining the periods of bubble formation, the first four bubble periods are generally associated with economic cycles. For instance, intense housing demand supported by factors such as economic growth and low-interest rates characterises the first bubble period from January 2015 to August 2015. Similarly, the second bubble period from November 2015 to November 2016 can be linked to an increase in housing loans and high investor interest. The third and fourth bubble periods are typically associated with liquidity increases in the market and rapid rises in housing prices. In this direction, potential triggers for bubble formation include low-interest rates, liquidity abundance, rising housing demand, speculative investments, and government policies encouraging the housing sector. In particular, low-interest rates and expansive monetary policies may have contributed to increased housing loans and investor interest, thus supporting the formation of the bubble.

The most intriguing period among the obtained results is the latest housing bubble formation period, which emerged immediately after the earthquake. This period deserves special attention due to several critical factors and warrants a thorough evaluation due to its significant implications. In this context, it is obvious that Türkiye implemented negative interest rate policies despite the increasing interest rates globally, from before the earthquake disaster until the period when the transition to orthodox policies took place after the elections. There is a strong possibility that this will pave the way for a bubble in the housing market, as has been the case in other periods. However, the fact that this period coincides with the largest earthquake disaster in Türkiye's history cannot be overlooked; it is of paramount importance. It is undeniable that the earthquake's correlation with housing bubble formation is not coincidental, especially considering the sudden breach of the critical value in the BSADF series immediately after the earthquake. Initially, in January 2023, the BSADF test statistic was below the critical threshold for bubble formation, at 0.968 compared to a critical value of 1.208. However, in February 2023—the month of the earthquake—the test statistic surged to 2.492, surpassing the critical value of 1.244, marking the beginning of a pronounced housing bubble. This dramatic spike underscores the earthquake's impact on the housing market, fuelling an acute imbalance in supply and demand that spurred rapid price escalation. The BSADF series continued its upward climb, peaking at 4.100 in May 2023, well above the 1.33 critical threshold. This apex indicated the bubble's maximum intensity, reflecting a highly speculative phase marked by accelerated buying and rising prices, particularly in the earthquake-affected regions and beyond. Yet, from June 2023 onwards, the BSADF values declined steadily, suggesting the onset of the bubble's deflationary phase as the market began to adjust. By December 2023, the bubble had fully dissipated, indicating a normalisation of housing prices. This cycle—from rapid inflation to eventual deflation—illustrates the housing market's sensitivity to exogenous shocks, regulatory changes, evolving investor sentiments, and the complex interplay of supply-demand factors following significant natural disasters.

Figure 1: Periods of Housing Bubble Formation According to the Backward SADF Test Results



It may be suggested that the February 2023 earthquake, which impacted approximately 13 million people, caused severe disruptions in Türkiye's housing market, resulting in a housing bubble with significant price inflation. The disaster not only led to a drastic reduction in the housing stock in the affected regions but also spurred a wave of internal migration as people sought safer living conditions in other areas of the country. This movement intensified demand in relatively unaffected regions, creating a heightened demand for housing that outpaced the available supply. Additionally, in cities with higher seismic risks, even those unaffected by the recent earthquake, many residents experienced renewed apprehension about potential future earthquakes. This led to an increased demand for newly constructed or structurally sound buildings, further straining housing availability. The combination of reduced housing supply in impacted areas, increased migration, and heightened caution towards earthquake-resilient housing ignited a surge in prices across the market, reinforcing the bubble formation beyond what the BSADF test alone indicated. The econometric analysis thus illustrates how the intersection of reduced supply, elevated demand in safe zones, and psychological responses to seismic risk collectively drove the post-earthquake housing bubble—a phenomenon that underscores the profound and far-reaching impact of natural disasters on market dynamics. This study does not claim that the last bubble formation was solely caused by the earthquake. In other words, the recent housing bubble cannot be attributed solely to the earthquake. However, it is clear that the seismic event was a key factor in igniting the market's speculative frenzy. Apart from the earthquake disaster experienced during this period, there were other crucial factors that triggered the formation of this bubble in the housing market. In this respect, the following points outline the potential reasons behind the recent housing market bubble formation:

1. Direct earthquake-related factors:

- Sudden decrease in building stock: The seismic event rendered a substantial number of buildings unusable (either collapsed or severely damaged), creating a surge in the demand for housing in an area inhabited by 13 million people. This scarcity aligns with **fundamental value models**, where the supply-demand imbalance drives prices up beyond intrinsic values, setting the groundwork for speculative behaviour.
- Displacement of population: The displacement of people from earthquake-affected areas to various parts of Türkiye has led to increased mobility, contributing to the diffusion of the housing bubble across the country. **Rational bubble models** may interpret this as a response to perceived future price increases in previously stable regions, where displaced populations have increased demand.
- Increased demand for safe housing in historically seismic regions: Even in areas not directly affected by the earthquake but historically prone to seismic activity, residents' heightened concerns about safety have fuelled demand for secure housing, contributing to bubble formation. Fear-driven demand in other seismic zones illustrates **psychological factors** in speculative bubbles, particularly **herding behaviour** and **overvaluation due to anchoring bias**, as households seek safety and are willing to pay premiums for secure housing.

2. Market conditions unrelated to the earthquake but influenced by it indirectly:

- Inflationary effects: The anticipation of ongoing inflationary trends in Türkiye, coupled with increased housing demand, led to pricing based more on the future value of properties than their current worth. Inflationary trends and price adjustments based on anticipated future values rather than current valuations reflect **overconfidence and speculative exuberance** within **behavioural finance models**, as buyers may overvalue properties with expectations of continued appreciation.
- Rise in foreign currency and foreign demand for housing: The surge in the exchange rate made domestic properties more affordable for foreigners, prompting sellers to adjust prices accordingly. This is consistent with **asymmetric information theories**, where non-local buyers with different valuation strategies influence market prices, potentially creating distortions that heighten bubble formation.
- Housing as an investment vehicle: The perception of housing as a lucrative investment akin to stocks or foreign exchange, driving an increase in demand. The perception of real estate as an investment commodity, akin to that of stocks, reveals a **speculative shift in asset perception**. Investors, betting on continuous price increases, align with **rational expectation models** that predict speculative buying when assets are considered detached from fundamental values.
- Asymmetric information and moral hazard in the market: The heightened demand for housing led to opportunistic behaviour, with sellers taking advantage of buyers' situations to demand higher prices, especially from earthquake victims needing new housing either in the affected area or in different regions. This behaviour is consistent with **the moral hazard and market asymmetry models**, where price inflation persists due to unequal bargaining power and limited alternatives for urgent buyers.

3. Financial Market Dynamics and Credit Accessibility

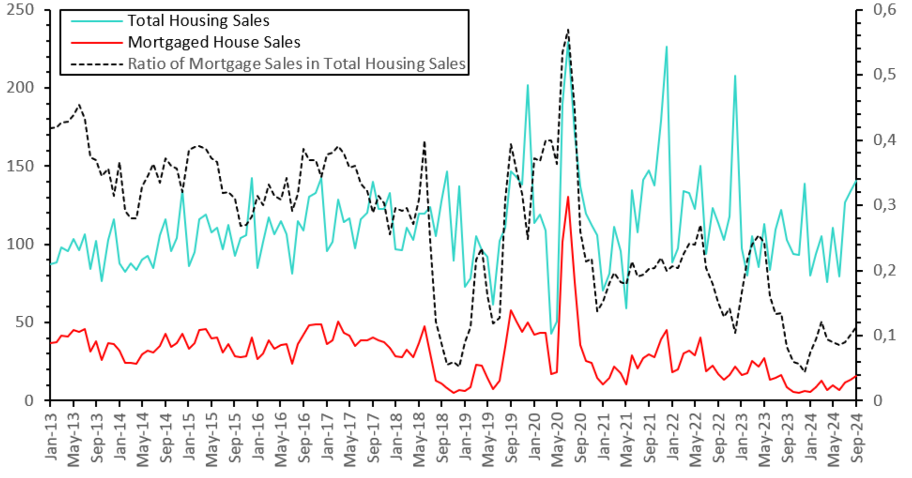
- Ease of credit and borrowing conditions: Low interest rates may have substantially broadened access to housing credit, facilitating borrowing at favourable rates. Particularly before the shift back to orthodox policies after the election, these low rates potentially enabled a larger segment of the population to obtain mortgage financing, thereby stimulating housing demand. In line with **Minsky's Financial Instability Hypothesis**, expanding credit access and debt cycles are likely to encourage asset price bubbles, suggesting that easier borrowing conditions could have contributed to speculative price inflation.

- Investor speculation due to low-interest rates or anticipated rate changes: Market actors may have anticipated that the continuation of significantly negative real interest rates was unsustainable, foreseeing eventual rate increases that would tighten credit conditions. This expectation may have spurred speculative demand, with investors seeking to leverage favourable credit terms before rates increased. Consequently, speculative housing demand during the low-rate period may have contributed to asset bubbles as buyers aimed to capitalise on prospective price appreciation. This aligns with **rational bubble models**, where market participants' expectations of future price gains foster speculative demand, thus potentially inflating housing prices ahead of anticipated credit tightening.
- Impact of emergency public housing initiatives in earthquake-affected regions: In response to the urgent housing needs of the 13 million people affected by the earthquake, extensive government-led construction projects were initiated in the impacted areas, effectively transforming these regions into large-scale construction zones. This rapid expansion of public housing construction likely placed upward pressure on the demand for building materials, labour, and land. Such large-scale state intervention, combined with heightened private sector activity, may have influenced housing market dynamics nationwide by driving up costs and amplifying the housing bubble. This is consistent with **market frictions and supply chain effects**, where public intervention in housing markets intensifies resource constraints and contributes to speculative pricing in related markets.

The trajectory of the BSADF series during this period is particularly noteworthy, with the test statistic used to detect the bubble peaking in May 2023 and then displaying a steady downward trend after that. This shift signals the beginning of a deflationary phase in the housing bubble, which ultimately dissipated by December 2023. The primary question here is why the BSADF series saw a downward break. The simplest explanation for this situation can be expressed as the elimination or alleviation of the issues explained above as possible causes of bubble formation. First, several factors may explain this, including the population gradually overcoming the initial shock of the earthquake, a reduction in migration from earthquake-affected areas to other regions, and the return of temporary migrants to the impacted zones.

Afterwards, most importantly, the policies implemented by the economic authorities, particularly the Central Bank's post-election monetary tightening, have had a profound impact on the housing market. As part of efforts to control inflation, interest rates were raised, which directly increased borrowing costs and, consequently, housing expenses. Additionally, credit access was restricted under these contractionary policies, making it more difficult for individuals to obtain mortgage financing. This led to a notable reduction in mortgage-driven demand, evident in the declining share of mortgage sales within total housing sales, as illustrated in Figure 2. This decrease in mortgage sales, which aligned with the downward movement of the housing bubble's trajectory, is a significant market reaction, highlighting a strong correlation between these restrictive financial conditions and the reduced demand in the housing sector. By December 2023, when the bubble had fully dissipated, the share of mortgage sales had dropped to approximately 4.36% (in April 2023, the month before the curve broke down, this rate was at its peak in recent months at 25.42%), the lowest level within the data period analysed. This decline in mortgage sales is not merely coincidental; it aligns closely with the downward trend in the BSADF series, indicating that the reduced demand for mortgage-driven housing played a critical role in the deflation of the bubble. Furthermore, as interest rates rose, investor preferences began to shift towards less risky options, such as savings, further curbing investment-driven demand for housing.

Figure 2: Ratio of Mortgage Sales in Total Housing Sales



In summary, two main factors underpin the deflation of the housing bubble. First, the gradual fading of the psychological and physical impacts of the earthquake and the normalisation of market conditions; and second, the Central Bank's contractionary monetary policy, which includes higher interest rates and restricted credit access to counter inflationary pressures. Together, these factors have dampened both investment and mortgage-based demand, stabilising housing prices and contributing to the bubble's decline.

5. Conclusion and Evaluation

Speculative bubble formation refers to the pricing of an asset significantly higher than its intrinsic value. This phenomenon is crucial in financial markets as it can trigger macroeconomic crises, as seen in the case of the Mortgage Crisis in the United States, which escalated into one of the most significant financial crises globally. Additionally, it can disrupt income distribution, significantly impacting societal welfare. As widely observed, there has been a steep increase in housing prices in Türkiye recently. Are these increases based on real fundamentals, or are they entirely a "bubble"? This contentious issue can be identified using econometric methods.

The earthquake disasters that struck Türkiye on February 6-7, 2023 have had profound and far-reaching effects on various aspects of the country, including its housing market. This paper aimed to investigate the impact of these earthquakes on the housing market, specifically focusing on the potential formation of a housing bubble. The data period from January 2010 to September 2024 was analysed using the Generalised Supremum Augmented Dickey-Fuller (GSADF) and Backward Supremum Augmented Dickey-Fuller (BSADF) methods to identify housing bubble formations and their durations. The empirical findings offer substantial insights into the speculative dynamics of Türkiye's housing market, revealing several distinct periods of bubble formation. Notable instances include from January 2015 to August 2015, from November 2015 to November 2016, from May 2018 to January 2019, from May 2019 to June 2019, and from February 2023 to December 2023, each reflecting phases of rapid price escalation influenced by macroeconomic factors and shifts in market conditions. However, the most significant period detected through the GSADF and BSADF tests is the housing bubble triggered by the February 2023 earthquakes, which caused a sharp increase in housing prices and a severe disruption in the supply-demand equilibrium. Unlike prior bubbles that evolved over time, this bubble emerged abruptly in response to the catastrophic natural disaster.

These findings underscore the profound impact of sudden supply shocks and population displacement on market dynamics, particularly in high-risk seismic regions. The earthquake-induced housing bubble in Türkiye offers a unique case study that broadens our understanding of speculative dynamics in housing markets, particularly in regions prone to seismic activity. Unlike typical housing bubbles, which often arise gradually due to extended periods of economic exuberance or policy shifts, this bubble emerged abruptly following a catastrophic natural event. This divergence underscores the significant impact of sudden supply shocks and population displacement on market prices, illustrating how external, non-economic shocks can trigger speculative cycles under conditions of heightened demand and limited supply. The findings reveal that, in high-risk seismic areas globally, housing markets may be highly vulnerable to similar speculative pressures in the aftermath of natural disasters. As such, this study emphasises the critical need for policymakers in these regions to implement adaptive regulatory measures that can mitigate the inflationary effects of crisis-driven demand, stabilise housing availability, and enhance resilience against future market disruptions.

Several factors contributed to the post-earthquake housing bubble, including the sudden decrease in building stock, displacement of populations, increased demand for safe housing, inflationary effects, rise in foreign demand, perception of housing as an investment, and market asymmetries. These factors, coupled with regulatory measures and monetary policies, influenced the severity and duration of the housing bubble. The findings of this study illustrate how the earthquake-induced bubble diverges from traditional speculative bubbles, aligning closely with Minsky's Financial Instability Hypothesis and models that emphasise market inefficiencies and psychological factors. Specifically, the sudden supply shock caused by the earthquake created conditions ripe for speculative behaviour, theories on asset bubbles driven by herding behaviour, overconfidence, and anchoring bias. The combination of low interest rates, heightened demand for safe housing, and increased investor activity demonstrates the interplay between external shocks and existing market dynamics, illustrating a situation where speculative pricing extended beyond intrinsic values. This context reinforces the relevance of behavioural finance models, which account for psychological drivers and market frictions that can intensify bubble formation in times of crisis.

The downward break in the BSADF series, which can also be considered as "the fair price curve" in the housing market, after June 2023 can be attributed to various factors, including the population's adaptation to the earthquake's aftermath, reduced migration, government policies, increased interest rates, and restricted credit availability. This downward shift continued until December 2023, when the series dropped below the critical threshold, indicating the bubble's complete deflation. These factors collectively played a crucial role in mitigating the housing bubble's impact, leading it into a full deflationary phase.

In conclusion, the empirical analysis confirms that the February 2023 earthquakes triggered a housing bubble in Türkiye's housing market. The findings underscore the importance of considering external shocks, such as natural disasters, in assessing housing market dynamics and risks. Another point to be emphasised based on the recent bubble formation is that the central bank's post-election interest rate hikes played a pivotal role in curbing this bubble, as reflected in the declining share of mortgage-based sales within total housing sales. As interest rates increased, borrowing costs rose, which reduced the affordability of mortgages, leading to a marked decrease in mortgage-driven demand. This shift aligned with the housing market's deflationary trend, where mortgage sales as a share of total sales dropped significantly, reaching their lowest level at the point when the bubble had completely dissipated by December 2023. This correlation between restrictive monetary policy, declining mortgage sales, and the deflation of the housing bubble emphasises the impact and necessity of timely policy interventions in stabilising speculative markets. These findings highlight the importance for economic authorities to maintain an active role in monitoring and intervening in the housing market as needed, especially in response to external shocks, to address supply-demand imbalances, and to mitigate the risks associated with future housing bubbles. Moving forward, policymakers and stakeholders need to continue monitoring the housing market closely, implement prudent regulatory measures, and address supply-demand imbalances to maintain market stability and mitigate the risks associated with housing bubbles.

In this sense, this study contributes valuable insights to the literature on housing market bubbles, emphasising the need for comprehensive analyses that integrate external shocks and economic factors. Further research can explore long-term trends, policy implications, and risk management strategies in the context of post-disaster housing markets, providing a robust foundation for informed decision-making and sustainable market development.

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RESEARCH ARTICLE

Populism and Income Inequality: Is Income Inequality in Türkiye a Political Choice?

Dila ASFUROĞLU[1]

ABSTRACT

The argument that national inequalities are political and thereby driven by political decisions implies that income distribution is not merely an economic phenomenon but also a political one. Hence, this study explores the impact of populist governance on income inequality in Türkiye. In doing so, this study addresses whether income inequality in Türkiye is a political choice, drawing on economic, social, and political data over the years 2008-2022. According to the results of the quantitative analysis, the share of income for the working class has fallen, the income gap between the lowest and highest deciles of the working class has narrowed, and the potential for fiscal interventions to reduce income inequality is not realised. In return, the income inequality that existed in 2008 has persisted at the same magnitude over the years. In other words, even if income inequality is not an explicit political choice, the populist governance in Türkiye between 2008 and 2022 has chosen not to contribute to the solution to this prevailing inequality.

Keywords: Populism, income inequality, Türkiye
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1. Introduction

Despite the efforts of several United Nations agencies, global inequality emerged as a major theme by the mid-twentieth century as the income gap between the wealthiest 20% of people in the richest countries and those in the poorest expanded 24.67-fold from 1820 to 1997 (UNDP, 1999). In this respect, Lockwood (2020) argues that global and national inequalities are not only intertwined but also politically driven, shaped by structures of power, political decisions, and institutions. This claim implies that income distribution transcends mere economic phenomena, embodying political dimensions as well. Therefore, studies on national income inequality also require an investigation of a country's political structure. In line with this, the current study examines the impact of populist governance on income inequality in Türkiye.

Findings of this study indicate that, despite the growth in real gross domestic product (GDP), the share of income for the working class has fallen in recent years, a trend observed even with the decreasing population growth rate. Conversely, the share of income accruing to capitalists in national income has risen. The income gap between the lowest and highest deciles of the working class has narrowed over the years, leading to a trend towards income levelling at or near the minimum wage level. The size of the informal economy and the proportion of unregistered workers have declined, which has led to increased tax collections. Despite the potential for fiscal interventions to reduce income inequality through increased tax revenues, this reduction was not materialised. Meanwhile, Türkiye has been grappling with a chronic domestic debt problem, persistent and high inflation, impoverishing growth due to a competitive exchange rate regime, and an education system increasingly leaning towards privatisation. These factors have collectively contributed to the persistent state of income inequality. Hence, the reduction of income inequality does not appear to have been a priority or a deliberate choice under populist governance during the 2008-2022 period.

Events such as the global economic crisis in 2008, subsequent economic and political developments, growing income inequalities due to neoliberal policies, the Brexit referendum, and Donald Trump's election as president have fuelled a surge in the political science literature on populism. However, the definition and conceptualisation of populism remain contested. While some scholars regard populism as a political style (Decker, 2006; Knight, 1998; Viguera, 1993), others consider it as a political strategy (Ducatenzeiler, Faucher and Rea, 1993; Laclau, 2005; Weyland, 2001, 2017; Mudde and Kaltwasser, 2017). A common element in these definitions is the reference to "the elite" versus "the people". Mudde (2004) offers an ideational strategy perspective, defining populism as "thin-centred ideology" that divides society into two groups: the "pure people" and the "corrupt elite". According to this view, politics is an expression of the people's general will, where opponents are deemed evil. Direct communication and charismatic leadership are emphasised as key aspects of populism. They also claim to speak up for the oppressed[1] based on common sense with the aim of creating no change in their values but with the agenda of altering their political status. Hence, populism is regarded as reformist, but not revolutionary (Sawicky, 1998).

Research on the emergence of populism has identified several contributing factors. Oxhorn (1998) attributes the recurrent populism in Latin America to high levels of inequality and socioeconomic heterogeneity, which facilitate mass mobilisation through populism. Mair (2006) states that the diminishing importance of political parties creates a proper basis for a direct relationship with the people via populism in Europe. Farmisano (2012), Algan et al. (2017), and Guiso et al. (2017) link populism in the US to the economic crisis[2]. Mikucka-Wójtowicz (2019) points out that the resurgence of populism in Croatia and Serbia stems from societal dissatisfaction with political parties along with how democracy has failed to meet expectations and economic crises. Inglehart and Norris (2017) and Pastor and Veronesi (2020) also find that rising inequality fosters populism. In short, populism in the political sense tends to arise in the middle of social and/or economic crises with political resentment, a lack of confidence in solving a social

[1] Basu (2024) claims that they speak for the nationalist and the religious majority.

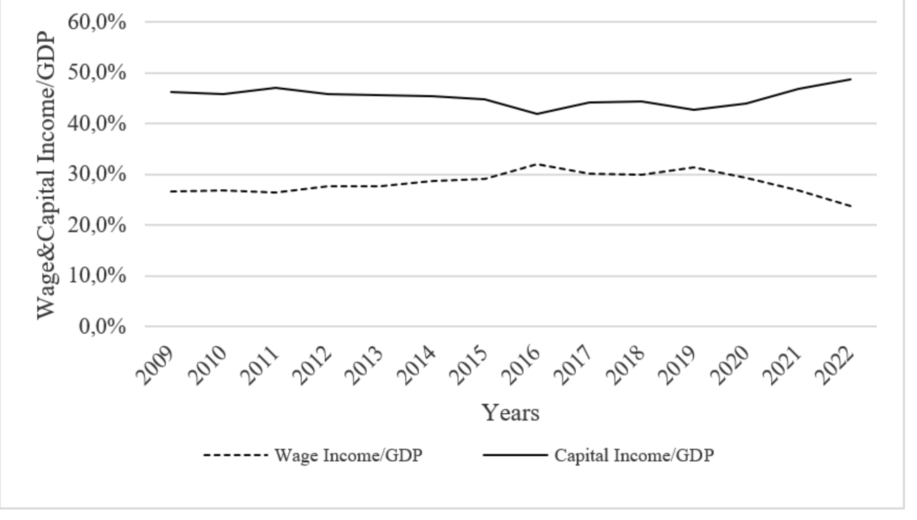
[2] As economic causes of the emergence of populism, globalisation (Rodrik, 2018a) and high concentrations of international trade (Colantone and Stanig, 2018) are also suggested.

problem by the current political system, an alleged challenge to "the way of life", and the presence of charismatic leaders. This aligns with dependency and modernisation theories, which posit that socioeconomic processes shape politics. Hence, it is evident that populist governance not only emerges from economic processes but also influences them. However, the literature exploring the reciprocal relationship between populism and income inequality is still infantile. Hence, this study seeks to bridge this gap with a quantitative analysis.

In economic terms, "(macro)economic populism" describes policies that prioritise income redistribution and economic growth, often overlooking the risk of high inflation and external constraints (Dornbusch and Edwards, 1990). Sachs (1989), Dornbusch and Edwards (1991), and Acemoglu, Egorov and Sonin (2013) argue that populist leaders generally harm the economy. This is primarily because such leaders tend to favour short-term, opportunistic policies to win voter support rather than adopting rational, long-term strategies. For instance, populist leaders use expansionary fiscal policies for short-term economic stimulation and increased consumption, but these policies eventually hinder growth and escalate inflation in the long run. Dornbusch and Edwards (1990) observe that populist economic programmes typically share certain features: dissatisfaction with the growth trajectory, high economic inequality, underestimation of budget deficit risks, and neglect of the inflationary consequences of expansionary policies, along with promises of income redistribution and economic reshaping. In other words, myopic and expansionary policies with acute results are considered macroeconomic populism at first. Then, Rodrik (2018b) asserts that economic populism is used as an equivalent term for policies aiming at income redistribution from the rich to the poor, also motivated by rising income disparities. Sachs (1989) and Wilkinson and Pickett (2009) also argue that income inequality is a critical factor for social problems that could give rise to populism. In return, populist policies influence how the GDP is distributed among economic agents. Therefore, exploring the effect of populist governance on income inequality facilitates understanding whether income inequality results from political choices, as the ultimate promise of populism is reduced inequality. Therefore, this study seeks to determine whether income inequality in Türkiye is a political choice by analysing economic, social, and political data.

Piketty (2014) demonstrates that income inequality deepens when the rate of return on capital exceeds the growth rate of technology, which is the same rate as the growth of GDP per capita. This happens as capital income grows faster than wage income. Figure 1 displays the evolution of capital and wage incomes in Türkiye over 2009-2022, for which data are available.

Figure 1: Evolution of Income Types



Source: TURKSTAT

Figure 1 suggests that wage and capital income move symmetrically in opposite directions. This indicates an increasing trend in income inequality, particularly since 2016. In parallel with this, various databases and scholars have recognised that Türkiye has been under populist rule since 2003. Taşkın (2008) categorises the policies of the Justice and Development Party (AKP) as conservative populism; Kyle and Meyer (2020) classify Recep Tayyip Erdoğan's terms as prime minister and president as cultural populism; and Funke, Schularick, and Trebesch (2022) label it as right-wing populism[3]. Thus, Türkiye provides an appropriate outlet to study the effects of populist policies on economic inequality.

[3] The terms of the AKP are also labelled as a conservative democracy by Moudouros (2014), a hegemonic project by Yalvaç and Joseph (2019), and Erdoğan as an autocrat by Yilmaz and Bashirov (2018).

The selection of the starting point for the analysis period is based on two primary considerations. First, the Turkish Statistical Institute (TURKSTAT) revised its data definitions in 2008 (and again in 2014), thereby limiting data availability to post-2008 rather than 2003. To ensure definitional consistency while still maintaining a sufficiently long time span for robust results, the analysis begins from 2008. Second, scholars, such as Öniş (2015) and Akkoyunlu and Öktem (2016), divide the AKP's rule into periods in terms of the party's democratic governance and the success of its economic policies. The general view is that the years leading up to 2008 were characterised as the "golden years" of democratic reforms and economic growth under the AKP. In contrast, the period after 2008 was marked by poor economic performance and rising authoritarianism. Therefore, focusing on 2008-2022, using annual data, allows for a more nuanced understanding of the impact of these changes on economic inequality.

The contribution of this study to the literature is three-fold. First, it integrates insights from two disciplines, namely, political science and economics. Second, this paper analyses the effect of populism on income inequality, a perspective largely overlooked in the existing literature. The dominant view in the literature suggests that economic inequalities fuel populism, where inequality destroys social cohesion and arouses feelings of tension, insecurity, threat, and the need for security-driven allegiances, leading to populism (De Bromhead, Eichengreen and O'Rourke, 2013; Bischi, Favaretto and Carrera, 2020). However, this article sheds light on the possible vicious circle in the relationship between populism and income inequality by approaching the issue from the other direction, i.e., analysing how populism may in turn induce income inequality. Lastly, to the best of my knowledge, this is the first study to investigate the economic effects of populist policies specifically in the context of Türkiye.

The remainder of the paper is organised as follows. After a summary of the existing literature, Section 2 describes the analysis where the impact of various policies on income inequality is evaluated and presents the findings of the economic, social, and political data. Finally, Section 3 discusses the findings.

1.1. Literature Review

The recent political science literature exploring populism in Türkiye is quite diverse. Cinar (2016) identifies the determinants of the electoral hegemony of the AKP employing Ordinary Least Squares (OLS) analysis. Religiosity, the provision of better public infrastructure services, and electoral institutions have a positive effect on the AKP's electoral success, whereas the share of the population out of social security and unemployment have a negative impact. In a content analysis of parliamentary group speeches, Elçi (2019) gauges that Recep Tayyip Erdoğan is the most populist political figure, with Kemal Kılıçdaroğlu being the least. Altınörs (2021) examines the authoritarian populism-migration nexus, suggesting the importance of geopolitics in understanding global populism. Yilmaz and Erturk (2021) conclude that the populist narrative of the AKP and its leader are necropolitical, which is a tool used for legitimising and sustaining authoritarian stability. Bulut and Hacıoğlu (2021) measure populist communication styles using the content coding of parliamentary group speeches. They stress that foreign policy populism and discursive religious symbolism are key factors in the AKP's ability to remain in power. Yilmaz and Demir (2023) argue that the AKP's Islamist civilizational populist narrative has broadened to encompass all diasporic Sunni Muslim communities in forging the transnational people.

From the perspective of the economics discipline, income inequality has been the subject of extensive research. For instance, Aksoğan and Elveren (2012) investigate the effect of defence expenditures on income inequality in Türkiye from 1970 to 2008 by employing causality and cointegration methods. According to their results, defence expenditures have a negative impact on inequality. Ak and Altintaş (2016) explore the legitimacy of Kuznets' inverted U hypothesis in Türkiye between 1986 and 2012 using the Autoregressive Distributed Lag (ARDL) model Bound Test method. They observe a U-shaped relationship, with income inequality initially improving during periods of economic growth and then deteriorating as per capita income rises. In a regression-based decomposition method between 2006 and 2014, Limanlı (2017) determines that education per capita had the highest impact on income inequality in Türkiye. Dasdemir and

Tunali (2023) find that an increase in the spread of capital ownership decreases the GINI coefficient in Türkiye. By applying the Shapley and Owen methods, Gemicioğlu, Kızılırmak and Akkoç (2024) show that inflation and indirect tax policies pursued during 2003–2019 were favouring the rich.

The study of the impact of populism on income inequality often revolves around specific populist tools. For example, with a situation analysis, Çalışkan (2010) attributes the lack of a significant decline in income inequality since the 1960s to the governments' failure to make adequate use of social policies for fairness in income distribution. In an analysis of the effect of fiscal policy instruments on income inequality between 1990 and 2016, Teyyare and Sayaner (2018) conclude that increased public expenditures, institutional quality, and taxes reduce income inequality, while increased public borrowing raises it. In a comparative study of Türkiye and Chile about the results of their policies, both following similar political and economic neoliberal policies in combating poverty and income inequality, Erkul and Demir-Erkul (2019) find that Türkiye pursues less effective policies than Chile. By employing employs the Vector Autoregression (VAR) between 1987 and 2018, Topuz (2021) indicates that the rise in public domestic debt increases income inequality. Findings of the ARDL Bound Test method of Bükey (2022) indicate that a raise in private sector wages increases the Gini coefficient, while a similar effect in the minimum wage decreases the Gini coefficient.

There are a handful of papers exploring the relationship between populism and income inequality. Sachs (1989) argues that the "populist cycle" leads to ineffective policies that make the whole society worse off due to poor economic performance, as high inequality creates political pressure for policies aiding the poor. Despite their eventual failure, populist policies continue to be driven by a highly uneven income distribution. Dornbusch and Edwards (1990) describe the characteristics of macroeconomic populism, where policies favour income redistribution and economic growth while understating the risk of high inflation, external constraints, and a deficit that would cause the collapse of the economy. By moving beyond populism, Acemoglu, Vindigni and Ticchi (2011) study the impact of the efficiency of state capacity on income inequality. Their theoretical model establishes that in democracies, the political process results in an effective bureaucracy with redistributive policies, whereas in non-democracies, the rich may favour an inefficient state to avoid redistribution by controlling the politics. In a later study, Acemoglu et al. (2013) that populist policies originate as a strategy for politicians to designate that future policy will be in line with the median voter in an analytical model. These populist redistributive policies are not only harmful for the rich but also the poor; overall, they often negatively affect economies.

2. Analysis and Results

Several factors influence income distribution, with population growth being a significant determinant in developing countries. Rapid population growth adversely affects income distribution by preventing the labour force from receiving a larger share of the growing income compared to the past and by failing to provide sufficient employment opportunities for the young population in the coming years.

Table 1: Population, Growth of GDP and Shares of Labour Compensation

Years	Annual Population Growth (‰)	Nominal Value Added Growth	Nominal GDP Growth	Real GDP Growth	Compensation of Labour % Value Added	Compensation of Labour % GDP
2008	13.1	..	..	0.8%	..	..
2009	14.5	..	..	-4.8%	29.9%	26.7%
2010	15.9	14.4%	16.0%	8.4%	30.6%	26.9%
2011	13.5	20.4%	20.3%	11.2%	30.0%	26.4%
2012	12	12.9%	12.6%	4.8%	31.4%	27.7%
2013	13.7	14.4%	15.3%	8.5%	31.7%	27.8%
2014	13.3	13.7%	12.7%	4.9%	32.5%	28.7%
2015	13.4	14.0%	14.4%	6.1%	33.0%	29.1%
2016	13.5	11.8%	11.7%	3.3%	36.3%	32.0%
2017	12.4	20.0%	19.3%	7.5%	34.1%	30.2%
2018	14.7	21.2%	19.9%	3.0%	33.5%	30.0%
2019	13.9	15.2%	14.7%	0.8%	34.8%	31.3%
2020	5.5	15.6%	17.1%	1.9%	32.9%	29.3%
2021	12.7	44.4%	43.6%	11.4%	30.1%	26.9%
2022	7.1	107.3%	107.0%	4.9%	26.5%	23.7%

Source: TURKSTAT and The World Bank

Table 1 reveals a general downward trend in the population growth rate, with the lowest rate of 0.55% occurring in 2020. In contrast, gross value added and GDP at current prices demonstrate a positive growth trend from 2010 to 2022, peaking in 2021 and 2022. However, real economic growth shows significantly lower growth rates compared to nominal values. In other words, when GDP is adjusted for inflation, the growth rates are more modest. Moreover, real economic growth changes in parallel with the population growth rate. That is, GDP tends to rise with an increasing population growth rate and fall when it decreases. This correlation can be attributed to labour force expansion in line with population growth, which influences overall economic growth. The positive growth rates, except for 2009, indicate an expanding real economy. A growing economy alongside a declining population growth rate could be a sign of either an increase in labour productivity (as detailed in Table 6) and/or technological progress. However, the share of labour compensation in the growing economic pie has fallen, especially in recent years, as shown in the last two columns. This decline in labour's share of value added and GDP is somewhat counterintuitive; one would expect it to rise with a decreasing population growth rate. Yet, the opposite trend has been observed, indicating that the benefits of economic expansion and increased productivity have not proportionally reached labour compensation. In other words, the potential contributions of larger GDP and higher productivity to alleviating income inequality are not reflected in labour income, thereby widening the gap between labour and capital income.

Policies aimed at preventing unemployment and boosting employment help mitigate income inequality by enabling individuals to work and to receive a share of the increased income. Additionally, factors such as the duration of bureaucratic procedures, the existence, inclusiveness, and strictness of legal regulations and rules, and the tax levels play a crucial role in affecting the informal economy. An expanding informal sector not only hampers the effectiveness of policies aimed at reducing income disparities due to decreased tax revenues but also widens income disparities due to the failed formation of competitive markets and emergence of new business lines.

Table 2: Institutional Data and Informality

Years	Unemploy-ment Rate	Government Effectiveness	Regulatory Quality	Rule of Law	Electoral Democracy Index	Informal Economy %GDP (DGE)	Informal Economy %GDP (MIMIC)	Informal Labour %
2008	9.7%	0.290	0.269	0.023	0.564	28.6%	32.1%	..
2009	12.6%	0.290	0.289	0.049	0.551	28.2%	33.5%	..
2010	10.7%	0.315	0.313	0.050	0.531	28.2%	32.6%	..
2011	8.8%	0.365	0.393	0.015	0.526	28.1%	31.4%	..
2012	8.1%	0.432	0.451	-0.037	0.519	27.7%	31.3%	..
2013	8.7%	0.399	0.463	-0.004	0.471	27.4%	30.9%	..
2014	9.9%	0.393	0.433	-0.076	0.399	27.1%	30.8%	34.5%
2015	10.2%	0.200	0.274	-0.232	0.362	26.7%	30.7%	33.4%
2016	10.8%	-0.006	0.193	-0.342	0.303	26.2%	31.2%	33.6%
2017	10.8%	0.014	0.044	-0.318	0.285	25.9%	30.7%	34.1%
2018	10.9%	-0.068	0.016	-0.391	0.290	25.6%	30.9%	33.6%
2019	13.7%	-0.020	-0.020	-0.348	0.288	..	..	34.8%
2020	13.1%	-0.159	-0.025	-0.420	0.288	..	..	30.9%
2021	12.0%	-0.119	-0.101	-0.433	0.283	..	..	29.0%
2022	10.4%	-0.199	-0.245	-0.458	0.276	..	..	26.8%

Source: The World Bank, TURKSTAT[4] , ILOSTAT and V-Dem

[4] Since TURKSTAT uses different definitions for unemployment data before and after 2013, the data are fragmented. In order to stick to a single definition, only post-2014 data are presented.

According to Table 2, the average unemployment rate between 2008 and 2022 was 10.7%. Although there was a decrease in unemployment following 2009, it began to rise again starting in 2014. The persistence of double-digit unemployment rates suggests a lack of general improvement in the labour market, thus limiting opportunities for people to earn income through employment. This conclusion is further supported by the declining population growth rate, as shown in Table 1, indicating the ineffectiveness of policies aimed at reducing unemployment. The size of the informal economy, as calculated via the Dynamic General Equilibrium (DGE) and Multiple Indicators Multiple Causes (MIMIC) methods by The World Bank's Prospects Group, constitutes approximately a quarter and a third of the GDP, respectively. An overall downward trend in the informal economy and a reduction in the proportion of unregistered workers imply that there should be an accompanying increase in tax revenues (as shown in Figure 2), which could be potentially used to shrink inequality.

The government effectiveness data, shown in the third column of the table, gauges the perceptions of the citizens regarding the quality of policy formulation, implementation and public services, the independence of public service from political pressures and, the credibility of government commitment to its policies. Regulatory quality data evaluate the government's capability to develop and enforce policies and regulations and to implement policies that encourage private sector development. The rule of law data assesses public trust in property rights, courts, contract enforcement, and police, as well as the extent to which these rules are respected. The decline and negative values in these estimates, which range between -2.5 and 2.5, particularly after 2015, indicate a diminishing public's perception of trust in these institutions. The electoral democracy index measures the legitimacy of electoral competition, the freedom of civil and political organisations, election integrity, and the impact of elections on leadership change. With values ranging from 0 to 1, the index has halved over 14 years, thereby hinting at reduced executive responsiveness to citizens. In short, these political data corroborate the established categorisation of the AKP's governance post-2011 as having unfavourable outcomes for institutional integrity.

High inflation leads to a deepening of income inequality by shifting income from labour to capital, adversely affecting the income of wage earners. Capital owners can hedge their income against inflation with positive real interest returns from their savings, whereas fixed-income earners experience the erosion of their real income by inflation. Therefore, effective monetary policies aimed at regulating income distribution should ensure low inflation and economic stabilisation. While expansionary monetary policies could improve income distribution in the short run, their continuous pursuit can lead to higher inflation, ultimately deteriorating income distribution in the long run.

Table 3: Employee and Shareholder Income Distribution

Years	Inflation (CPI, annual change)	Labour Income Distribution Ratio (D10/D1)	Net Operating Surplus and Mixed Income % Value Added	Net Operating Surplus and Mixed Income % GDP
2008	10.4%	66.54	..	..
2009	6.3%	66.30	51.9%	46.3%
2010	8.6%	48.03	52.1%	45.9%
2011	6.5%	47.99	53.5%	47.1%
2012	8.9%	46.49	52.0%	45.9%
2013	7.5%	45.51	52.1%	45.6%
2014	8.9%	36.59	51.3%	45.4%
2015	7.7%	36.32	50.7%	44.7%
2016	7.8%	29.41	47.5%	41.9%
2017	11.1%	29.64	49.9%	44.2%
2018	16.3%	27.73	49.5%	44.3%
2019	15.2%	26.48	47.4%	42.7%
2020	12.3%	..	49.4%	43.9%
2021	19.6%	..	52.5%	46.9%
2022	72.3%	..	54.5%	48.8%

Source: TURKSTAT and ILOSTAT

Table 3 shows that annual inflation was maintained in single digits from 2009 to 2016 with successful monetary policies. However, it subsequently escalated to double digits and reached hyperinflation levels in 2022. This inflationary trend has heterogeneous impacts: while capital owners can protect themselves against inflation using financial instruments in their portfolios, employees, who rely more on cash transactions and have limited access to such instruments, suffer more from high inflation. This disparity is evident when comparing columns 4 and 5 of Table 3 with columns 6 and 7 of Table 1, respectively, which show that the income share of capital owners (i.e., net operating surplus and mixed income) is increasing, while labour income share is decreasing. The ratio of labour income distribution in the third column, representing the ratio of total labour income shares between the top and bottom deciles, decreased from 66.5 in 2008 to 2.5 times less in 2019, the most recent year for which data are available. This indicates a narrowing gap between the lowest and highest labour income earners. However, considering also the rising share of capitalist income, this suggests that those in the upper deciles of the working class are converging to the income levels of those in the lower deciles. In other words, prolonging this trend potentially leads to a levelling of the labour market around the minimum wage.

There are several other monetary indicators important for altering income inequality, such as policy and interest rates. The interaction between policy rates, domestic debt, and market interest rates is intricate. In a system where domestic debt, policy and market interest rates follow each other, an increase in the policy rate can mitigate demand-pull inflation by boosting savings and reducing consumption. Yet the same policy can also trigger cost-push inflation through higher credit costs. Therefore, the effect of monetary policy on inflation and thereby income distribution hinges on an accurate understanding of inflation dynamics. However, it is certain that domestic borrowing tends to have a negative impact on low-income groups, as higher interest rates primarily benefit high-income savers, while interest expenses are financed by taxes levied across the entire society.

The second column of Table 4 denotes that the money supply measured by M3 in 2022 increased by 17.4 times compared to 2008. The annual growth rates of the money supply, listed in the third column, have been consistently rising, except for the decline in the rate of increase in 2011 and 2014, with a notable acceleration since 2020. Even if this steep increase in 2020 might be attributed to liquidity provisions due to the COVID-19 pandemic, no similar unexpected macroeconomic shocks have been experienced that could have explained the

Table 4: Monetary Measures and Inequality

Years	Money Supply (M3)	Money Supply Growth Rate	Policy Interest Rate (Repo)	Market Interest Rate (Deposits)	Domestic Debt Stock (Million TL)	Increase in Domestic Debt	Domestic Debt/GDP	P80/P20
2008	458,383,776.0	..	19.81	..	274.80	..	..	8.055
2009	520,674,414.0	13.6%	..	..	330.00	20.1%	32.8%	8.548
2010	616,200,873.9	18.3%	..	..	352.8	6.9%	30.2%	7.94
2011	700,491,311.0	13.7%	10.84	13.97	368.80	4.5%	26.3%	8.041
2012	791,992,774.0	13.1%	10.94	15.13	386.50	4.8%	24.4%	7.962
2013	950,979,183.0	20.1%	6.77	13.72	403.00	4.3%	22.1%	7.693
2014	1,063,151,797.0	11.8%	11.05	14.76	414.60	2.9%	20.2%	7.4
2015	1,238,083,234.2	16.5%	10.67	14.70	440.12	6.2%	18.7%	7.565
2016	1,450,681,529.4	17.2%	9.40	15.04	468.64	6.5%	17.8%	7.679
2017	1,675,831,302.6	15.5%	11.59	14.77	535.45	14.3%	17.1%	7.54
2018	1,988,304,794.7	18.6%	17.40	23.04	586.14	9.5%	15.6%	7.751
2019	2,575,267,171.0	29.5%	20.35	25.36	755.10	28.8%	17.5%	7.412
2020	3,418,684,238.7	32.8%	10.28	15.19	1060.30	40.4%	21.0%	8.009
2021	5,165,828,236.3	51.1%	18.75	20.86	1321.20	24.6%	18.2%	7.645
2022	8,443,279,036.5	63.4%	14.00	26.58	1905.30	44.2%	12.7%	7.936

Source: The Ministry of Treasury and Finance, CBRT and TURKSTAT radical rise in the subsequent years. Comparatively, the 13.9-fold increase in GDP calculated at current prices, but only a 90% rise in real terms, given in Table 1 over the same period, indicates that money supply growth has outpaced output growth. This disparity, in return, has contributed to the high inflation, as evidenced in Table 3. However, the lack of a close correlation between policy and market interest rates complicates the attribution of inflation to specific types of inflationary pressures, namely demand-pull or cost-push, due to interest changes. This suggests the difficulty in pinpointing the exact drivers of inflation in Türkiye.

Deposit rates have consistently been higher than the policy rate in Türkiye, with policy rates generally declining following each hike. Between 2011 and 2018, the domestic debt stock increased in a controlled manner, but a recent acceleration in its growth rate may reflect the country's low savings rate, modest income levels, and challenges in boosting tax revenues. Contrary to expectations, the reduction in the informal economy, as indicated in Table 2, did not lead to a corresponding decrease in domestic debt. This trend suggests a chronic issue, as evidenced by the domestic debt stock to GDP ratio averaging above 20%. The last column of the table presents the P80/P20, which measures the income of the richest 20% relative to the poorest 20%, where a decrease in this ratio means a reduction in income inequality. Over the 14-year period, despite some fluctuations, the average ratio stood at 7.8, and income inequality only diminished by 1.5% from 2008 to 2022, indicating a persistent issue with income disparity. In other words, the broken link between market and policy interest rates, unanchored and high inflation, and persistently high domestic debt prevented monetary policy from addressing income inequality.

Social harmony and justice in income distribution are closely linked. Achieving a relatively fair and equitable income distribution in a society cannot occur spontaneously and requires deliberate government intervention through various policies. Policies can change income distribution through changes in primary and secondary income distribution by influencing social, economic, cultural, and political factors. Primary income distribution refers to the initial allocation of gross factor incomes, such as interest, wages, profits, and rents, among the factors of production without government intervention. Secondary income distribution means the net income distribution after the governmental adjustments in the primary income distribution through subsidies, taxes, social security premiums, and social expenditures (Ataç, Önder and Turhan, 2008). Hence, government policies in money, pricing, foreign trade, fiscal matters, wealth, and education can significantly alter these income distributions. Additionally, the nature of the economic system, whether it is based on market economies or welfare states, the degree of governmental involvement in the system, the economy's current state, the growth strategy, the development plans pursued by the government, and the overall level of the country's development are also among the key factors in designing policies for changing income distribution.

Table 5: Sectors and International Measures

Years	Agriculture, Forestry and Fishing	Manufacturing	Construction	Accommodation and Food Service Activities	Real Effective Exchange Rate	Terms of Trade	Current Account Balance
2008	96	109.8	118.9	96.6	111.13	..	-5.12%
2009	100	100	100	100	113.62	..	-1.75%
2010	107.7	109.2	116.7	108.3	120.17	..	-5.74%
2011	111.4	131.3	145.8	132.8	103.31	..	-8.87%
2012	113.8	134.1	157.7	143.8	110.95	..	-5.37%
2013	116.5	147.3	180.3	156.9	100.89	92.49	-5.75%
2014	117.2	155.5	188.9	169.2	105.69	94.06	-4.05%
2015	128	164.7	198.3	175.6	98.99	100	-3.08%
2016	124.7	171.3	208.4	164.1	93.48	103.63	-3.07%
2017	130.8	187.2	227.9	187.9	86.26	98.14	-4.65%
2018	133.8	189.9	223.7	216.2	76.30	94.42	-2.59%
2019	137.8	185.6	204.4	221.4	76.06	94.48	1.42%
2020	145.8	191.2	193.1	143.3	61.96	98.47	-4.43%
2021	141.4	226.8	191.9	205.5	47.70	85.93	-0.88%
2022	143.2	236.7	178.3	271.4	54.84	75.7	-5.37%
Average	123.2	162.7	175.6	166.2	-	-	-

Table 5 provides the index values[5] for Türkiye's GDP, calculated using the production method for selected activities, with 2009 as the base year. Among the main sectors comprising GDP, namely agriculture, manufacturing, construction, and services, the manufacturing sector has been showing the highest production in recent years relative to the base year. However, when considering average production since the base year, construction leads with an index value of 175.6, followed by the services sector with an index value of 166.2. This comparison implies that construction and tourism are the locomotive sectors of Türkiye's economic growth.

The "Turkish Economic Model", introduced in 2021, seeks growth and development through a competitive exchange rate strategy, similar to the approaches used in Far Eastern countries. This model necessitates an analysis of foreign trade policies in addition to sector-specific growth strategies. For example, an import-substitution growth strategy is expected to benefit fixed-income earners by boosting domestic demand. In contrast, an export-oriented growth model might disadvantage labour income, as achieving comparative advantages often relies on cheap labour. In economies focused on export-driven growth, incentives typically favour entrepreneurs. However, policies that excessively undervalue the local currency to stimulate exports can paradoxically reduce the national income, thereby reducing the income share of all economic segments. Consequently, both foreign trade and exchange rate policies play a significant role in determining income distribution. They influence the balance between different economic sectors and income groups, affecting the allocation of national wealth across the economy.

A rise in the real effective exchange rate in Table 5 means a real appreciation of the Turkish Lira. Based on the index value of 100 for the base year 2003, the Lira has continuously depreciated, aligning with competitive exchange rate

[5] The share of the mentioned activities in GDP are not preferred here to facilitate the comparison. Because the data exclude taxes and subsidies, administrative and support service activities, or professional, scientific, and technical activities.

practises. This policy seeks to stimulate growth[6] by substituting imports and boosting exports. Theoretically, a stronger currency should positively influence growth by encouraging savings, investment and employment (Glüzmann, Levy-Yeyati and Sturzenegger, 2012) and by easing the balance of payments constraints (Razmi, Rapetti and Skott, 2012). However, the terms of trade data in column 7, with 2015 as the baseline, show a downward trend with values persistently below 100. The values of terms of trade, calculated by dividing the unit value index of exports by that of imports, above 100 enhance national welfare through foreign trade, whereas values below 100 indicate a detrimental effect on the country's welfare. In this respect, the trend of terms of trade implies that the anticipated welfare benefits from a competitive exchange rate policy have not realised. Furthermore, a consistent negative current account balance signals a deficit, indicating that investment, service, and transfer revenues are insufficient to offset the foreign trade deficit. In the light of this and considering the convergence of incomes across the top and bottom deciles in Table 3, the situation in Türkiye might exemplify "impoverishing growth", as conceptualised by Bhagwati (1958). Put differently, the government's competitive exchange rate strategy and its selection of sectors as growth engines through foreign trade and economic policies did not lead to improvements in income disparity.

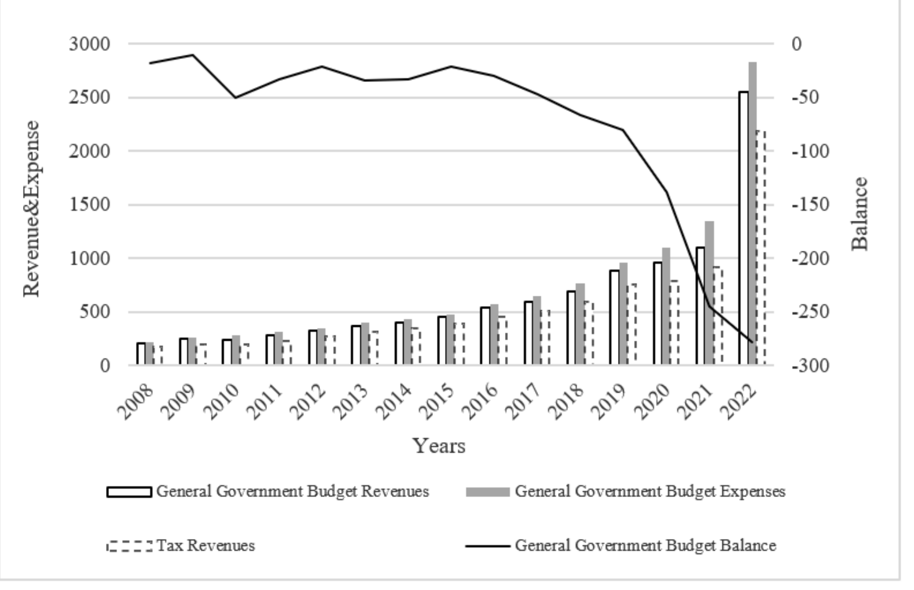
An unequal distribution of wealth inevitably leads to income inequality, primarily because substantial savings are typically made by the wealthy. To mitigate this inequality, implementing tax policies that redistribute income and wealth, policies that broaden wealth distribution at the grassroots level, and providing subsidies or tax concessions for low-income earners are crucial. Moreover, policies aimed at preventing the concentration of property and wealth within groups are vital for income redistribution. Examples of such policies include selling shares of privatised government enterprises to lower- and middle-income groups and offering social housing to residents at reasonable prices with affordable instalments. By enabling the working class to own capital and property,

[6] For detailed information on the requirements under which a competitive exchange rate can favourably affect growth and welfare, see Ökten and Asfuroğlu (2022).

such measures encourage them to contribute more effectively to the economy. As they work harder and more productively to manage housing instalments and invest in shares, they not only boost overall economic growth but also increase their share of total income. Investment, essential for wealth creation, requires savings. Since high-income groups have more savings opportunities than low-income groups, policies that encourage savings among the latter play a central role in reducing income inequality. For this purpose, instruments such as government savings premiums, compulsory savings, and low-interest loans can be effective.

Taxing different income groups at varying rates and providing diverse levels of transfers can redistribute income among these groups. Utilising taxes from higher-income groups for public services needed by lower-income groups, channelling transfers and public spending towards the lower-income groups and the unemployed, and directing public investment expenditures to underdeveloped regions and sectors are key strategies for diminishing income inequality. Implementing progressive tax policies, reducing indirect taxes, increasing wealth taxes, and exempting minimum wages from taxation are fiscal approaches that favour low-income groups. Additionally, enforcing laws to prevent tax evasion is vital, as inadequate tax revenues reduce the funds available for addressing income inequality. A public deficit can also lead to higher real interest rates and the need for domestic borrowing, benefiting capital owners and further skewing the income distribution away from labour incomes. In short, fiscal policies are pivotal in shaping the difference between primary and secondary income distributions.

Figure 2: Fiscal Policies

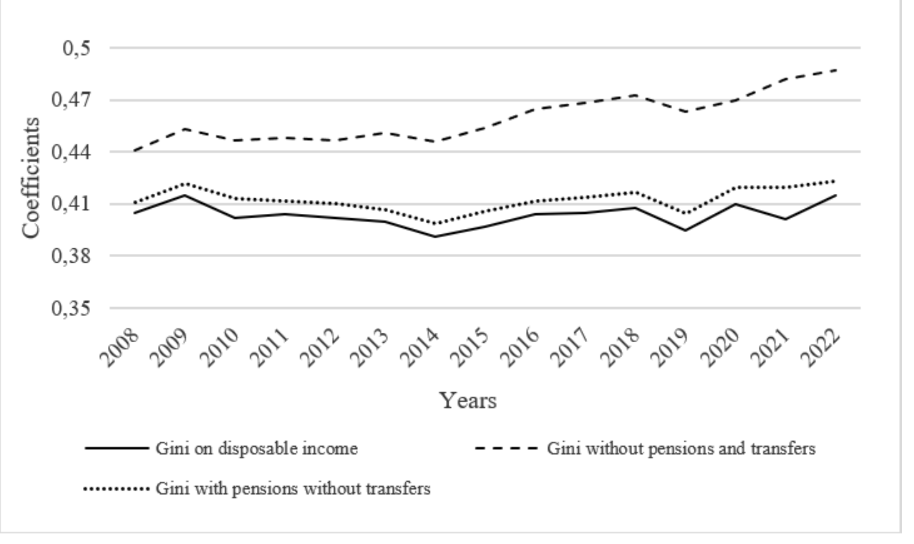


Source: The Ministry of Treasury and Finance

Figure 2, which presents data in millions of Turkish Liras, illustrates that the general government budget expenditures have exceeded revenues each year, resulting in a budget deficit. Note that the deficit has intensified over the last seven years, as demonstrated by the steepening slope of the budget balance on the line graph's right axis. Tax revenues, a significant component of budget revenues, have seen a substantial increase since 2009, reaching a level in 2022 that is 11.8 times higher than that in 2008. This implies a significant increase in the potential resource for reducing income inequality. However, when this growth in tax revenues is compared to the P80/P20 ratio in Table 4, a proportional decrease in income inequality is not observed. The P80/P20 ratio's mere 1.5% reduction over the same period suggests that, despite the increase in tax revenues, fiscal policies have not been effectively utilised to mitigate income inequality. While it is unrealistic to expect all tax revenues to be dedicated to this purpose, the limited change in the income distribution ratio indicates a missed opportunity for more impactful fiscal interventions.

The Gini coefficient, ranging from 0 to 1, is a widely used measure of income inequality, where a value approaching one signifies greater inequality. In Figure 3, the line chart displays the Gini coefficient based on household disposable income, while the dashed line shows the Gini coefficient calculated excluding all types of social transfers like pensions, survivor's, disability, and sickness benefits together with education- and family/children-related allowances. Lastly, the dotted line demonstrates the Gini coefficient calculated excluding all types of social transfers except pensions and survivor's benefits (i.e., including pensions, voluntary retirement, elderly, widow, and orphan pensions, and excluding all other social transfers).

Figure 3: Gini Coefficients



Source: TURKSTAT

The Gini coefficients calculated using disposable income and those without social transfers have closely followed each other, with both indicating a recent increase in income inequality. In fact, the coefficient representing income without any social transfer additions consistently shows higher inequality, which has been particularly rising since 2019. This trend suggests that social transfers play a critical role in mitigating income inequality, not pensions for pensioners, the elderly, widows, orphans, and voluntary pensioners. The similarity in the Gini coefficients across all calculations from 2008 to 2022, with their recent increase, indicates an ongoing and worsening deterioration in income distribution. The data imply that, despite various measures, the gap between different income groups is not narrowing effectively, highlighting the lack of more targeted or robust policies to address this issue.

Being equipped with advanced knowledge and skills determines the level of income earned, changing the established distribution of income. Providing widespread vocational and technical training to enhance the labour force's quality is crucial in this context. Moreover, effective coordination and planning between educational institutions and employment sectors are key to aligning with the demands of the labour market. These factors contribute to balancing supply and demand, which can reduce income inequality. Moreover, the organisational structure of the public administration, the ability of the public administration to adapt its organisation, personnel, and the provision of fast and efficient services for the public without wasting resources are also among the drivers affecting income distribution.

Table 6 presents the index values of GDP for specified economic activities, calculated via the production method using 2009 as the base year. In 2020, compared to 2009, index values increased for all activities except education together with administrative and support service activities, which exhibited a decrease in 2019. The most significant increase was in administrative and support service activities, followed by one in professional, scientific, and technical activities, and education activities recorded the least growth. The activity with the highest average GDP was administrative and support service activities, while the lowest was public administration, defence and compulsory social security.

The administrative and support service sector encompasses activities, including rental and leasing, travel agency and related services, investigation and security activities, building-related services, landscaping activities, and office management (İŞKUR, 2021). The public administration and defence sectors involve activities aimed at business efficiency enhancement, administration,

Table 6: Economic Activities and Productivity

Years	Education	Professional, Scientific, and Technical Activities	Human Health and Social Work Activities	Administrative and Support Service Activities	Public Administration and Defence; Compulsory Social Security	Efficiency of Labour (%)	Labour Utilisation (%)
2008	98.7	97.4	95.9	102.8	98.3	-0.3	-0.1
2009	100	100	100	100	100	-4.1	-2.1
2010	102.8	108.3	102.4	100.4	99.4	2.5	4.2
2011	108.1	117.9	110.8	116.9	101.5	5.5	3.9
2012	113	125.6	114.3	128.4	105.6	2.1	1.3
2013	123	134.7	121.5	149.4	110	6.8	0.3
2014	132.6	143.8	122.6	168.6	114.8	-0.1	3.6
2015	136.8	167.6	124.7	193.5	116.1	4.1	0.6
2016	140.3	168.4	133.9	212.3	124.1	2.3	-0.3
2017	146.7	187.1	135.9	233.3	127.5	4.8	1.3
2018	154.5	182.6	146.6	229.3	147.8	2.5	-0.9
2019	161.2	183.9	153.9	224.3	157.4	3.8	-4.3
2020	158	185.6	166.2	201.3	164.9	17.9	-14.4
2021	167.1	213.5	187.8	239.2	172.1	-6.2	17.6
2022	172.3	238.3	200.5	264.7	174.4	-1.1	5.3

Source: TURKSTAT and OECD

dispatch of border and coast guard operations, response to domestic emergencies, oversight of research and development policies, and various social security functions such as managing sickness, occupational accident benefits, unemployment insurance, maternity support, temporary disability, and pension schemes. The compulsory social security sector includes public administration activities, foreign affairs services, justice and judicial operations, organisations of health, education, cultural services, and other social services, and compulsory social security functions. Despite the integral role of social security transfers in mitigating inequality, as inferred from Figure 2, the average resources allocated for public administration, defence, and social security have been relatively lower compared to administrative and support service activities. This indicates that while social security transfers are crucial for reducing inequality, the growth in resources dedicated to these areas has not been substantial.

The activities in columns 2, 3, and 4 are expected to contribute to reducing unemployment and enhancing labour productivity, given that education and health expenditures are also linked to human capital. To assess this, the last two columns of Table 6, showing the percentage changes in employee productivity and labour utilisation, respectively, are relevant. Efficiency of labour is measured as GDP in real prices per hour worked, whereas labour utilisation is calculated by dividing the hours worked by the population size. Both indicators show fluctuations in the rate of increase over time, with occasional decreases in levels. Interestingly, the data reveal a discrepancy between the index values and volatility. Specifically, while index values for these activities are rising, their impact on productivity is not consistently positive. The correlation between professional, scientific, and technical activities and labour utilisation is modest at 0.15, and it is even lower for education activities. In other words, despite the increased GDP value attributed to these sectors, their influence on enhancing productivity is relatively limited. This suggests that the activities directed towards education and professional services, including accounting, auditing, consulting and, research and development, may not be fully addressing the actual needs of productivity. Consequently, these sectors' potential to positively influence income inequality through enhanced productivity has not been fully realised.

Effective education policies are vital for ensuring equality of opportunity among individuals. To prevent educational monopolisation and thus provide equal educational opportunities, the government can implement policies such as granting national access to education, supplying necessary educational materials like books, and covering educational expenses. Disparities in educational facilities, particularly the lack of adequate schools and dormitories in rural areas, can trigger rural-urban migration. Migrants often end up being used as a low-cost labour force in urban areas, which can further widen income inequality. Furthermore, the high cost of quality education can create a barrier where only high-income groups can afford the best educational opportunities, perpetuating income inequality across income groups and, in return, generations. This scenario stresses the importance of making quality education accessible to all income groups to bridge the inequality gap.

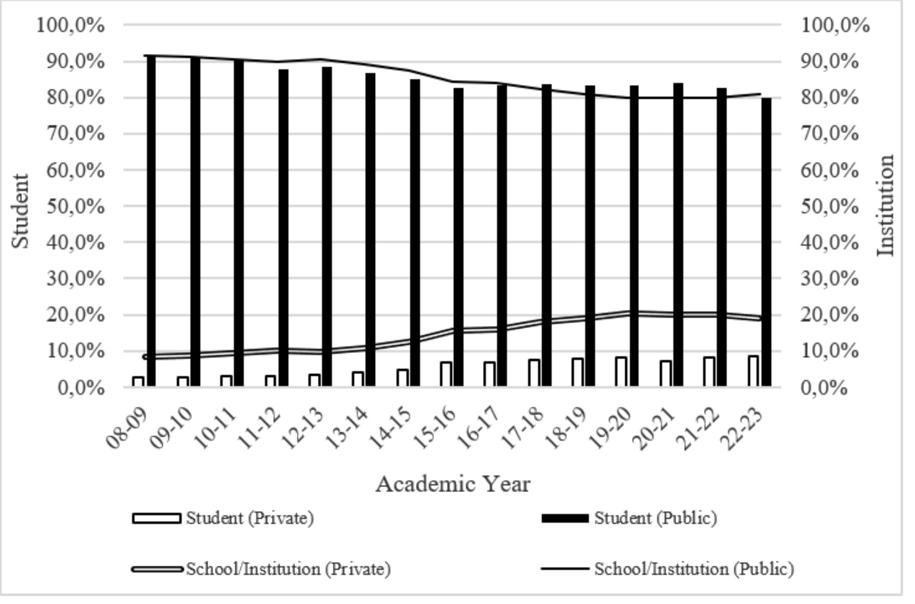
Focusing on the population aged six and above, Table 7 presents the changes in educational attainment between 2008 and 2022. The data show a 23.7% decrease in the number of primary education graduates, a 246.7% increase in high school and equivalent vocational school graduates, and a 231.6% rise in college or university graduates. The net schooling rates, which represent the proportion of students in the appropriate age group for each education level, exhibit varied trends. There has been a decline in net enrolment rates for primary school, middle school, and primary education levels since 2012, the earliest year for which data are available, but an increase for secondary education. This suggests that while overall educational attainment has risen, the growth in the population eligible for primary school, middle school and primary education levels has outpaced the actual enrolment in these levels. Additionally, the last two columns of the table, covering formal education data, show that from the academic year 2008-2009 to 2022-2023, there has been a 63.2% increase in the total number of formal educational institutions and a 29.7% rise in student numbers. The breakdown of these increases between public and private institutions is detailed in Figure 4. This indicates substantial growth in the education sector, although wedges in enrolment rates at different education levels suggest ongoing challenges in achieving national education access.

Table 7: Education

	Level of Education Completed			Net Schooling Rate (%)				Sum of Formal Education	
Years	Primary Education	High School and Equivalent Vocational School	College and Faculty	Primary School	Middle School	Primary Education	Secondary Education	Institution	Student
2008	6615736	9970816	3508954	..	..	..	58.52	45969	15351849
2009	7432613	10379231	4320813	..	..	..	64.95	46100	16137436
2010	10820045	11374336	4566049	..	..	..	66.07	46287	16845528
2011	11986436	11883336	5495749	..	..	..	67.37	46427	16905143
2012	12669905	12096830	5913187	98.86	93.09	98.8	70.06	61592	17234452
2013	13018720	12085335	6706780	99.57	94.52	99.31	76.65	61936	17532988
2014	10690444	12602922	7447269	96.3	94.35	97.1	79.37	59509	17559989
2015	9323169	12990847	8340145	94.87	94.39	96.44	79.79	61203	17588958
2016	8481757	13717008	8922146	91.16	95.68	96.51	82.54	63153	17702938
2017	8691859	13965346	9246040	91.54	94.47	96.12	83.58	65568	17885248
2018	8832635	14785993	9754499	91.92	93.28	96.05	84.2	66849	18108860
2019	5678694	15426019	10257791	93.62	95.9	97.69	85.01	68589	18241881
2020	5468879	15773910	11006443	93.23	88.85	93.93	87.93	67125	18085943
2021	5132420	16697592	11637287	93.16	89.84	94.34	89.67	70383	19155571
2022	5048202	17442997	12166766	93.85	91.21	95.29	91.7	75019	19904679

Source: TURKSTAT and The Ministry of National Education

Figure 4: Public and Private Education



Source: The Ministry of National Education[7]

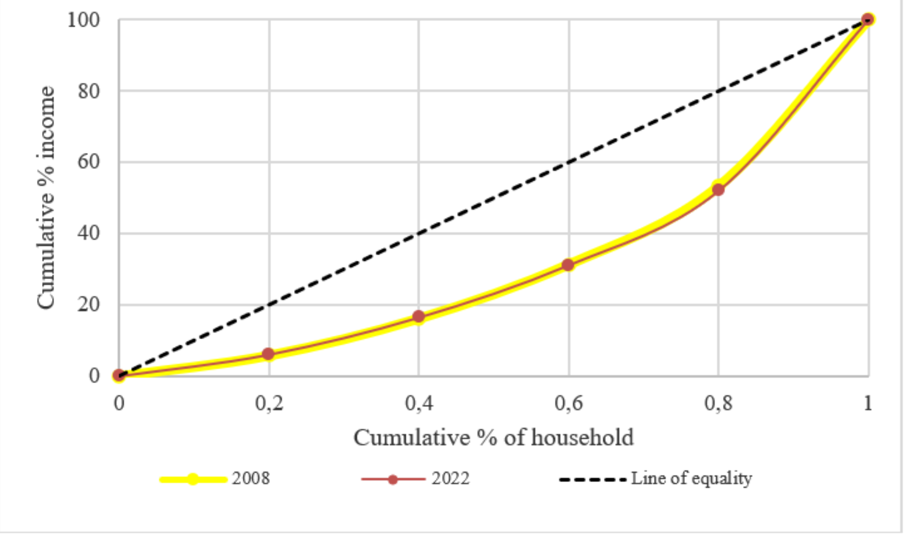
The data demonstrated by the black solid columns show a decreasing trend in the proportion of students in formal public education relative to the total number of students, while the share of students in private institutions illustrated by the white hollow columns has increased over the years. This trend is consistent with the percentages of the institutions. In other words, between 2008 and 2022, there has been a notable shift towards privatised education, with an increasing number of students attending fee-based private institutions. Consequently, this shift predominantly benefits those from higher-income families, suggesting a growing inequality in access to education services. Thus, the potential of education as a means to create equality of opportunity appears to be diminishing, with educational advantages increasingly skewed towards those who can afford private education.

Despite the rise in educational levels and the total number of educational institutions, persistent income inequality is evident in Türkiye. This is demonstrated

[7] The percentages do not add up to 100% due to the presence of open education institutions.

by the declining ratio of labour compensation as a percentage of gross value added in Table 3, the stagnant or non-decreasing values of the P80/P20 ratio in Table 4, and the nearly constant Gini coefficients over the years depicted in Figure 2. To visualise this ongoing inequality, the Lorenz curve is a useful tool. It graphically represents the distribution of income across various population percentages, allowing for a clear comparison with the line of absolute equality. By analysing the Lorenz curve, the extent of income inequality can be gauged, illustrating the proportion of total income held by different segments of the population.

Figure 5: Lorenz Curve



Source: TURKSTAT

Figure 5 features the Lorenz curves for 2008 and 2022, representing the income distribution across the first to the last quintile groups, each constituting 20% of the population. The curves, based on median income data, are remarkably distant from the 45-degree line, which symbolises perfect income equality. This distance indicates significant income inequality. Moreover, the curves for 2008 and 2022 almost entirely overlap, suggesting that the income shares of these quintile groups have remained largely unchanged over the 14-year period. This lack of change implies that the level of income inequality present in 2008 has persisted through to 2022.

3. Conclusion

The main argument of this study, which presumes that national inequalities are politically driven and thus a product of political decisions, suggests that income distribution is not only an economic phenomenon but also a political one. This highlights the importance of considering a country's political structure in analyses of national income inequality. Accordingly, this study examines the impact of populist governance on income inequality in Türkiye. In essence, it addresses whether income inequality in Türkiye represents a political choice, drawing on economic, social, and political data spanning 2008 to 2022, a period characterised by populist governance in Türkiye.

Findings of this study indicate that, despite the growth in real GDP, the share of income for the working class has fallen in recent years. Conversely, the share of income accruing to capitalists in national income has risen. The income gap between the lowest and highest deciles of the working class has narrowed over the years. This suggests a trend towards income levelling at or near the minimum wage level. The size of the informal economy and the proportion of unregistered workers have declined, which has led to increased tax collections. Despite the potential for fiscal interventions to reduce income inequality through increased tax revenues, this reduction was not materialised. Additionally, the anticipated welfare benefits from implementing a competitive exchange rate have not been achieved. Instead, this foreign trade policy has triggered impoverishing growth. There has been a deterioration in various political perception indicators, signalling a move towards automatisation. Meanwhile, Türkiye has been grappling with a chronic domestic debt problem, persistent and high inflation, and an education system increasingly leaning towards privatisation. These factors have collectively contributed to the persistent state of income inequality. In conclusion, the measures of income inequality have not shown significant changes from 2008 to 2022, indicating that the level of income inequality present in 2008 continues to prevail.

Neoliberalism emphasises free markets, minimal state intervention, privatisation, and deregulation as pathways to economic growth, often deprioritising redistribution in favour of market efficiency, which intensifies inequality. In response, populist leaders frequently frame inequality and economic challenges in their rhetoric, using anti-inequality narratives to mobilise political support. They may implement tokenistic measures, such as cash transfers, which provide immediate but superficial benefits to their voter base without addressing structural inequality (Fischer, 2020). Populist leaders also tend to rely on patronage networks, selectively distributing resources to loyal constituencies rather than pursuing universal redistribution (Kenny, 2017). Furthermore, they often frame inequality in cultural or nationalistic terms, blaming external forces (e.g., immigrants, global markets) instead of addressing domestic economic structures, thereby diverting attention from systemic reforms (Leser and Pates, 2021). Additionally, populists may increase spending on visible, populist-friendly projects, such as subsidies or infrastructure, which do not necessarily address income inequality (Joppke, 2023). Systemic redistributive policies are often avoided because they risk alienating elites or large business interests, which are critical for political funding and alliances, thereby maintaining the status quo. In short, populism frequently prioritises short-term political gains over long-term structural reforms, resulting in inaction or superficial policies on income inequality despite its rhetorical prominence (Onis and Kutlay, 2020).

One of the key reasons for the AKP's rise to power (Yalvaç and Joseph, 2019, among others) was widespread dissatisfaction with previous neoliberal policies. In their 2002 general election manifesto, when the AKP first came to power, the party explicitly addressed income inequality, dedicating 18 pages to social policies, with three pages specifically focused on the issue (AKP, 2002). However, in their 2007 manifesto, the emphasis shifted to showcasing the outcomes of their earlier social policies rather than detailing concrete measures to reduce income inequality (AKP, 2007). Over the years, the AKP has implemented various social initiatives, such as "Support for Young People Getting Married (Evlenecek Gençlerin Desteklenmesi)," "Family Support Programme (Aile Destek Programı)," and "Birth Assistance (Doğum Yardımı)." Additionally, before several elections, they distributed goods like coal and pasta (NTV, 2014), established city hospitals in 22 provinces (AKP, 2023), and constructed infrastructure projects, including bridges, tunnels, and highways, using the build-operate-transfer model. However, this approach led to the emergence of specific companies that frequently secured tenders for such projects between 2005 and 2022 (BirGün, 2022). Despite these efforts, the analysis in this paper concludes that the fiscal policies aimed at addressing income inequality were not systematically redistributive enough to counterbalance fiscal spending on initiatives like "Public Private Partnerships (Kamu Özel İşbirlikleri)". As a result, the Lorenz curves during the analysis period remained largely overlapping, and the Gini coefficients showed little to no improvement.

This paper does not aim to investigate the reasons behind the rise of populism in Türkiye or the disparity between populist rhetoric and its reality regarding inequality. As such, it does not establish a definitive causal link from populism towards the widening of income inequality, as the time span analysed does not permit for this type of regression analysis. Instead, the study explores various aspects of income inequality in relation to populism in Türkiye from 2008 to 2022, highlighting the historical economic and social effects associated with populist policies. During this period, institutional arrangements and power dynamics deteriorated, and tools that could have mitigated historical patterns of exclusion, such as the tax system, access to education, and social spending, were not effectively utilised. Hence, the findings clearly indicate that populism in Türkiye between 2008 and 2022 did not actively contribute to addressing existing income inequality, despite its ultimate promise. In other words, reducing income inequality did not appear to have been a priority or deliberate policy choice under populist governance in this period.

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Appendix

Data	Source
Annual Population Growth	TURKSTAT
Nominal Value Added Growth	TURKSTAT
Nominal GDP Growth	TURKSTAT
Real GDP Growth	World Bank
Compensation of Labour % Value Added	TURKSTAT
Compensation of Labour % GDP	TURKSTAT
Unemployment Rate	TURKSTAT
Government Effectiveness	World Bank
Regulatory Quality	World Bank
Rule of Law	World Bank
Electoral Democracy Index	V-Dem
Informal Economy %GDP (DGE)	World Bank
Informal Economy %GDP (MIMIC)	World Bank
Informal Labour %	ILOSTAT
Inflation (CPI, annual change)	TURKSTAT
Labour Income Distribution Ratio (D10/D1)	ILOSTAT
Net Operating Surplus and Mixed Income % Value Added	TURKSTAT
Net Operating Surplus and Mixed Income % GDP	TURKSTAT
Money Supply (M3)	Ministry of Treasury and Finance
Policy Interest Rate (Repo)	CBRT
Market Interest Rate (Deposits)	CBRT
Domestic Debt Stock (Million TL)	Ministry of Treasury and Finance
Domestic Debt/GDP	Ministry of Treasury and Finance
P80/P20	TURKSTAT
Agriculture, Forestry and Fishing (GDP Index)	TURKSTAT
Manufacturing (GDP Index)	TURKSTAT
Construction (GDP Index)	TURKSTAT
Accommodation and Food Service Activities (GDP Index)	TURKSTAT
Real Effective Exchange Rate	CBRT
Terms of Trade	TURKSTAT
Current Account Balance	World Bank
Education (GDP Index)	TURKSTAT
Professional, Scientific and Technical Activities (GDP Index)	TURKSTAT
Human Health and Social Work Activities (GDP Index)	TURKSTAT
Administrative and Support Service Activities (GDP Index)	TURKSTAT
Public Administration and Defence; Compulsory Social Security (GDP Index)	TURKSTAT
Efficiency of Labour (%)	OECD
Labour Utilization (%)	OECD
Level of Education Completed	Ministry of National Education
Net Schooling Rate (%)	TURKSTAT
Sum of Formal Education	Ministry of National Education

Data availability statement: The data underlying the study can be obtained from 10.5281/zenodo.8348811.

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RESEARCH ARTICLE

Foreign Direct Investment, Brand Value, and Economic Performance: A Multinational Analysis

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ABSTRACT
The visibility and dependability of multinational corporations' products increase with the fact that they introduce their goods to markets in other nations through foreign direct investments. The method for presenting products to international markets through foreign direct investments reveals the product's reputation and therefore the brand's development value. This study examines the relationship between foreign direct investments and brand value in Australia, Canada, China, France, India, Japan, Spain, the USA, and the UK for the period 2007-2023. The majority of studies in the literature attempt to explain the impact of brand value on foreign direct investments. However, very few studies explain the impac foreign direct investments on brand value and 1st generation unit root tests were generally used. Unlike existing studies, In this study, the second-generation unit root test, Durbin-Hausman cointegration, and Common Correlated Effects Mean Group estimation methods were used. As a result, it is anticipated that this study will contribute to the literature in this regard. The findings show that increases in foreign direct investments boost brand value.

Keywords: Brand value, Foreign direct investments, Panel data analysis
JEL Clasification: D02, F21, C23

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1. Introduction

The barriers of custom between nations have been destroyed, and economic integrations have started to grow day by day as a result of the spread of globalization in terms of economic, social, and political terms, and the increase in financial liberalization. Because of this, international trade in products and services has started to pick up speed (Çeştepe, Tatar and Erdogan, 2023). However, developments in technology also lead to the imitation of a product. The introduction of a product to the market, the production of the same or similar product elsewhere, and the imitation of the product are a rapidly evolving situation. Increasing product variety decreases product prices, which is in favor of consumers according to the law of demand. However, it may result in negative outcomes such as a decrease in the producer's market share and profit rate. As a result, manufacturers attempt to distinguish their products from their competitors by creating brand value for their products. Manufacturers can increase the reliability of their products in the eyes of consumers, protect their market shares, increase their profit shares, and increase their competitive power in the international arena in this manner.

Brand value and foreign direct investments (FDI) have a symbiotic relationship. With the brand image they create, multinational corporations can increase their FDI. At the same time, the brand image they create elevates their products above their competitors. By doing this, companies will be able to defend their current markets and open up new ones. As a result, by increasing their profit rates, these companies contribute significantly to the increase in national income in their respective countries. Similarly, multinational corporations can use FDI to promote their products in foreign markets. Companies can ensure the positive development of brand value in this manner by increasing the product's reliability and image.

Nevertheless, there are not many studies that address this in the literature. Therefore, this study will fill this gap in the field. Accordingly, the study investigated how FDI affects brand value. Within the parameters of data availability, a model has been developed in this regard utilizing data for Australia, Canada, China, France, India, Japan, Spain, the USA, and the UK from 2007 to 2023. As anticipated, the results have concluded that FDI raises brand value in the countries under investigation.

The first section of this study, which explores the association between brand equity and FDI, discusses the significance of brand value and how it interacts with FDI. The second section addresses national and international research on the association between branding and FDI. The empirical study that explains the relationship between FDI and brand value is examined in the third chapter. In the fourth section of the study, the results obtained from the empirical analysis are presented. The discussion and conclusion were made in the final section.

2. Theoretical and Empirical Literature

Brand value refers to a company's capacity to conduct commercial operations and manage its managers in a manner that enables it to meet its objectives (Gupta et al., 2020). Companies use brand value to differentiate their products from those of their competitors and to make these products trustworthy in the eyes of consumers. Branding has started to gain importance in parallel with the change in the global economy from a macro perspective in general (Ökten et al., 2019). A company's brand contributes to its performance as an intangible asset and a marketing tool. It affects the economic trend of societies in this way.

As previous research has shown, with the advancement of technology since the Industrial Revolution, production capabilities have advanced rapidly (Yıldız, Arslan and Çeliköz, 2022). As a result, the need for consumption is rising every day. To meet the rising consumer demand and accelerate economic progress, civilizations are working to produce more goods and services. With the spread of globalization and free trade, raw materials, capital, and labour move freely today, and the resources owned cannot be considered a sufficient indicator of international competition (Ulutaş and Yıldırım, 2020; Bilgin, Marco Lau and Karabulut, 2012).

Countries are competing to attract domestic and foreign consumers in an era of increasing trade wars and globalization. Major macroeconomic events such as trade wars, pandemics, and global economic crises may have an impact on the link between brand value and FDI (Smith, 2020; Kaya, 2019; Choudhury, 2019; Anderson, 2021; Fan et al., 2022). These macroeconomic events impact capital flows and investors' perceptions of risk (Himounet, 2022). Reduced FDI may result from countries' economic stability because of rising market risks and uncertainty during financial crises (Doe, 2019).

Supply and demand chains may be disrupted during pandemics (Moosavi, Fathollahi-Fard and Dulebenets, 2022). Foreign investments and brand value may suffer because of this situation (Johnson, 2021). On the other hand, the increase in online services during the pandemic period may lead to the rise in the value of some brands while causing others to lose value (Gourinchas, Kalemli-Ozcan and Penciakova, 2020).

The increasing tariffs and trade restrictions resulting from trade wars can undermine investor confidence and create uncertainty in the markets where companies operate (Fan et al., 2022; Choudhury, 2019). FDI may be impacted by international trade wars. Trade restrictions and increased tariffs may discourage foreign investment (Liu and Zhang, 2021).

In this new economic paradigm, the economy' dynamics are driven by intangible assets such as computerized information (software and databases, etc.), innovative ownership (science and non-scientific R&D, copyrights, designs, and trademarks, etc.), and economic capacities (Ökten et al., 2019). In this regard, several nations and commercial enterprises have been exerting significant efforts in the name of branding from the past to the present. Companies can gain a competitive advantage by producing high-value products, presenting these products to domestic and international markets, and finally, creating a brand by distinguishing themselves from similar products (Chang, 2020). Because of branding, businesses can project a confident, stable, and dependable image to their customers. The goal of branding is to identify the markets in which companies operate, protect these markets from competitors, and differentiate the products obtained from other products (Ulutaş and Yıldırım, 2020).

Through FDI, the business may raise capital, improve its financial stability, and fortify its financial structure, which enables it to make investments in marketing initiatives and expansion projects (Yılmaz, 2023). With the financial support provided in this way, opportunities can be expanded to increase marketing and promotional expenditures to enhance brand awareness (Jones and Wren, 2019). The knowledge and technology that foreign investments bring to the board can help the business create new products and improve its operational efficiency (Vujanović et al., 2022). The brand' market position and consumer perception of its worth may both improve because of the developments brought about by this situation (Petersen and Pedersen, 2017).

FDI gives the company that invests access to international markets. This circumstance may increase the brand' value globally and make it easier for consumers to recognize it in foreign markets (Andersson and Forsgren, 2019).

Companies that attract foreign investment are typically seen as more dependable manufacturing facilities (Zhang, 2022). This makes it possible for customers, suppliers, and business partners to view the developed brand as more trustworthy and legitimate, which raises the brand' value (Fung, 2020).

FDI may help businesses stand out from the competition and increase their competitive power. Foreign investments help brands sustain their market superiority, which eventually raises brand value, particularly in developing economies (Zhang and Zhao, 2018). FDI may thus boost the company' competitiveness and strengthen its position in the market as a result of these advances, which will raise the value of the brand (Dunning, 1993; Eiteman, Stonehill and Moffett, 2016).

Since the 1980s, there has been an increase in the number of studies on branding and measuring brand value (Ökten et al., 2019). The global business climate is dynamic and complex (Montanari, Giraldi and Galina, 2019). Due to the expansion of open international trade, globalization, and ever-increasing technical advancements, factor mobility across nations has become unrestricted. The availability of the same or a comparable product in another market is a circumstance that is rapidly evolving. Multinational corporations develop a brand image to protect their market shares, boost their profit margins, and retain their ability to compete globally by granting access to new foreign markets. The first analysis of brand value, according to Ercan et al. (2010), was conducted by Rank Havis Mc Dougall in 1988 to thwart attempts by Goodman Fielder Wattie, one of the major players in the English food sector, to acquire his own business. It was accomplished by having Interbrand, a consulting firm, determine the brand value. (Ulutaş and Yıldırım, 2020). Following company executives' recognition of the importance of brand value, multinational corporations such as Canada-Dry and Colgate-Palmolive began to incorporate experts in this field into their organizational structures. (Lassar, Mittal and Sharma 1995).

According to Dunning (1981), the OLI (Ownership-Location Internalization) model, also known as the OLI Paradigm or the eclectic paradigm, the inflows and, outflows of FDI are determined by ownership, location, and internalization (Da Cruz, Floriani and Amal, 2020). The firm's ownership advantage can be expressed as having some tangible (naturally limited resources, financial capital, economies of scale, technology, etc.) or intangible values (patent, trademark, etc.) (Wagner, 2020). Companies; It has a privileged entry into markets because it owns naturally limited resources, patents, and trademarks. Patents, trademarks, and economies of scale are the exclusive property of multinational corporations, and by utilizing these advantages, corporations can outperform their rivals by achieving higher marginal profits and lower marginal costs (Denisia, 2010).

FDI contributes significantly to the well-being of both developed and developing countries. FDI has gained prominence recently as an important financing tool in place of foreign debt, particularly because developing countries provide the capital required for economic growth. According to Dunning's OLI Paradigm, the location advantage allows the country chosen for investment to develop its international branding strategy. FDI that improves a country's development, on the other hand, improves the country's brand image and provides more competitive advantages. (Montanari et al., 2019). Opening up a company to international trade and selling its products in other countries' markets can help boost brand image by increasing positive opinions about that product.

Offering the same or a similar product to another market is a rapidly developing situation because of globalization, rapid developments in international trade, increasing economic integrations, and rapidly developing technology. This is why there is a need to develop brand value because of the rise in the number of products available to consumers and the manufacturers' need to win their trust, maintain their market share, and raise their profit margins. As a result, multinational corporations and countries are expanding their product offerings to new markets by increasing FDI. By fostering a favourable image in the eyes of the customer, businesses can raise the product's brand value and, consequently, the profit share.

According to Montanari et al. (2019), branding and FDI interact with each other. Although a country's brand image is not required to attract FDI, it does influence the outflow of FDI from that country. FDI outflows help boost the image of the nation by increasing brand recognition.

According to Fetscherin (2010), a high inflow of FDI indicates a strong country brand. More FDI strengthens the brand image. The efforts of a country to develop a brand image are dependent on its progress in international trade, such as FDI, as well as national policies and domestic economic stability.

Kalamova and Konrad (2010) conducted an OLS (Ordinary Least Squares regression) analysis on data from 64 developed and developing countries from 2005 to 2006. According to the study's findings, the national brand index increases FDI inflows into the domestic country. Aleidan (2021) conducted a similar study. Examining the effect of Saudi Arabia's geographical brand on FDI, Aleidan (2021) concluded that geographical branding increases FDI using the structural equation model. Based the study's outcomes, international investments in the host country are associated with political and economic issues, including the country's image and its good impact on international investors.

Lahrech, Alabdulwahab and Bouayach (2020) conducted a random effect analysis on data from 2009 to 2014 from 10 countries with the best national brand index. The findings show that there is a strong and positive relationship between national branding and FDI. Host countries with strong national brands have a competitive advantage in attracting foreign investment. Branding is one of the elements influencing the entry of FDI into a nation, according to Napolitano, Ibrahim, De Nisco and Papadopoulos (2018), who conducted an OLS regression analysis for MENA countries. According to this study, a country's efforts to maintain the ideal exchange rate, increase market openness, and develop brand image are more effective than other political and economic improvements in attracting FDI. A nation's brand image can be used as a strategy to draw in FDI, according to studies like those by Bitzenis (2004), Metaxas and Tsavdaridou (2011), Cleeve (2012), Matiza and Oni (2014), Hong and Kim (2017), and Sirr, Garvey and Gallagher (2012). A negative image created by a country can reduce FDI inflows, whereas a positive image created by a country can increase FDI inflows. At the same time, cultivating a positive image positively impacts the FDI.

According to the literature review findings, most studies on FDI and branding evplain the impact of branding on FDI. There are few studies examining the effect of FDI on brand value. This gap in the literature is addressed in this study by investigating the impact of FDI on brand value in Australia, Canada, China, France, India, Japan, Spain, the USA, and the UK, using annual data for the period 2007-2023. The majority of studies in the literature attempt to explain the impact of brand value on FDI, and there are very few studies explaining the impact of FDI on brand value. Additionally, in the studies conducted, 1st generation unit root tests were generally used. Unlike existing studies, this study uses the second-generation unit root test and CCEMG (Common Correlated Effects Mean Group) analysis to examine the relationship between FDI and brand value. Subsequently, it is expected that the study would close a gap in the literature in this field. The findings imply that increased FDI boosts brand value.

3. Methodology and Data

3.1. Description of the Data Sets

Data from the countries of Australia, Canada, China, France, India, Japan, Spain, the USA, and the UK are used in the empirical analysis portion of this study, which investigates the relationship between brand value and FDI. The data used are organised in annual periods from 2007 to 2023. While the World Bank provides data on FDI and GDP per capita, the Brand value data were obtained from the Brand Finance Branch Directory Official website. The net FDI (% GDP) data were obtained using the following method.

$$\text{Net FDI} = \frac{\text{Net FDI (current US\$)}}{\text{GDP (current US\$)}} * 100$$

The model obtained with the variables used in the empirical application part of the study is expressed as follows.

Model: $bv_{it} = \alpha_0 + \alpha_1 nfdi_{it} + \alpha_2 pgdp + \epsilon_{it}$

In the model, bv represents brand value, nfdi is net FDI, and pgdp is the real per capita national income.

3.2. Methodology

In this study, the relationship between brand value and FDI was examined. Before starting with the stationarity study, a cross-sectional dependence analysis was performed to achieve more precise outcomes from the analyses. Cross-sectional dependence analysis produces more precise results when determining the unit root and cointegration analyses to be used in the next phase. Cross-sectional dependence was examined using the Breusch and Pagan (1980) LM, Pesaran (2004) CD_{LM}, and Pesaran, Ullah, and Yamagata (2008) LMadj test methods. Then, the stability analysis was tested using the second-generation unit root test (CADF), which can be used when discovering the cross-sectional dependence. Because the variables are stationary at different levels [I (1) and I (0)] and there is cross-sectional dependence in the series and the model, the Durbin-Hausman cointegration method was used to determine if the variables were cointegrate. After determining that the variables were cointegrate, the CCEMG estimation method was employed to estimate the long-term coefficients because the variables were stationary at different levels and the series showed cross-sectional dependence.

3.2.1.Cross-Sectional Dependency

Cross-section dependency occurs when a change in one of the economic units affects the other economic units. Globalization and increased free trade make it nearly impossible for countries to act independently of one another. As a result, the results will be more accurate if the cross-section dependency analysis is carried out before the stationarity analysis of the variables. The LM test developed by Breusch and Pagan (1980) is the first cross-sectional dependence analysis. Equation 1 displays the regression equation for the LM test.

$$LM = T \sum_{i=j}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \sim X^2_{N(N-1)/2} \tag{1}$$

H_0: No cross-section dependency (H_0: Cov $(u_{it}, u_{jt}) = 0$ $for\ all\ i\ and\ t, i = j -$)

H_1: There is a cross-section dependency (H_1: Cov (u_{it}, u_{jt}) $\neq for\ at\ lst\ one\ couple, i \neq j -$)

ρ_{ij} expresses the correlation coefficients derived from the model's error terms.

The asymptotic distribution of x^2 is obtained from N for all (i, j) while $T_{(i,j)} \to \infty$.

Pesaran (2004) developed the CD_{LM} test, which can be used when the time dimension is greater than the cross-sectional dimension (T>N) or T<N. The regression equation is shown as follows.

$$CD_{LM} = \sqrt{\frac{2T}{N(N-1)}} \left\{ \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \rho_{ij} \right\} \tag{2}$$

H_0: No cross-section dependency (H_0: Cov $(u_{it}, u_{jt}) = 0$ $for\ all\ i\ and\ t, i = j -$)

H_1: A cross-sectional dependency is present. (H_1: Cov $(u_{it}, u_{jt}) \neq$ $for\ at\ least\ one\ couple, i \neq j -$)

Pesaran, Ullah and Yamagata (2008) obtained the LMadj test by adding the variance and mean to the test statistic. The LMadj test regression equation is written as follows.

$$LM_{adj} = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T\hat{\rho}_{ij}^2 \; \frac{(T-k)\hat{\rho}_{ij}^2 - \mu_{Tij}}{\vartheta_{Tij}} \tag{3}$$

H_0: No cross-section dependency (H_0: Cov $(u_{it}, u_{jt}) = 0$ $for\ all\ i\ and\ t, i = j -$)

H_1: There is a cross-section dependency (H_1: Cov $(u_{it}, u_{jt}) \neq$ $for\ at\ least\ one\ couple\ \ i \neq j -$)

k= regressors number, μ_{Tij}=average ϑ_{Tij}=variance.

3.2.2. Panel Unit Root Test

Pesaran (2007) developed the CADF unit root test, which can be used when cross-sectional dependence between variables is discovered. It can also be used when N>T (Pesaran, 2007). The estimation equation is as follows.

$$\Delta y_{it} = a_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + \sum_{j=0}^{p} d_{ij} + \Delta\bar{y}_{t-j} + \sum_{j=1}^{p} \delta_{ij}\, \Delta y_{i,t-j} + e_{it} \tag{4}$$

H_0: It has a unit root (H_0: b_i=1)

H_1: It has no unit root (H_1: b_i ≠1)

CIPS (Cross-Sectionally Augmented Unit Root Properties) statistics are used in CADF unit root analysis by comparing test statistics and critical values using absolute values (Pesaran, 2007). Equation 5 represents the CIPS statistics equation.

$$CIPS(N,T) = N^{-1} \sum_{i=1}^{N} t_i(N,T) \tag{5}$$

H_0: It has a unit root (H_0: b_i=1)

H_1: It has no unit root (H_1: b_i ≠1)

3.2.3. Homogeneity Test

The delta test developed by Pesaran and Yamagata (2008) was used to determine whether the slope coefficient was heterogeneous or homogeneous.

The test was developed from Swamy's (1970) homogeneity test. The estimation equation is as follows.

For large sample, $\widetilde{N} = \sqrt{N}(\frac{N^{-1}\,\tilde{S}-k}{\sqrt{2k}})$ (6)

For a small sample, $\widetilde{N}_{adj} = \sqrt{N}\left(\frac{N^{-1}\,\tilde{S}-E(\tilde{Z}_{iT})}{\sqrt{Var}(\tilde{Z}_{iT})}\right)$ (7)

H_0: Slope coefficients are homogenous $(\beta_i = \beta)$
H_1: Slope coefficients are heterogeneous $(\beta_i \neq \beta)$

N, S, and k represent the number of horizontal sections, the Swamy test statistic, and the explanatory factors, respectively.

3.2.4. Durbin-Hausman Co-integration Test

Durbin-Hausman test is a cointegration analysis method developed by Westerlund (2008) that can be applied when the variables are stationary at different levels. The Durbin Hausman panel statistics are examined when the cross-section is homogeneous, and the Durbin Hausman group statistics are examined when the cross-section is heterogeneous (Westerlund, 2008). The regression equations and hypotheses for DHp and DHg are expressed as follows.

$$DH_g=\sum_{i=1}^{N}\hat{S}_i(\widetilde{\emptyset}_i-\widehat{\emptyset}_i)2\sum_{i=2}^{T}\hat{\epsilon}_{it-1} \tag{8}$$

$H_0=\emptyset_i=1$, for all i's, it has no cointegration.
$H_0=\emptyset_i<1$, it is expressed in this way for some i, it has cointegration.

$$DH_p=\hat{S}_n(\widetilde{\emptyset}\text{-}\widehat{\emptyset})^2\sum_{i=1}^{N}\sum_{i=2}^{T}\hat{\epsilon}_{it-1} \tag{9}$$

$H_0=\emptyset_i=1$, for all i's, it has no cointegration.
$H_0=\ \emptyset_i\ =\emptyset$ ve $\emptyset_i<1$, created this way for all i's, it has cointegration.

3.2.5. CCE Analysis

When it is determined that the variables are cointegrate, the phase of estimating the long-term coefficients is completed. The CCE (Common Correlated Effects) method developed by Pesaran (2006) was used to estimate the long-term coefficients in this study. The CCE method is an analysis methodology that enables long-term coefficient estimation when the series are stationary at various levels. At the same time, because it is a forecasting method that takes into account the cross-sectional dependence in the series, it can produce results that are more reliable for the long-term coefficient estimate method. In the CCE analysis, the CCEP (Common Correlated Effects Pooled) estimator is used if the slope coefficient is homogenous, and the CCEMG estimator is used if the slope coefficient is heterogeneous (Pesaran, 2006). As a result, because the slope coefficient was heterogeneous in the obtained homogeneity test, CCEMG analysis was used to estimate the variables's long-term coefficients. The estimation equations of the CCE and CCEMG analyses are asfollows:

$$y_{it}=\alpha_i' d_t+\beta_i' x_{it}+\epsilon_{it} \tag{10}$$

$$\epsilon_{it}=\gamma_i' f_t+\varepsilon_{it} \tag{11}$$

d→n*1 observable (fixed, trend, seasonal puppets) effects
f→m*1 unobservable effects

$$\hat{b}_{\mathrm{CCEMG}}=\frac{1}{N}\sum_{1=i}^{N}\hat{b}_{\mathrm{i}} \tag{12}$$

$\hat{b}_{\mathrm{i}}=(X_i'\dot{M}_i X_i)^{-1}X_i'\dot{M}_i y_i$ → Each cross-CCE section is an estimate.

4. Results

In the panel data analyses, the presence of cross-sectional dependence in the series caused a change during the estimation methods used in the empiricial analyses and the results obtained. Therefore, before proceeding to unit root and cointegration analyses, we examined whether there is a cross-section in the obtained model and variables. Table 1 displays the results of the variables's cross-sectional dependency analyses.

Table 1: Cross-Sectional Dependency test results

Variables	LM	LM_{CD}	LMadj
$Model_1$	126.9 (0.0000)	10.26 (0.0000)	19.17 (0.0000)
bv	155.1 (0.0000)	10.69 (0.0000)	29.48 (0.0000)
nfdi	47.62 (0.0932)	-0.3987 (0.6901)	1.758 (0.0787)
pgdp	244.3 (0000)	12.55 (0000)	52.46 (0000)

Note: The values in parenthese show the probability value (*p*-value)

The findings indicate that the bv and pgdp variables exhibit cross-sectional dependence, whereas the nfdi variable does not. Nevertheless, all three cross-sectional analysis tests (LM, LM_{CD}, and LMadj) have determined that the given model exhibits cross-sectional dependence. Therefore, for the variable stability analysis, the CADF unit root test was used.

Table 2: CADF Panel Unit Root test results

	CIPS STATISTICS				
	Level		1. Difference		
Variables	**Test Statistics**	**P-value**	**Test Statistics**	**P-value**	**Result**
bv	-1.992	0.222	-2.425	0.021*	I(1)
nfdi	-1.829	0.387	-3.471	0.000*	I(1)
pgdp	-2.721	0.002*			I(0)

Note: * indicates significance at the 5% level

The results of the variable stationarity analysis are shown in Table 2. According to the findings, the bv and nfdi variables used in the model are stationary at the I (1) level, while the pgdp variable is stationary at the I (0) level. After the stationarity analysis, the homogeneity test was applied to predict which statistical method should be used in the Durbin-Hausman cointegration analysis.

Table 3: Homogeneity Test Results

Models	**Test**	**Test statistic**	**P-value**	**Decision**
Model	$\tilde{N}$	4.901	(0.000)*	Heterogeneous
	$\tilde{N}_{adj}$	5.605	(0.000)*	

Note: * indicates significance at the 5% level.

The homogeneity test results are shown in Table 3. Both the and estimation approaches show that the H_0 hypothesis is rejected. Therefore, it was decided that the slope coefficient was heterogeneous.

Table 4: Durbin-Hausman Panel Cointegration Test Analysis Results

	Durbin-Hausman Testi	
	Test statistic	**p-value**
DH-g (Group)	-1.994	0.023*
DH-p (Panel)	-1.231	0.109

Note: * indicates significance at the 5% level.

Because of the homogeneity test, it has been determined that the slope coefficient is heterogeneous. As a result, the Durbin-Hausman Panel Cointegration study was based on the DH-g (Group) estimation results. Table 4 shows that the Ho hypothesis is rejected because the p-value of the DH-g estimator is less than the 0.05 significance level. Therefore, it has been concluded that there is a cointegration relationship between the variables in the long term.

Table 5: CCEMG Analysis Test Results

Common Correlated Effect Mean Group (CCEMG)			
Dependent Variables: bv	**Coefficients**	**Std. Er.**	**P-values**
nfdi	0.8157	0.0406	0.045*
pgdp	4.2246	1.3856	0.002*
Wald-Test	11.44 (0.0033)*		

Note: * indicates significance at the 5% level.

After determining that the variables were cointegrate, the CCEMG estimation method was used for long-term coefficient estimation. Table 5 displays the estimation results of the CCEMG analysis. This shows that nfdi and pgdp have a significant and positive relationship with brand value. In the countries under consideration, the brand value rises as per capita income and FDI rise. The developed countries of the USA, Japan, Germany, the UK, Canada, and France are experiencing rapid growth in FDI inflows and outflows. China and India have also experienced the fastest economic growth and the greatest increase in FDI recently. As a result, the rising levels of FDI and economic development in these nine countries ensure that brand values are positively impacted.

5. Discussion and Conclusion

Trade barriers between countries have been removed because of increased economic cooperation, and information exchange has begun to spread rapidly with technological advancements. As an outcome, the movement of goods and services between countries and regions has been revitalized. Rapid economic liberalization and an increase in FDI both considerably contributed to this. It benefits by increasing the mobility of goods and services, economic development, commercial activity, and product diversity. However, this situation has created a need for manufacturers to demonstrate the differences between their products and other products, to demonstrate the superiority of these products, and to ensure the reliability of their products in the eyes of the consumer. As a result, companies attempt to brand their products to reflect the features of their products, avoid losing market share, and increase profit rates. In this sense, FDI and brand value are inextricably linked.

Multinational corporations can improve the dependability of their products and make them more recognizable by increasing their FDI and expanding their product offerings to new markets. By doing this, the brand value and reputation of the items can both improve. Similarly, increased FDI results from high brand value. Because consumers regard products with high brand value as more trustworthy. They are more popular in the market than comparable products. This will increase FDI.

In the study's econometric analysis, the Durbin Hausman test was considered to examine the cointegration relationship, and CCEMG analysis was used to examine the variable coefficient estimation. The analysis findings indicate a considerable and positive correlation between real per capita income and brand value and FDI. Increases in FDI and per capita real income increase brand value. Montanari et al. (2019) and Fetscherin (2010) found similar results. Increased FDI in Australia, Canada, China, France, India, Japan, Spain, the USA, and the UK ensures the products' recognition and dependability. Parallel to this, the brand value of these products rises.

In conclusion, FDI and brand value in a country's economy are directly proportional. Consequently, it is critical to implement policies that encourage FDI to build a trustworthy brand image. The development of social responsibility projects by multinational companies under FDI can have a positive impact on the brand's reputation. Investments in areas that attract the local community's interest, such as education, environmental protection, or health, can increase the brand's value. Government regulations that encourage or require foreign investors to participate in social responsibility programmes can boost societal support and improve the country's investment environment. It is important for multinational companies to develop marketing and RP strategies to strengthen brand perception in the country where they invest. Increasing options for active communication in local media and social platforms can help raise brand awareness. Governments can highlight foreign investors's success stories to foster an attractive investment climate in their homeland. This can be encouraging for other possible investors. The government's support policies for boosting FDI, such as tariff reductions and incentive strategies to encourage additional investment, can help the country's image. This makes it simpler and quicker to realize the growth in the brand value of the manufactured goods. At the same time, the government's implementation of incentive policies that increase R&D activities can enable innovation activities and therefore the development of new products. In this context, the government's implementation of R&D incentive policies plays an important role in increasing the brand value of countries. As a result, integrating R&D expenditures or R&D personnel in future studies of brand value and FDI may serve as an extension of the focus of those studies.

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RESEARCH ARTICLE

Ceremonial Economics: A General Review

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ABSTRACT
Ceremonial economics explores how traditional values, myths, and rituals intersect with economic practices and institutions. It differentiates between "ceremonial" practices based on tradition and cultural values and "instrumental" practices based on efficiency and problem-solving capabilities. This field, rooted in institutional economics, emphasizes the tension between preserving established social orders and fostering innovation. Scholars can gain insights into the broader implications of economic systems by understanding how ceremonial practices influence economic behavior and social cohesion. This pluralistic approach comprehensively analyzes how ceremonial and instrumental practices interact within various economic systems. The main goal of this study is to develop a detailed and all-encompassing framework for ceremonial economics. A key aspect of this will involve comparing ceremonial economics principles with institutional economics. Additionally, the study will delve into various aspects of ceremonial economics, specifically focusing on cultural and social aspects. Furthermore, the study conducts four examples to provide practical insights into the application of ceremonial economics.

Keywords: Ceremonial Economics, Institutional Economics, Rituals, Economic Practices
JEL Classification: Z0, P5, B5

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Introduction

Ceremonial economics is a specialized field examining the intersection of traditional cultural norms, myths, and rituals with economic activities and institutions. This area of study distinguishes between "ceremonial" practices, which are rooted in tradition and cultural values, and "instrumental" practices which are justified by their effectiveness and problem-solving capabilities (Ziegler, 2017). Institutional economics examines the delicate balance between maintaining existing social structures and encouraging innovation. By delving into the impact of ceremonial practices on economic behavior and social unity, scholars can obtain valuable insights into the larger consequences of different economic systems.

The field of ceremonial economics is highly interdisciplinary, drawing insights from diverse academic disciplines such as economic sociology, anthropology, political science, and cognitive sciences. Scholars in this field employ various methodologies, including laboratory experiments, formal modelling, and social network analysis, to explore and understand the broader social impacts of economic and ceremonial exchanges. Through their research, they shed light on how these exchanges shape and influence larger social structures and interactions (Smith & Lobo, 2019). This comprehensive approach allows for a detailed analysis of the interconnectedness of ceremonial and instrumental practices within diverse economic frameworks.

Ceremonial economics encompasses various traditional practices that are central to the economic and social structures of many indigenous communities. One prominent example is the potlatch ceremony, which has been integral to the traditions of Indigenous peoples in the Pacific Northwest (Beck,1993). The potlatch is a complex socio-economic event that involves the redistribution of wealth and resources, often through the hosting of a lavish feast and the gifting of valuable items. It serves as a means of reinforcing social hierarchies, solidifying relationships, and maintaining social cohesion within the community.

Beyond the potlatch, rituals play a vital role in the economic and social fabric of these communities. These rituals are not merely symbolic but are essential for maintaining the balance of power, reaffirming community bonds, and preserving cultural traditions. By examining these ceremonial practices, we gain valuable insight into the intricate interplay between economics, social dynamics, and cultural identity within these indigenous societies (Dimmelmeier & Heussner, 2018).

Polanyi's (1968; 2000) concept of the embedded economy is particularly relevant in this context. He posited that in non-market societies, the notion of pure economic institutions, as defined by formal economic models, does not hold. Instead, economic activities, exemplified by "provisioning," are intricately intertwined with and embedded within non-economic institutions such as kinship, religion, and political structures. This interdependence highlights the complexity of economic interactions in these societies, which cannot be fully understood through a purely economic lens. The relationship between this idea and the ceremonial economy will be discussed in the first chapter.

Archaeological research and in-depth historical analyses consistently demonstrate the significant impact of large-scale feasting and gift-giving practices on ancient economies. These findings highlight the complex interplay between ritualistic traditions and economic systems across diverse cultural and historical settings.

The field of ceremonial economics addresses a diverse array of current issues, exploring topics such as the impact of government interventions on Indigenous cultural practices and the wider societal effects of market-based transactions. Detailed analyses in this area explore the intricate relationship between economic efficiency and the preservation of cultural values, providing insights into the lasting relevance of ceremonial economics in understanding historical and contemporary economic dynamics.

The primary objective of this study is to create an intricate and comprehensive framework for ceremonial economics. A crucial element of this endeavor will be a thorough comparison of ceremonial economics principles with those of institutional economics. Moreover, the study will explore the diverse facets of ceremonial economics, placing specific emphasis on its cultural and social implications. In addition, the study undertakes three detailed case studies as a means to offer practical insights into the real-world application of ceremonial economics.

The initial segment of this study will delve into the theoretical frameworks underpinning ceremonial economics, exploring its cultural and social dimensions. The subsequent section will concentrate on an analysis of ceremonial practices, incorporating historical examples of these concepts. Additionally, this part will address other fields related to ceremonial economics. Finally, the last section will present a critical evaluation and debates of the field.

1. Theoretical Framework

Ceremonial economics is a field of study that delves into the complex interplay between ceremonial and instrumental practices within economic institutions. Ceremonial practices are rooted in tradition, values, and myths, and they often play a significant role in shaping economic behavior and decision-making. On the other hand, instrumental practices are driven by the need to solve specific economic problems and challenges. This dynamic interaction between tradition-based ceremonial practices and problem-solving instrumental practices shapes the functioning of economic institutions and the broader economic system (Ziegler, 2017).

The works of Thorstein Veblen (1899) and Clarence Ayres (1927 and 1962) within the framework of Original Institutional Economics have highlighted the significant role of science, education, and expertise in shaping social institutions. However, there remains a need for a deeper exploration of how institutionalists contribute to our comprehension of the development of knowledge, the evolution of scientific practices, and the influence of institutional structures on these processes. This section aims to address this gap by focusing on the ceremonial aspects of science, higher education, and expertise offered by institutionalist interpretations. These are considered important pillars within the political economy of knowledge and the formation of truths.

Veblen's The Theory of the Leisure Class (1899) marks the inception of original institutionalism. It delves into a thorough analysis of the norms and conduct of the affluent industrial elite of the late nineteenth century, commonly referred to as the "leisure class." Veblen meticulously illustrates how processes of differentiation, elitism, and status unfold within capitalist industrialist societies, shaping the behavior of the leisure class through pecuniary emulation, conspicuous leisure, and consumption, all aimed at maintaining and perpetuating their elevated status. Furthermore, Veblen accentuates the significance of preserving archaic traits to uphold existing hierarchies, discrimination, symbolisms, and rituals, all of which contribute to the power dynamics of the leisure class.

The 19th-century rise of the leisure class was deeply influenced by the societal changes stemming from the industrial revolution. The industrial revolution significantly shaped the behaviors, consumer habits, and mindsets of this emerging social group. Their privileged position in society was maintained through traditional "ceremonial" practices, which played a pivotal role in differentiating and strengthening their elevated social status. According to Veblen, the simultaneous existence of these age-old ceremonial practices and the new values embraced by the leisure class is essential for comprehending the complex transformations within modern institutions (Böck & Almeida, 2018).

As mentioned in the introduction, Polanyi (1968 and 2000) claimed that in non-capitalist, pre-industrial economies, livelihoods are not derived from market exchanges but rather from the principles of redistribution and reciprocity. Reciprocity involves the mutual exchange of goods or services within long-term relationships. Redistribution indicates a strong political, such as kinship-based leadership, which collects and then reallocates subsistence goods according to culturally specific guidelines. In such contexts, economic decision-making is influenced not only by individual choices but also by social relationships, cultural values, moral considerations, politics, religion, and the potential for authoritarian leadership.

The distinction between types of economies can be elucidated through the concept of "embeddedness", which emphasizes the integration of economic activities—specifically provisioning processes—within broader social institutions. In non-market economies, for instance, kinship ties play a crucial role, illustrating that economic activity is not an isolated domain but rather intertwined with various economic and non-economic institutions. Consequently, exchange mechanisms are situated within a societal context, regulated by social norms and structures rather than occurring within a social vacuum. Additionally, institutions such as religion and the government exert influence on economic dynamics, demonstrating that socio-cultural obligations, norms, and values are pivotal in shaping individuals' livelihood strategies (Polanyi, 1968 and 2000).

Therefore, any analysis of economics that attempts to treat it as an isolated discipline, separate from its socio-cultural and political contexts, is fundamentally flawed. A comprehensive examination of economics should prioritize the study of the various social institutions that underpin people's livelihoods. The market is merely one of many institutions that influence economic transactions. In this regard, Polanyi's concept of the embedded economy aligns closely with the principles of the ceremonial economy. The ceremonial perspective also emphasizes the importance of rituals, religious beliefs, sociocultural structures, and the dynamics of vertical, horizontal, and diagonal learning processes. Understanding these elements is essential to fully grasping individuals' economic and social behaviors.

It is important to include Bugra's (1995) interpretation of Aristotle and Polanyi in this discussion. When we define economics as the science that studies the distribution of scarce resources among various uses to meet unlimited needs—following the formalist definition of economics as understood today—it becomes clear that Aristotle did not actually contribute to economics in this sense (Bugra, 1995).

Polanyi, who systematically tackled this topic, authored an article titled "Aristotle Discovers Economics" (1957) and established a theoretical framework that could assist in resolving the debate regarding Aristotle's influence on economics. A key component of this framework is the distinction between two definitions of economics: the "substantivist" definition and the "formalist" definition. Polanyi posits that among the various definitions of the economy, the essentialist perspective holds universal applicability. This definition characterizes the economy as a process mediated by human interactions with the environment. In all societal frameworks, barring market-driven contexts, this economic order is intricately woven into the social fabric, allowing for flexibility in alignment with non-economic objectives and values (Bugra, 1995). The basic components of ceremonial economics also confirm Bugra's interpretation.

Ayres (1962) introduced the concept of a ceremonial-instrumental (C-I) dichotomy in the social realm, expanding on Veblen's original theory regarding the values and patterns maintained by institutions. Ayres conceptualized institutions as functional categories that encompass various forms of social organization and behavior (Waller, 1982). Therefore, a comprehensive understanding of the C-I dichotomy is essential for grasping the emergence and development of institutions as integral components of social change, along with the values, norms, and principles they embody throughout this progression.

In conclusion, we can highlight two main points. First, social activities encompass various symbolic, traditional, and ceremonial components that significantly influence and shape our behavior. These elements play a crucial role in normalizing power dynamics and legitimizing the control exercised by specific systems and groups over technological advancements. As noted by Junker (1982), these aspects have a profound impact on our societal structures and interactions. Ceremonial behavior can be seen as a mechanism through which power is exercised and maintained within a given society. It encompasses a range of behaviors and rituals that serve to control, normalize, and manipulate social dynamics, often resulting in unequal power structures. At its core, ceremonial behavior is a collection of ideas and principles that perpetuate inequality, oppression, imperialism, and hierarchies. These concepts materialize through decrees, emotional conditioning, sacred rituals, and the establishment of a status system, ultimately shaping and reinforcing the power dynamics within a given social context (Junker, 1982).

Second, the instrumental aspects of a concept involve technical, rational, and practical processes that entail the use of tools and a scientific approach to reasoning to solve problems (Mayhew, 2010). These processes are focused on utilizing knowledge to address specific social issues. Rather than simply associating instrumentalism with technological determinism and optimism, the instrumental concepts encompass linkages, connections, and patterns among tools, epistemic concepts, and methods that foster democratizing and liberating relationships within institutional settings. According to original institutionalists, these instrumental aspects, particularly technological innovation, drive institutional change (Tool, 2000).

It is important to consider that practical aspects within the C-I division may be transformed or "encapsulated" by ceremonial elements, potentially altering their original meaning and purpose. This encapsulation would involve integrating new technologies, methodologies, and behaviors into established institutions while ensuring that the ceremonial values remain relatively unchanging, possibly even regressive, despite the influence of new technology on processes and efficiency (Papadopoulos, 2015). The presence of both instrumental and ceremonial elements does not necessarily prevent the use of instrumental components to control, influence, or exploit individuals who are involved in or influenced by ceremonial values.

Ayres's C-I dichotomy offers a valuable analytical framework for examining social institutions and their processes. This framework provides tools for evaluating the potential for institutional change. When applied to universities, we observe that ceremonial values maintain exclusive privileges, hierarchical structures, and unequal treatment in research and education. In contrast, instrumental values support efficient operations that contribute to social progress, promote inclusive academic and teaching practices, and ensure equal access for all. These values also foster epistemic democracy and encourage pluralism.

The modern university has long been pivotal in the creation and spread of knowledge and the development of expertise. It holds significant authority in establishing accepted truths within the scientific community. According to Arnoldi (2007), expertise is the result of a complex social process influenced by changes in public recognition and social dynamics, deeply rooted in hierarchical structures, differentiation, and status. Veblen (1918) emphasizes that even as universities become more commercialized, the ceremonial aspects and prestige associated with academic practices remain essential to university life and activities. In particular, the speed, form and method of dissemination of information continue to be directed by ceremonial practices. This evolution has coincided with the expansion of vocational training, profit-focused pursuits, and administrative changes within academic careers, while upholding the traditional elements of elitism and prestige.

The concept of the C-I dichotomy offers valuable insight into the process of institutional change and the necessary steps to modify the behavior of specific social structures. When we consider the formal higher education system and the role of experts, the theories proposed by Veblen and Ayres underscore the ceremonial aspects evident in practices and power dynamics, which are further reinforced by the incorporation of business values into universities. It is evident that technological advancements will be pivotal in reshaping the hierarchical foundations of higher education and the societal role of intellectuals. However, the specific mechanisms, circumstances, and implications of these changes remain unanswered. A thorough examination of ceremonial practices and cultures is crucial for understanding the institutional factors driving change, but it is equally important to comprehend the "meso" level, specifically how academics are interconnected and situated within disciplinary and university structures.

In short, institutional economics clearly distinguishes between two types of justifications for institutions. The first type, "instrumental practice," views institutions as mechanisms designed to address specific problems or challenges within a society or an organization. On the other hand, "ceremonial justifications" are based on traditional values, customs, or myths. Relying on ceremonial justifications can result in "ceremonial encapsulation," a situation in which economic progress is hindered as innovative activities are diverted away from their most socially beneficial uses. In other words, this situation may lead to inefficiency in resource allocation, that is, moving away from the Pareto optimum. This diversion can ultimately impede overall economic growth and development.

Furthermore, institutional economics employs a theoretical framework that incorporates "concessive holism". This method entails the analysis with one or a few pertinent institutions to elucidate the event and subsequently construct an explanatory framework based on these initial references. This approach diverges from traditional institutionalism, which primarily emphasizes individual behavior and property rights. In contrast, original institutional economists may regard the state, legal systems, or other prominent institutions as the foundational elements for their analysis.

1.1. Cultural and Social Aspects

The practice of rituals and festive events is deeply ingrained in the fabric of human culture. They serve as poignant reminders to a community of its shared beliefs and history, often occurring at specific times and locations. While some rituals are reserved for specific members, such as initiation rites and burial ceremonies, there are also public events that hold significance for the entire society. These include joyful celebrations like carnivals and New Year's festivities, which serve as communal markers for events like the onset of spring and the culmination of the harvest season (Wu, 2018).

Social practices, rituals, and festive events take on various forms such as worship rites, rites of passage, birth, wedding and funeral rituals, oaths of allegiance, traditional legal systems, traditional games and sports, kinship and ritual kinship ceremonies, settlement patterns, culinary traditions, and seasonal ceremonies. In addition, they involve several expressions and physical elements, including special gestures and words, recitations, songs or dances, special clothing, processions, animal sacrifices, and specific foods.

The customs and gatherings referenced are recurring rituals that play a pivotal role in shaping the daily lives of communities and social groups, holding great significance for many of their members. They serve as a powerful means of reinforcing the individual and collective identities of participants, whether enacted within public or private spheres. These rituals are deeply intertwined with momentous occasions such as the changing of seasons, crucial agricultural events, or pivotal milestones in the lives of individuals. They are intricately bound up with a community's traditions, collective memory, and social fabric.

The spectrum of rituals and festive events encompasses a wide variety of small intimate gatherings as well as large-scale social celebrations and commemorations. Each sub-domain displays its own unique diversity, yet there is a significant amount of overlap among them. These traditions are influenced by contemporary societal changes, including factors such as migration, individualization, formal education, the impact of religions with most followers, and the effects of globalization. These changes can have a profound impact on these practices, as they rely heavily on broad community participation. The phenomenon of migration, especially among young people, can result in practitioners leaving their communities and potentially endangering certain cultural practices. Nonetheless, social practices, rituals, and festive events often serve as opportunities for individuals to return home, celebrate with their families and communities, and reaffirm their identity and connection to their community's traditions.

Social practices are integral elements that significantly influence and shape the fabric of everyday life within a community. These practices are deeply ingrained and are recognized by all members, even if not everyone actively participates in them. They serve as a means to uphold and reinforce the community's identity and link it to its history. Take, for instance, the act of greeting. This can range from simple, informal gestures to elaborate and ritualistic ceremonies, each serving as a unique marker of the community's distinct identity. Similarly, the exchange of gifts within the community spans a spectrum, from casual and spontaneous occasions to meticulously planned and formal events that hold significant political, economic, and social symbolism.

Lastly, anthropologists commonly agree that the essential characteristic of ritual is its symbolic nature. For example, Firth (1968) defines ritual as "a form of organized conduct intended to affect human events, primarily symbolically and with an intangible referent, generally sanctioned by society.

There are also historical examples of the ceremonial economy, of which the theoretical infrastructure and cultural and social aspects are discussed. Analyzing these instances will yield valuable insights into the ceremonial economy and its associated practices from both theoretical and empirical perspectives. Therefore, it is crucial to accurately assess historical examples. The subsequent section delves into a discussion of historical examples and their relevant contexts.

2. Historical Examples and Related Fields

In this section, we'll start with the main historical examples. Then we'll analyze the related fields with ceremonial economics. Thus, the evolution of the ceremonial economy and its application across different historical periods will be explored, revealing the changes and the various areas in which it has been used from the past to the present.

2.1. Historical Examples

The first case study is named the Potlatch Ceremony. The potlatch ceremony is a traditional practice among Indigenous peoples of the Pacific Northwest Coast of Canada and the United States. This is a significant example of ceremonial economics, where a gift-giving feast plays a central role in the community's social, political, and economic structure. Among cultures such as the Heiltsuk, Haida, Nuxalk, Tlingit, Makah, Tsimshian, Nuu-chah-nulth, Kwakwaka'wakw, and Coast Salish, the potlatch ceremony serves as the primary governmental institution and legislative body. This ceremonial event is deeply rooted in the cultural fabric of these Indigenous societies, emphasizing social connections and redistributing wealth within the community (Benson, 2009).

During a potlatch, which was a significant social and ceremonial event among the indigenous peoples of the Pacific Northwest, wealthy chiefs and other elite members of the community would gather to distribute food, resources, and gifts such as blankets and fish to less fortunate members. This act of generosity was not only a display of wealth and status but also served to strengthen social ties and reaffirm the hierarchical structure within the community. The lavishness of the gifts and the generosity of the hosts during the potlatch were crucial in earning prestige and reinforcing the social status of the hosts and their families (Beck,1993).

The potlatch ceremony is a deeply meaningful and symbolic event steeped in ritual and tradition. It serves as a profound expression of cultural values, social status, and the deep bonds within the community. These ceremonies hold a significance that goes beyond simple celebrations; they play a vital role in shaping the social fabric of the community. Through the potlatch, wealth is redistributed, and social hierarchies are reaffirmed, ensuring the maintenance of balance and harmony within the community. Karl Polanyi (1957) articulated this redistribution as a crucial mechanism for economic integration, linking individuals within a group to broader social aggregates, whether that be familial units, local communities, nations, or larger entities. In contemporary welfare states, wealth is primarily redistributed through taxation processes. This redistribution framework typically involves a centralized authority—such as a tribal chief or feudal lord—who oversees the accumulation from trade and production, subsequently reallocating resources to the society's members. Despite legal prohibitions, the potlatch, a ceremonial feast practiced by the Indigenous peoples of the Pacific Northwest, has persisted as a meaningful and integral cultural tradition.

The system of ceremonial exchange and redistribution was also prevalent in Melanesia. This ritualistic form of exchange fulfilled various critical functions, which can be broadly categorized as economic, both at the communal and individual levels. At the community level, it operated as a vital mechanism incentivizing migrants to repatriate their resources to Ponam Island, thereby contributing to the overall economic stability of society. On an individual level, the exchange facilitated two primary outcomes (Carrier & Carrier,1991). Initially, the focus was on how residents could share the wealth sent back to the island by migrants. Additionally, there was a framework through which individuals could establish social credit, settle social debts, and foster the cooperation essential for life on Ponam Island. For migrants, this collaboration allowed them to preserve their social identity and claim their lineage property. Conversely, for residents, it enabled them to rely on their kin for assistance, particularly in terms of labor, when required (Carrier & Carrier,1991).

The second example is the classic Maya Civilization. The Maya society exhibited a complex hierarchical structure, characterized by a ruling elite whose political authority was frequently reinforced through sophisticated ritual practices. These rituals encompassed a range of activities, including offerings, mortuary rites, and public ceremonies, which served dual purposes: they not only legitimized the socio-political status of the elite but also functioned as mechanisms of economic exchange that reinforced kinship networks and social obligations within the community. (Saber & Mazouz, 2015).

Ritual offerings were typically performed by the ruling elite in conjunction with monumental architecture, such as pyramids and temples, where these ceremonies were vividly illustrated in art and inscriptions. These ceremonial centers evolved into venues for showcasing wealth and redistributing resources, thereby reinforcing the authority of rulers as intermediaries between the divine and mortal realms (Houston & Stuart, 1996). By orchestrating these rituals in prominent, communal spaces, the ruling elite could publicly assert their divine legitimacy and cultivate support from the populace, fostering a reciprocal relationship of loyalty and protection.

A salient illustration of ceremonial economics in the Maya civilization can be observed in the tradition of ancestor veneration practiced within kin-based units, referred to as "houses." According to Ringle and Bey (2012), these "houses" constituted the foundational elements of social identity and political organization. The deceased were typically buried alongside a range of offerings, including pottery, jade ornaments, and intricately carved stelae that often portrayed the deceased with divine attributes, thereby signifying the family's prestigious lineage. These rituals played a crucial role in reinforcing social hierarchies and status across generations. Through such practices of ancestor veneration, the Maya effectively reaffirmed the link between contemporary ruling elites and their eminent predecessors, thereby ensuring the continuity of political authority and the economic dominion over vital resources (Ringle & Bey, 2012).

Moreover, the economic resources devoted to these rituals were substantial. The creation of jade ornaments, intricate pottery, and large-scale stelae required skilled artisans and a significant investment in materials, which in turn invigorated the local economy. Mary Miller and Karl Taube (1993) emphasize that these items transcended mere offerings to the gods; they represented strategic investments in social capital. By commissioning artisans and redistributing gifts, the elites could strengthen their social networks, reward loyalty, and showcase their ability to effectively marshal resources.

The ceremonial economy of the Maya also played a crucial role in wealth redistribution, particularly during significant events such as the dedication of new temples or the celebration of important calendar dates. During these occasions, food, beverages, and other goods were distributed to the participants, creating a cycle of wealth and resource exchange that promoted social cohesion. This ritual economy shares similarities with the potlatch ceremonies of the Pacific Northwest, where the act of giving away wealth elevated the prestige of the giver and strengthened community bonds (Marcus, 1992).

In sum, the Classic Maya civilization exemplifies the intricate interplay between ceremonial practices and socio-economic frameworks. Through highly structured rituals and public spectacles of piety, the ruling elite could consolidate authority, regulate the distribution of resources, and foster social cohesion. This case study illustrates that ceremonial acts fulfilled religious imperatives and served critical economic functions; they effectively integrated the spiritual and material realms, reinforcing social hierarchies and kinship affiliations in a complex societal context.

One another is the Kula Ring. The Kula ring is an established ceremonial exchange system practiced by the Trobriand Islanders, who reside in the Milne Bay Province of Papua New Guinea. This intricate trading network involves the exchange of seemingly insignificant items, which are highly valued for their ability to bolster social status, affirm political authority, and carry ceremonial significance, rather than for their practical utility. Initially brought to the attention of the Western world by the renowned anthropologist Bronislaw Malinowski (1920), the Kula ring serves as a compelling demonstration of the concept that economies can be built upon reciprocal exchange, in contrast to monetary-based transactions. A striking feature of the Kula ring is the willingness of participants to undertake perilous voyages to deliver these items, underscoring the profound cultural importance of this intricate exchange system (Irwin & Shaw & Mcalister, 2019).

The Kula Ring represents a complex system of ceremonial exchange centered around two distinct categories of shell valuables: soulava (red shell necklaces) and mwali (white shell armbands). These artefacts are exchanged along a defined network of islands in the Massim Archipelago, traversing distances that encompass hundreds of miles and engaging multiple island communities. The circulation of soulava follows a clockwise direction, while mwali moves counterclockwise, creating a dynamic flow of these valuables as they are exchanged among partners in a sustained rotational circuit. Crucially, neither type of object has a permanent owner; instead, they are in constant motion, facilitating not only the exchange of goods but also the transmission of cultural narratives and social status. As each item transitions from one individual to another, it accrues historical significance and narrative layers, reinforcing the social fabric of the participating communities (Malinowski, 1922). This ongoing process exemplifies the intricate interplay between material culture and social relationships within these island networks.

The Kula exchange is significant because it does not rely on the traditional concepts of economic value or the accumulation of material wealth. Instead, the Kula is based on the symbolic and relational significance of the objects that are exchanged. Each participant in the Kula Ring gains prestige not from permanently owning these objects but from temporarily holding them and then passing them on. This process of exchange fosters complex social bonds and alliances among participants. As Malinowski noted, the Kula Ring is a system that "links men in lasting partnership, based on mutual duties of help and hospitality, loyalty, and respect" (Malinowski, 1922).

One of the distinctive features of the Kula Ring is that the exchange of soulava and mwali is not conducted in isolation; it is accompanied by acts of hospitality, feasting, and the exchange of various other goods. Although the Kula items themselves are not "used" for practical purposes, the act of exchange fosters a network of obligations and reciprocity. When an individual receives an item within the Kula Ring, there is an implicit expectation to reciprocate with a similar item later. This establishes a continuous cycle of exchange that can persist across generations. Such mutual obligations enhance inter-island relations, as the Kula partners depend on each other for trade, support, and even military alliances during times of conflict (Malinowski, 1922).

Malinowski's research elucidates that the Kula Ring operates not merely as a system of economic exchange but also as a vital mechanism for establishing social stratification and status within the Trobriand society. Prominent figures, such as village chiefs and elders, typically exert control over the more prestigious Kula items, thereby solidifying their elevated social standing. Participation in the Kula Ring is predominantly restricted to men, with the acquisition, exhibition, and exchange of Kula artifacts serving as indicators of prestige and expertise. Successful Kula transactions are reflective of the individual's reputation, adherence to established protocols, and adeptness in managing the intricate relational dynamics characteristic of this exchange system. Furthermore, the valuation of Kula objects is profoundly linked to their ceremonial origin and the social prestige of the parties engaged in their exchange (Weiner, 1983).

Moreover, The Kula Ring exemplifies what anthropologists classify as "reciprocal economics," or Ceremonial Economics, highlighting the role of economic exchanges in fulfilling social and symbolic functions that transcend mere material gain. Engagement in the Kula facilitates the reaffirmation of social bonds and the creation of extensive networks of influence that reach beyond local confines. Malinowski characterized this system as "an institution sui generis," encapsulating a complex interplay of economic, social, and spiritual elements. This challenges the conventional Western economic paradigms, which prioritize market-driven exchange and profit maximization (Malinowski, 1922).

This institution exemplifies how non-material exchanges can foster social cohesion and stability. For instance, the Trobriand Islanders' engagement in the Kula Ring helps to alleviate conflicts between different islands, as participants are bound by mutual respect and obligations of reciprocity. Through these ceremonial exchanges, the Kula Ring not only maintains peaceful relations but also serves as a form of social insurance and conflict resolution, becoming deeply embedded in the cultural fabric of their society (Sahlins, 1972).

In summary, The Kula Ring exemplifies how ceremonial and symbolic systems of exchange can underpin social and economic relationships with equal effectiveness as monetary systems. Malinowski's observations have significantly shaped subsequent anthropological and economic discourse, encouraging an in-depth exploration of exchange mechanisms that emphasize social and cultural capital rather than merely material wealth. This framework challenges conventional economic paradigms and highlights the importance of relational dynamics in the understanding of exchange processes.

The Sikret Fren ritual is another significant example of a gift exchange tradition practiced by members of the Anglican Church of Gilbert Camp, an unauthorized settlement located on the fringes of Honiara in the Solomon Islands. The ritual involves the exchange of identical gifts between ritual friends and holds great cultural and socio-economic significance within the community. This practice is examined through the lens of Gregory's analytical differentiation between Gift and Commodity and is contextualized within the region's rich cultural, historical, geographical, and socio-economic framework. The Sikret Fren tradition highlights how urban and peri-urban settlers leverage their cultural innovations to navigate the ethical and economic hurdles stemming from the disparities between their values and material circumstances (Carlà & Gori, 2014).

In the Sikret Fren ritual, participants partake in a sophisticated system of reciprocal exchange, where the ceremonial significance of giving and receiving goods is meticulously regulated by cultural tradition. This practice mirrors other Melanesian societies that prioritize gift exchanges, serving as an ostensible demonstration of loyalty, respect, and allegiance among individuals and groups. Anthropologist Nancy Munn (1992), who has extensively examined similar Melanesian exchange systems, posits that rituals like Sikret Fren are fundamentally aimed at the creation and renewal of social alliances. Each participant is anticipated to reciprocate with a gift of equivalent or greater value later. This reciprocal act transcends mere economic transactions; it embodies a profound statement of honor and social interconnectedness.

The ritual encompasses a structured sequence of actions: goods are displayed, presented, and received, accompanied by traditional speeches and gestures that highlight the significance of social protocol. The practice of gift-giving within the Sikret Fren binds individuals and groups in relationships that are anticipated to endure over time, as each gift carries an obligation for eventual reciprocation. This engenders a cycle of exchange that reinforces communal bonds and fosters interdependence among participants, a phenomenon noted by Maurice Godelier (1999) in his studies of Melanesian exchange systems. Through this cyclical exchange, the Sikret Fren established a social safety net, weaving families and communities into a fabric of mutual support.

In Sikret Fren, the incorporation of objects imbued with ceremonial significance and distinct to the ritual landscape is pivotal. These artifacts, meticulously crafted with symbolic intricacies, accrue value through their repeated invocation in ritualistic contexts. As Strathern elucidates, these items are "ineluctably tied to the reputations and identities" of their exchangers, thereby reinforcing the social prestige of both the donor and recipient (Strathern, 1990). This phenomenon constitutes a symbolic economy that fosters a communal historical consciousness, as the trajectories of these objects—transitioning between individuals and groups—integrate into the collective memory of the community. This process mirrors the dynamics observed in the Kula Ring, as articulated by Malinowski (1922), where the exchange of storied items serves to enhance social connectivity and cultural continuity.

In this context, the Sikret Fren ritual embodies the fundamental principles of ceremonial economics, where the true "value" of objects lies not in their material characteristics but in the social relationships and obligations they represent. The process of exchange serves as a mechanism for sustaining societal cohesion and nurturing mutual obligations that extend across generations. Economic anthropologists argue that systems like Sikret Fren challenge Western conceptions of economics by highlighting economies that fundamentally revolve around relational ties, reciprocity, and symbolic wealth, rather than mere monetary or material gain (Sahlins, 1972).

In conclusion, the Sikret Fren ritual demonstrates how ceremonial exchanges play a crucial role in shaping social structure and identity. By understanding Sikret Fren through the lens of ceremonial economics, we can see that the rituals of gift-giving and reciprocity function as a means to establish alliances, assert prestige, and reinforce the interconnectedness of Melanesian organization. This perspective reveals that ceremonial economics transforms exchanges from simple transactions into meaningful traditions, embedding social values, historical continuity, and collective memory into the everyday lives of the community.

Although a historical concept, ceremonial economics and mercantilism, despite originating from distinct historical and cultural settings, both underscore the intricate relationship between economic practices and the prevailing social power dynamics, political ambitions, and symbolic manifestations of wealth. Ceremonial economics primarily examines how rituals and modes of exchange contribute to reinforcing hierarchies within smaller, often community-oriented societies. Conversely, mercantilism delineates a comparable paradigm at the macro level, where state-directed economic strategies are employed to enhance national power and prestige on both domestic and international fronts. The interplay between these economic systems illustrates the fundamental role of economic activity as a medium for articulating and solidifying power relations and status within various societal frameworks (Das, n. d.).

In ceremonial economics, economic exchanges play a vital role in consolidating social status, establishing alliances, and reinforcing hierarchical relationships. A prime example of this is the Kula Ring in Melanesian societies, which illustrates how economic activities can be inherently ceremonial. In such systems, wealth circulates through structured, reciprocal exchanges that embody power, respect, and social cohesion, rather than merely focusing on material accumulation (Malinowski, 1922). These transactions signify wealth as a means of strengthening social bonds and political alliances, where the symbolic value of the exchanged items often surpasses their practical utility. Likewise, mercantilism can be understood as a systematic approach that intertwines wealth with state power and national prestige. Advocates of mercantilism posited that the accumulation of wealth—particularly in the form of bullion like gold and silver—was paramount to national strength. This philosophical framework led to the establishment of policies that prioritized export promotion, curtailed imports, and aimed to enhance a nation's resource base (Heckscher, 1937). Within this paradigm, wealth transcended mere accumulation; it served as a crucial indicator of a nation's status and influence on the global stage, akin to the role that ceremonial artifacts play in non-Western societies, where they symbolize authority and social capital within their respective contexts.

Both ceremonial economics and mercantilism underscore the ritualized use of wealth as a means of showcasing power. In ceremonial contexts, economic activities such as the potlatch ceremonies among the Indigenous communities of the Pacific Northwest involved the strategic giving and destruction of wealth to elevate social status and prestige within the community (Mauss, 1950). This approach to wealth, particularly through ceremonial display and redistribution, parallels mercantilist practices where European states accumulated and exhibited wealth through formidable navies, colonial acquisitions, and monopolistic trade networks. For instance, monopolistic entities like the British East India Company served as instruments of mercantilist policy, exemplifying the state's wealth and influence through ceremonial displays of economic power in colonized territories (Stern, 2012).

Ceremonial economics frequently employs redistribution as a strategy to enhance social cohesion. Systems of reciprocity and mutual obligation, evident in practices such as the potlatch or the Kula Ring, serve to bind communities together through gift-giving (Sahlins, 1972). This concept parallels the efforts of mercantilist states to establish economic dependencies and alliances via trade monopolies and colonial relationships, redistributing resources in ways that reinforced loyalty and dependence on the mother country. For instance, British mercantilist policies mandated that colonies trade exclusively with England, ensuring a steady flow of resources that contributed to British wealth while maintaining colonial reliance (Irwin, 1991).

In summary, ceremonial economics and mercantilism exemplify the interplay between economic systems and power dynamics, social stratification, and communal integration, transcending mere individualistic profit motives. In these frameworks, wealth functions as a critical instrument for sustaining both social and political order at various levels, whether local or global. They underscore the dual symbolic and structural dimensions of wealth, illustrating how economic practices are pivotal in reinforcing social and national prestige. This is often achieved through organized, and at times ritualistic, exchanges that enhance both collective identity and cohesion within societies or states.

New Institutional Economics, the general framework developed in 1972 by American economists Harold Demsetz and Armen Alchian, is another example. It builds upon the ideas of Ronald Coase and incorporates them into mainstream economic thought. This school of thought places a strong emphasis on the practical application of economic theories to understand and influence real-world phenomena through the design of institutions, regulations, and policy interventions (Schneider, 2020).

One of the key distinguishing features of is its departure from the more traditional, mainstream approach to economic reforms. Rather than advocating for broad, sweeping changes, institutionalists argue for a case-by-case reform approach. They believe that this approach is more effective in promoting social and political intervention in the economy, ultimately leading to more broadly distributed social provisioning.

The influence of ceremonial economics can also be seen in the development of New Keynesian economics. In 1987, a British economist, Dixon, demonstrated that the fiscal multiplier, which measures the effects of government spending on the economy, could rise due to imperfect competition in the output market. Dixon's research highlighted the influence of government expenditure on consumer behavior and free time, indicating that economic policies should consider the practical consequences of market imperfections (Dixon, 1987).

In ceremonial economics, transactions are primarily motivated by social and cultural imperatives rather than purely economic rationality. For instance, in the

Kula Ring of the Trobriand Islanders, the exchanged goods fulfill significant symbolic roles, enhancing participants' social status and prestige rather than addressing basic material requirements (Malinowski, 1922). These items often accrue additional value rooted in their ceremonial relevance and the reputations of former possessors, which disrupt conventional market dynamics and alter "demand" in ways that diverge from standard economic competition (Weiner, 1983). This phenomenon of socially constructed value reinforces a framework where the exchange value of goods is predominantly informed by symbolic factors rather than conforming solely to the supply and demand principles characteristic of perfectly competitive markets.

Imperfect competition in output markets occurs when factors other than pure market forces influence price and output. These factors include brand loyalty, market power, and unique product attributes. For instance, monopolistic competition features firms that differentiate their products to minimize the substitutability of their goods, allowing them to exert some control over pricing (Chamberlin, 1933). This process of differentiation is similar to the ceremonial context in which goods are assigned a unique social and symbolic value, effectively limiting competition among them. In both scenarios, products are not completely interchangeable; they possess distinct attributes related to their reputation, history, or brand, making them more desirable and thereby reducing the competitive pressure to lower prices.

Ceremonial economics often encompasses the selective exchange of goods that serve to reinforce social hierarchies and confer status. A prime example of this is the potlatch ceremonies conducted by Indigenous groups in the Pacific Northwest, where the accumulation and distribution of wealth are strategic actions that assert social rank and establish a hierarchical structure among participants (Mauss, 1950). This ritualistic economic framework not only creates exclusivity but also mirrors the dynamics of monopolistic competition, where entities differentiate themselves through unique selling propositions to enhance their market position. In markets characterized by monopolistic competition, firms leverage brand identity, strategic advertising, and product quality differentiation to cultivate customer loyalty, thereby mitigating direct substitutability and effectively limiting competitive pressures (Krugman, 1979). The symbolic and status-driven elements of ceremonial economics are similar to how companies in imperfectly competitive markets develop brand loyalty and exclusivity. By offering products or exchanges with distinct symbolic value, both ceremonial exchanges and firms in monopolistic competition establish exclusive niches that allow them to exert market power while avoiding complete competitive pressures.

In the realm of ceremonial economics, the valuation of exchanged goods is typically predetermined and influenced more by tradition and social constructs than by dynamic market-driven price fluctuations. This phenomenon mirrors the price rigidity observed in contexts of imperfect competition, where firms often maintain stable prices due to factors such as brand loyalty or the perceived intrinsic value of their offerings, notwithstanding changes in market conditions (Bain, 1956).

Within imperfect competition, price rigidity emerges primarily from consumers' allegiance to specific brands or firms, resulting in a scenario where prices do not necessarily fluctuate in direct response to alterations in supply or demand. Similarly, the ceremonial valuation of goods, which is fundamentally a socially constructed framework, enables a level of price stability contextually anchored in cultural significance. In a monopolistically competitive market, products can uphold consistent pricing as their perceived value is intrinsically linked to brand identity rather than purely to cost considerations or production variances.

In summary, both ceremonial economics and imperfect competition in output markets illustrate how non-material factors, such as social status, exclusivity, and symbolic value, influence economic interactions in ways that differ from pure competitive models. In both cases, economic exchanges involve more than just material utility; they serve as vehicles for social identity, prestige, and exclusivity. This dynamic diminishes the competitive pressures that typically drive prices down in a perfectly competitive market. This perspective highlights the complex and socially embedded nature of both ceremonial exchanges and imperfectly competitive markets, where value is shaped as much by symbolic meaning and relational dynamics as by market forces.

2.2. Related Fields

Ceremonial economics intersects with several related fields, each contributing unique perspectives and methodologies. We will explore four of them: economic anthropology, cultural economics, public anthropology, and political economy.

Economic anthropology explores how economic activities are influenced by social and cultural contexts. This field transformed from a specialized area in the early 20th century into a distinct sub-discipline within social and cultural anthropology. N. S. B. Gras first used the term "economic anthropology" to describe a combination of anthropological and economic studies with a primary focus on how "primitive people obtained a living." (Gras, 1927).

Economic anthropology focuses on the economic processes of allocating resources to specific social environments. It frequently involves collaboration between economists and anthropologists. A core concept in economic anthropology is the idea of spheres of exchange, as introduced by Paul and Laura Bohannan. This concept categorizes exchange objects into separate, non-interchangeable spheres, such as subsistence, wealth, and prestige, and is related to ceremonial exchange (Bohannan & Bohannan, 1968).

Ceremonial exchange, as defined by anthropologists, refers to intricate systems in which valuable items are publicly shown and then given to partners on a reciprocal basis over a period of time. This practice often involves a carefully orchestrated exchange of goods or services to establish and maintain social relationships within a community or between different groups. Typically, these occasions involve dancing and festivities, with participation from men, women, and children. This community involvement highlights the social significance of these complex events. These events also help to establish and uphold forms of political alliance between the partners, whether they are individuals or groups (Strathern & Stewart, 2005).

It is important to understand that exchanges often happen because of delayed reciprocity. Instead of both sides immediately exchanging items of value, one side typically gives first, which then obligates the recipients to reciprocate on a later occasion. This delay reflects the trust or obligation between the parties: relationships can become strained or hostile if the commitments are not honored. While there may be instances of immediate reciprocity, it usually happens over time in a series of incremental exchanges. The key point is that delayed exchanges of wealth help to maintain relationships. Knowing about these processes can provide insight into the social interactions of the people involved in these events (Sahlins, 1972).

Cultural economics is also a closely related field focusing on cultural phenomena, drawing from cultural studies and the humanities. Unlike broader institutional approaches, cultural economics places significant emphasis on the role of emotions, experience, and creativity in social actions. This subfield scrutinizes the participant-observer link more radically and tends towards strong notions of constructivism, highlighting the role of interpretation and subjectivity in empirical research. Cultural economists often explore various forms of representation and corporal practices, thereby diverging from traditional institutionalist economics in terms of epistemology and methodology (Dimmelmeier & Heussner, 2018).

Public anthropology draws on anthropological research to confront significant societal challenges, offering understandable and actionable perspectives on topics such as disaster response and worldwide economic disparities. Through simplifying anthropological discoveries, public anthropology encourages valuable discussions among the public and enhances the overall comprehension of economic systems and operations within society. This discipline emphasizes the significance of diverse forms of economic production and exchange, shedding light on their influence on everyday lives and interpersonal connections (Borofsky, 2011).

The perspective of the political economy provides an analysis of instances of global economic inequality and structural violence. This approach highlights the significance of cultural processes in influencing economic behavior, including individual preferences, tastes, and attitudes toward fairness. The anthropological concept of rational behavior within a cultural framework offers a deeper and more intricate comprehension of economic behavior compared to the traditional neoclassical economics concept of the rational economic man. This viewpoint helps us understand the reasons behind cultural differences in economic behavior (Schneider, 2020).

Ceremonial and institutional economics converge through their common emphasis on the ways in which social norms, power dynamics, and cultural practices influence economic behavior. Both frameworks posited that economic systems are embedded within social contexts, which not only affect economic decision-making but can, in certain instances, supersede traditional economic rationality. In conjunction with ceremonial economics, institutional economics—particularly as articulated by Thorstein Veblen and further advanced by Douglass North—examines economic behavior through the lens of social institutions. These institutions encompass both formal and informal "rules of the game" that include customs, norms, and legal frameworks (North, 1990). Veblen's notion of "conspicuous consumption," delineated in The Theory of the Leisure Class (1899), underscores this perspective by suggesting that economic choices are frequently driven by social signaling and status pursuit rather than pure utility maximization. Institutional economics posits that these socially embedded preferences prompt individuals to make choices that reinforce established societal structures and hierarchies. This dynamic parallelly mirrors the function of ceremonial exchanges, which serve to maintain and affirm social bonds and relationships (Veblen, 1899).

Ceremonial and institutional economics highlight that economic actions are often motivated by non-material factors, including social approval, respect, and the nurturing of relationships. Marcel Mauss's seminal work, The Mauss (1950), offers valuable insights into the nature of gift-giving as a form of ceremonial exchange that forges bonds among individuals and communities through obligations related to giving, receiving, and reciprocating. The potlatch ceremonies among Indigenous groups in the Pacific Northwest serve as a further illustration of how such ceremonial exchanges are used to redistribute wealth, thereby asserting social status and reinforcing community ties. In potlatch, the act of giving—even the destruction of wealth—becomes a conduit for gaining prestige and respect (Mauss, 1950).

Institutional economics supports the idea that institutions significantly influence preferences and restrict choices, leading individuals to prioritize social harmony or status over purely economic incentives. Geoffrey Hodgson (2006) posits that institutions are enduring structures that direct behavior by embedding specific values and norms within society, thereby affecting economic interactions by shaping individuals' motivations and aspirations. Consequently, the value of economic exchanges is often determined more by the cultural context in which they occur than by market forces alone. This perspective in institutional economics offers a framework for understanding how ceremonial exchanges can establish and perpetuate values that extend beyond mere utility.

In both ceremonial and institutional economics, economic transactions serve as mechanisms for articulating and reinforcing social hierarchies and power dynamics. The Kula Ring exemplifies this through its intricate system of exchange, where participants accumulate social capital by trading esteemed items, thus enhancing their social standing within the community (Weiner, 1983). This network of exchanges is heavily contingent upon established relationships, and the value ascribed to these items is significantly shaped by the reputation of past holders and their historical narratives.

Institutional economics parallels this by acknowledging that economic transactions are intricately organized around power relations and institutional frameworks. Douglass North's institutional theory posits that economic interactions mirror the underlying power structures within a society, where institutional norms and rules delineate the distribution of advantages in the marketplace (North, 1990). In this regard, institutional mechanisms not only facilitate economic activities but also perpetuate social order, akin to how ceremonial exchanges embed and uphold social status and relational networks. In markets with strong institutional rules, dominant firms can take advantage of brand loyalty and social influence, leading to a concentration of market power. Institutional economists argue that these "rules of the game" often hinder perfect competition and create inequalities by favoring established players over new entrants (Hodgson, 2006). Similarly, in ceremonial exchanges, exclusive and socially structured networks restrict participation, giving preference to those with established status, which reinforces their positions within the social hierarchy.

Ceremonial economics illustrates that the value of goods is often fixed and determined by tradition rather than by market fluctuations. For instance, in the Kula Ring, the value of shell necklaces is based on their ceremonial history and previous ownership rather than supply and demand. This stability in value, which is governed by social norms and traditions, resembles price rigidity in institutional economics. In this context, prices and values can remain steady due to factors such as brand loyalty, institutional rules, or consumer expectations.

Institutional economics explains that price rigidity often occurs because of established brand identities or consumer loyalty, which means that prices do not necessarily change with varying demand (Bain, 1956). Similar to ceremonial exchanges, where symbolic and relational values determine the worth of goods, institutional rules and consumer perceptions affect the stability of prices and values in modern markets. In both scenarios, economic value is not solely a function of market conditions; rather, it is socially constructed and maintained by established norms and institutions.

In summary, both ceremonial and institutional economics elucidate the profound impact of social norms, cultural significances, and institutional frameworks on economic behavior. These perspectives foreground the idea that economic exchanges frequently play a role in reinforcing social order, preserving relationships, and expressing power dynamics. This challenges traditional economic paradigms that emphasize rationality and utility maximization. Within these frameworks, economic actions are not solely viewed as profit-maximizing endeavors; rather, they are conceptualized as vital to the maintenance and continuity of social and cultural systems.

3. Criticisms and Debates

Ceremonial economics focuses on the relationship between institutional structures and economic processes, and it has sparked various debates and criticisms within the academic community. One key criticism revolves around the tension between practical innovations and traditional ceremonial aspects, especially within the university system and the field of economics. This tension suggests two potential outcomes: either new technologies will be absorbed by existing structures, worsening existing inequalities, or a rise of new and inclusive cultures that foster epistemic democratization and pluralism (Guizzo, 2024). Many critics contend that if the former scenario were to occur, it could potentially strengthen monopolies in specific areas of expertise, leading to further marginalization of less dominant voices within those fields.

One critique of ceremonial economics is its emphasis on traditional, pre-industrial, or non-market societies, which some argue constrain its relevance in contemporary, globalized economies characterized by market-driven transactions. Detractors contend that ceremonial economics may not adequately address the complexities inherent in global trade, financial markets, and capitalist frameworks, where considerations of utility and profit maximization frequently overshadow symbolic value. Polanyi (1944) argued that market-based economies are embedded within specific institutional frameworks, making ceremonial interpretations less relevant in situations where material gains often outweigh social and symbolic concerns. Similarly, North (1990) claimed that although institutions influence behavior, the formal rules that underpin contemporary economies frequently function autonomously from the symbolic practices highlighted in ceremonial economics.

Critics contend that the framework of ceremonial economics may disproportionately highlight the symbolic and ritualistic dimensions of economic interactions, potentially neglecting practical and material considerations. The Kula Ring serves as a prominent illustration of this phenomenon; however, some anthropologists argue that participants simultaneously engage in pragmatic trade while undertaking their ceremonial exchanges. This suggests a coalescence of utilitarian and ceremonial motivations that is often underestimated in analyses that focus solely on the ceremonial aspects (Dalton, 1961). Such a perspective invites a more nuanced understanding of the dual economic functions inherent in these practices.

Another criticism pertains to the methodology employed in the study of ceremonial economics. This field often relies on ethnographic methods, which can be subjective and highly context dependent. Critics argue that such methodologies may lead to overgeneralization or anachronistic interpretations of economic behaviors. Goody (1977) cautioned against romanticizing "primitive" economies, warning that it is essential to interpret ceremonial practices within the broader socioeconomic context. Furthermore, the symbolic meanings associated with ceremonial exchanges can be challenging to quantify or measure, complicating comparisons across different societies and economies.

Some scholars critique ceremonial economics for its tendency to idealize the egalitarian and community-oriented dimensions of ceremonial practices while overlooking the entrenched power dynamics and disparities they frequently perpetuate. For example, the potlatch ceremonies observed in the Pacific Northwest are often viewed as mechanisms of redistribution; however, they simultaneously function to reinforce existing hierarchies and consolidate elite power (Wolf, 2010). Graeber (2001) posits that although ceremonial exchanges are designed to strengthen social bonds, they can inadvertently sustain systems of exploitation, as the obligations to give and reciprocate may impose substantial burdens on participants with less social capital.

Neoclassical economists have criticized ceremonial economics for dismissing rational-choice models and emphasizing cultural and social factors. They contend that ceremonial economics fails to explain how individuals make choices under constraints or how markets allocate resources efficiently. Becker (1976) challenged approaches that stray from utility maximization, suggesting that symbolic and cultural behaviors could be integrated into rational-choice frameworks instead of being treated as separate phenomena.

Ceremonial economics has also faced criticism for its inclination to essentialize cultures by concentrating on ceremonial practices and exchanges. This focus can result in static and reductionist representations of societies, neglecting the fluid and evolving character of cultural and economic practices. Clifford (1988) cautioned against the perception of cultural practices as immutable, underscoring the importance of contextualizing ceremonial exchanges within their historical and political frameworks to achieve a more nuanced analysis.

The role of values in scientific practice is a topic that generates debate within the academic community. While Max Weber advocated for a value-free approach to social science, most institutionalists argued against a strict division between scientific and normative factors (Martyn, 2018). This divergence in views has led to ongoing discussions and differing perspectives on the relationship between values and scientific inquiry. There has been a discussion and disagreement regarding the inclusion of values in economic analysis.

Moreover, the formal inclusion of economic advancements within existing structures has consequences for the reputation of academic institutions and the regulation of knowledge generation in universities. Institutionalists emphasize how these formal values can obstruct the acceptance of new approaches and viewpoints, thereby maintaining a hierarchical prestige system that is resistant to change.

The Community Economy approach emphasizes the importance of ethical considerations and collective survival over individualist or universal prescriptions, adding another layer to the debate on economic approaches. Proponents argue that ethical questions are best negotiated through relationships in specific contexts, while critics caution that this approach may lack the consistency needed for broader application and policy formulation. This approach prioritizes the well-being of the community and encourages a nuanced, context-specific understanding of ethical considerations, raising important questions about its broader applicability and potential impact on policy formulation (Hill & Diprose, 2019).

For individuals interested in gaining a thorough understanding of ceremonial economics, there are various significant publications that offer valuable perspectives and in-depth analyses. One such notable work is "Ceremonial Economics: A Social-Institutional Analysis of Universities, Disciplines, and Academic Positioning" by Danielle Guizzo (2024) , which presents a comprehensive exploration of how institutional ceremonial values and the hierarchical structure of prestige impact the economics discipline and the generation of knowledge within academic institutions. Additionally, the Journal of Economic Issues' 2024 volume, which includes Guizzo's article, provides a broader context on the evolving debates and perspectives within the field.

To gain a better understanding of related topics, readers could explore historical and recent analyses of ceremonial institutions and their impact on economic and social instability, unequal distribution, and crises related to race, ethnicity, and gender. The following works highlight the intricate and varied nature of institutionalist scholarships. They present several research topics that extend beyond pure economic theory to encompass broader social implications, thus offering a rich and multifaceted perspective on the subject.

Conclusion

In this article, we present a comprehensive exploration of an interdisciplinary approach that delves into the impact of social institutions and cultural practices on economic behaviors and outcomes. Our aim is to present a challenge to the conventional economic model, which frequently emphasizes individual rationality and property rights to the exclusion of other factors. We advocate for a more holistic analysis that incorporates cultural and historical contexts to provide a more nuanced understanding of economic phenomena.

The discussion delves into the distinction between ceremonial and instrumental economics. Ceremonial practices are rooted in traditional values and social duties and are often associated with rituals and symbolic significance. On the other hand, instrumental practices prioritize effectiveness, problem-solving, and efficiency. This dichotomy is particularly significant as it highlights how adherence to tradition can at times impede innovation and economic advancement, a concept referred to as "ceremonial encapsulation." This article underscores that this encapsulation can intensify social disparities by favoring established norms over forward-thinking solutions.

The Kula Ring among the Trobriand Islanders, the Potlatch among Pacific Northwest tribes, and various aspects of the Classic Maya civilization serve as key case studies that demonstrate the intricate connection between economic activities and their profound embeddedness within social and cultural contexts. These examples underscore the idea that economic behaviors carry substantial social meanings that go beyond mere utility, often being influenced by a complex interplay of social, cultural, and historical factors.

This article explores the intricate economic ramifications of ceremonial economics, shedding light on how cultural norms impact the distribution and exchange systems within communities. It delves into the intricacies of market dynamics through empirical studies, acknowledging the diverse range of prices and outputs, thus questioning the concept of a perfectly competitive market. Moreover, it investigates the infusion of currency into traditional economies, which adds layers of complexity to resource allocation and economic interactions. This underscores that in ceremonial economics, the concept of wealth encompasses more than just the accumulation of assets.

However, critics of ceremonial economics express concerns about the possibility of reinforcing inequalities within current institutional frameworks and discuss the impact on academic knowledge production. The article delves into how the conflict between traditional values and modern economic practices shapes a dynamic environment in which innovation may be hindered or reshaped through traditional perspectives.

Moreover, modern economic theories like New Institutional Economics and New Keynesian Economics deeply explore the importance of ceremonial economics, recognizing the impact of institutional environments on economic behavior. This conversation underscores the need to consider a range of interconnected disciplines, such as economic anthropology and cultural economics, to obtain diverse analytical viewpoints on the intricate relationship between culture and the economy.

Future studies on the ceremonial economy could be exciting. As social structures advance, ceremonial economics may enhance its relevance by examining the continuity of ritualized practices within modern economic frameworks, the increasing importance of digital symbolism in transactions, and the complex interactions between traditional economic rituals and contemporary practices. This approach can provide deeper insights into the resilience of cultural and economic behaviors in the middle of rapid change.

For instance, the rise of digital economies is transforming ceremonial practices and creating new forms of symbolic value. Cryptocurrencies, non-fungible tokens (NFTs), and online reputation systems can be analyzed through the concept of ceremonial economics. For instance, NFTs often derive their value from cultural significance, social prestige, and uniqueness rather than from practical utility (Haskel & Westlake, 2018). Their exchange reflects the principles of ceremonial economics, where value is connected to symbolic meaning and social recognition. As digital platforms play an increasingly prominent role in economic interactions, ceremonial economics offers valuable insights into how symbolic exchanges impact behavior within these spaces. The rituals associated with social media "likes," influencer endorsements and digital tipping systems exemplify the integration of ceremonial elements into digital economies, ultimately reinforcing status and social connections.

Sustainability can be another field of work. Ceremonial practices frequently underscore the principles of reciprocity and equilibrium, which closely align with contemporary sustainability objectives. Indigenous ceremonial economies, exemplified by the potlatch of the Pacific Northwest and the Andean concept (reciprocal exchange), offer critical frameworks for examining sustainable, community-oriented economic systems (Mauss, 1950). As global discourse increasingly gravitates towards sustainable development, the insights derived from ceremonial economics can inform innovative economic paradigms that prioritize relational dynamics, community resilience, and ecological integrity, in contrast to the conventional focus on profit maximization. Elinor Ostrom's (1990) research on community-managed resources highlights how traditional collective governance practices often resonate with ceremonial economic principles, underscoring the importance of cooperation and shared stewardship. These findings can inform the development of policies aimed at fostering sustainable and inclusive economic practices.

As ceremonial practices become commodified within the global economy, the authenticity and cultural integrity of these rituals encounter significant challenges. Tourism, for instance, often transforms traditional ceremonies into spectacles for consumption, thereby stripping them of their original meanings (Greenwood, 1989). Similarly, cultural artefacts utilized in ceremonial exchanges are increasingly being commercialized for international markets, prompting ethical questions surrounding ownership, representation, and value. Future research in ceremonial economics should focus on addressing the tensions between commercialization and the symbolic and social significance of rituals. It is also important to explore how communities can maintain control over their ceremonial practices during external pressures.

The future of ceremonial economics is also increasingly dependent on its capacity to integrate traditional and contemporary economic frameworks. As markets grow more interconnected globally, ceremonial exchanges play a pivotal role in influencing relationships across both informal and formal economic systems. For example, migrant communities often uphold traditional ceremonial practices while simultaneously adapting these rituals to align with new cultural and economic landscapes (Levitt, 2001). This dual engagement underscores the persistent significance of ceremonial economics within hybrid economic environments.

Lastly, ceremonial economics can offer significant insights into behavioral economics by emphasizing the influence of psychological factors, cultural contexts, and social norms on economic decision-making processes (Thaler, 2014). Practices such as vacation shopping, corporate gifting, and tipping exemplify the ritualized behaviors that infuse contemporary economies with ceremonial significance. Policymakers can leverage the principles of ceremonial economics to craft interventions that resonate with existing cultural norms, thereby enhancing trust, promoting cooperation, and fostering community engagement.

In summary, the field of ceremonial economics demonstrates significant potential as a robust framework for analyzing the symbolic and sociocultural dimensions of economic behavior in both historical and contemporary settings. By investigating the ways in which rituals evolve in response to technological advancements, cultural shifts, and ecological transformations, this discipline can provide critical insights into the persistent influence of symbolic exchanges on economic structures. Moreover, the integration of ceremonial economics with behavioral and institutional economics paves the way for the development of innovative policies and practices that prioritize sustainability. These insights underscore the continued relevance of ceremonial economics in deciphering and addressing the complexities inherent in economic systems within an increasingly dynamic global context.

The conclusion drawn from this work underscores the critical importance of adopting a holistic and integrated approach to economic analysis—one that deeply acknowledges and respects the complex and multifaceted nature of human social behavior, as well as the cultural foundations that underpin various economic practices. This article posits that by situating economic activities within their specific social and cultural contexts, we can achieve a more nuanced and profound understanding of the mechanisms that drive economic systems.

Moreover, it highlights the imperative of incorporating ceremonial dimensions into economic discussions. These dimensions often reflect the values, traditions, and social norms that shape the way communities engage in economic activities.

By recognizing and integrating these ceremonial aspects, we not only enrich our comprehension of economic interactions but also enhance the relevance and applicability of economic theories to real-world situations. This broader, more comprehensive perspective has significant implications for policymaking. By considering the cultural and social values that underpin economic transactions, policymakers can develop strategies that are not only economically sound but also culturally sensitive and socially inclusive. Such policies can better promote equitable and sustainable economic development, as they would respect the diverse values and practices of different communities, ultimately leading to more effective and resonant economic solutions.

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RESEARCH ARTICLE

Spatial Econometric Analysis of the Ecological Footprint of European Countries

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ABSTRACT

This study explains the effects of various economic factors on the ecological footprint of 34 European countries in 2022 using spatial econometric techniques. Unlike previous studies on the ecological footprint, this study presents more comprehensive results by including spatial effects in the model using spatial econometric techniques for 34 countries for 2022. This study analyzes the lagged effects of per capita GDP growth, trade openness, and renewable energy use on the ecological footprint. The spatial Durbin Model was confirmed as the most appropriate through diagnostic tests and selection criteria. The results show that per capita GDP growth, trade openness, and renewable energy usage positively and significantly affect the ecological footprint. Additionally, the spatially lagged per capita GDP growth rate has a negative impact on the ecological footprint, while the spatially lagged trade openness has a positive impact, both of which are statistically significant. These findings underscore the importance of considering the environmental impacts of economic policies to achieve sustainable development. Furthermore, the identification of spatial effects in the spread of ecological footprints highlights the need to address environmental issues not only at the national level but also in relation to neighbouring countries.

Keywords: Ecological Footprint, Spatial Econometric Analysis, Spatial Durbin Model

JEL Classification: Q57, C21, O44

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1. Introduction

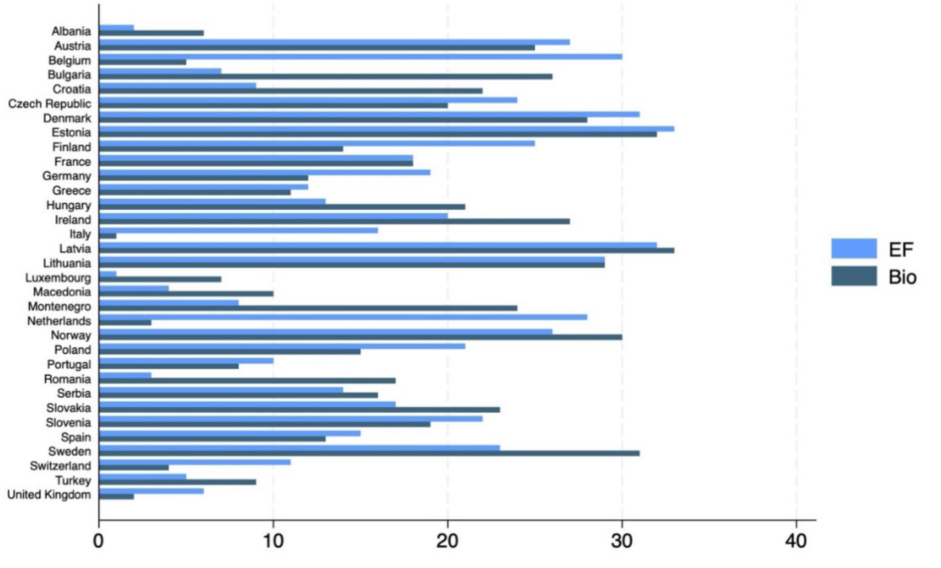
The key to sustainability lies in comprehending the considerable transformation in human spatial and material relationships with the rest of the environment, as urbanisation reflects ecological change despite seeming to indicate economic or demographic shifts (Rees and Wackernagel, 2008, p. 537). Given a specific level of technology, it is possible to determine the land or water area necessary to sustainably produce any resource or ecological service utilised by a population or economy, with most of the natural income originating from terrestrial and associated aquatic ecosystems. By calculating the total for all significant consumption categories, a cautious area-based approximation of the natural capital prerequisites for that population or economy can be obtained. This is the actual "ecological footprint" of the region's population (Rees and Wackernagel, 2008).

The ecological footprint (EF) measures how much biologically productive water or land is needed to generate the renewable resources that a population consumes sustainably and assimilate the waste generated using current technology. Biocapacity (BC) measures the biologically productive supply of a given area (e.g., cropland, pasture, forest, productive sea) available to meet this demand. Suppose the EF and the BC correspond to the economic supply and demand concepts. When employed jointly, they constitute the EF/BC accounting framework. EF is larger than BC; it leads to an ecological deficit in renewable resource accounting. When a nation has an ecological deficit, it can be offset by engaging in trade with countries possessing ecological reserves or depleting its ecological assets. Even nations with ecological reserves may face a local deficit. On the other hand, if the EF (ecological footprint) is smaller than the BC (biocapacity), it implies the existence of an ecological reserve. The ecological footprint is reduced in each area with lower consumption per capita, a smaller population size, and higher resource efficiency due to superior technology (Schaefer et al., 2006, p. 5).

The calculation of ecological footprints relies on two fundamental principles: Firstly, it is possible to monitor most resources we utilise and the waste we generate; secondly, the majority of these resources and waste streams can be converted into the biologically productive land area required to maintain these processes (Wackernagel et al., 1999, p. 377).

The graph below shows the Biocapacity and Ecological Footprint values for European countries in 2022, measured in global hectares(gha) per capita.

Figure 1: Biocapacity (Bio) and Ecological Footprint (EF) for European Countries (gha per capita)



Countries whose biocapacity is greater or equal to their ecological footprint paint a more positive picture regarding sustainability. Estonia, Finland, Latvia, Norway, and Sweden are among these countries. Italy has the lowest biocapacity, while Latvia has the highest. Luxembourg has the lowest ecological footprint, and Estonia the highest.

The primary goal of this research is to demonstrate the spatial effect on the ecological footprint of European countries and to reveal the factors influencing the ecological footprint of European countries using spatial econometric techniques. To this end, the literature section of the study includes ecological footprint studies conducted in European countries and studies explaining ecological footprints through spatial econometric techniques. Following this, the paper discusses the methodology and econometric analysis and presents the results.

2. Literature Review

2.1. Ecological Footprint Literature of the European Countries

Destek, Ulucak and Doğan, (2018) used panel data from 1980 to 2013 to investigate the determinants of the ecological footprint. The study conducted in EU countries discovered a U-shaped relationship between real income and the ecological footprint. Renewable energy and trade openness negatively influence the degradation of the environment in the EU countries, whereas non-renewable energy has a beneficial impact.

Saint Akadiri et al., (2019) analysed the determinants of the ecological footprint using a balanced panel dataset covering 16 EU countries from 1997 to 2014. The PMG-ARDL analysis revealed that non-renewable energy consumption has a negative effect on environmental quality, whereas renewable energy consumption has a positive effect on environmental sustainability. Rahman et al. (2019) employed the ecological footprint as a comprehensive measure to evaluate environmental quality. Their research on Central and Eastern European countries (CEE) indicated that economic growth's influence on the ecological footprint is not consistent, showing a lack of consistency. Additionally, the study identified an N-shaped relationship between per capita income and the ecological footprint when expressed in cubic functional form. The results also showed that financial development and a significant negative impact are associated with energy use on environmental degradation. Renewable energy significantly contributes positively by decreasing the ecological footprint and enhancing the environmental quality. Causality tests identified a two-way causal relationship between the ecological footprint and energy consumption, financial development, per capita GDP, biocapacity, and human capital. Furthermore, there was a one-way causality relationship between renewable energy and the ecological footprint. Saqib and Benhmad (2021) investigated 22 European countries from 1995 to 2015. Their research showed a quadratic relationship between income growth and the ecological footprint, supporting the Environmental Kuznets Curve's (EKC) validity. While energy consumption has a positive impact on the ecological footprint, the study found no significant influence of population growth on the environmental quality. The study analysed causality and found a unidirectional causality relationship between the gross domestic product (GDP) and the ecological footprint. Additionally, there was a bidirectional causality relationship between energy consumption and the ecological footprint. Researchers conducted a robustness analysis to validate the long-term estimation. Furthermore, the study concluded that population growth in Europe poses less of a challenge to environmental sustainability compared to the impact of intensive energy consumption.

Adedoyin, Alola and Bekun, (2020) study used balanced panel data from 16 European Union countries between 1997 and 2014. The study identified a cointegration among the ecological footprint, economic growth, research and development (R&D) expenditures, and renewable and non-renewable energy consumption. The findings revealed a significant negative relationship between R&D expenditures and the ecological footprint over time, implying that R&D expenditures have a notable effect on the environmental sustainability of the countries. The study additionally confirmed that employing renewable energy contributes to the reduction of the ecological footprint. Conversely, carbon emissions escalate due to the consumption of non-renewable energy and economic growth. The panel causality test identified the mutual causal relationships between the ecological footprint, R&D expenditures, and energy consumption, alongside the bidirectional causality between the ecological footprint and economic growth. Furthermore, the findings validated the Environmental Kuznets Curve (EKC) hypothesis for the analysed EU countries. Addai, Serener and Kirikkaleli (2022) explained the ecological footprint using quarterly time series data from 9 Eastern European countries between 1998 and 2017. Their findings indicated a negative relationship between urbanisation, economic growth, and the ecological footprint.

Saqib et al. (2023) investigated the presence of the environmental Kuznets curve and the pollution haven hypothesis across 16 European countries from 1990 to 2020. The findings revealed that the pollution haven hypothesis is valid, with foreign direct investment (FDI) having a negative impact on ecological footprints. The EKC hypothesis was confirmed when the GNP and ecological footprint relationship followed a reversed U-shaped curve. The study also discovered that the ecological footprint negatively correlated with renewable energy but a positive correlation with the energy structure. Furthermore, panel causality tests revealed a two-way causality between the GNI and the ecological footprint. In contrast, a one-way causality was observed between FDI, renewable energy, energy structure, and the ecological footprint on human capital. Wang et al., (2023) evaluated the impact of several factors on the ecological footprints of 14 developing European Union economies between 1995 and 2020 using panel data. According to the study, renewable energy and technological innovation are positively affect the environmental sustainability, as they decrease environmental degradation. Conversely, financial development, non-renewable energy consumption, and foreign direct investment (FDI) have a negative impact on environmental sustainability as they increase environmental degradation.

2.2. Ecological Footprint Literature with Spatial Econometric Analysis

Zambrano-Monserrate et al. (2020) applied a dynamic spatial panel data model from 2007 to 2016 in 158 countries. Their findings indicate that GDP, incapacity, and trade openness all positively affect countries' ecological footprints, with incapacity and trade openness having strong indirect effects in both cross sections, while GDP shows significant direct effects. Abdo et al. (2022) used spatial panel data analysis from 1992 to 2018 to study 57 Belt and Road Initiative countries. The analysis demonstrated GDP, urbanisation, and FDI positively impact the consumption of ecology, carbon, and non-carbon footprint. In contrast, globalisation and total natural resource rent have a negative impact. Furthermore, regarding spillover effects, GDP increases ecological, carbon, and non-carbon footprint consumption; foreign direct investment increases ecological and carbon footprint consumption. In contrast, globalisation and total natural resource rent decrease the consumption-based ecological footprint and non-carbon footprint consumption, respectively.

Using spatial econometric methods, Kassouri and Alola (2022) investigated factors influencing the ecological footprint of 28 sub-Saharan African countries between 2000 and 2017. The study revealed that biological capacity plays a significant role in reducing the ecological footprint. However, globalisation and urbanisation exert pressure on the environment, making it challenging to decrease the ecological footprint. Additionally, the research confirmed the hypothesis of the EKC, indicating a curvilinear relationship between the per capita ecological footprint and the per capita gross domestic product (GDP). Ramirez (2014) used forest cover, water coverage, and literacy variables to explain Colombia's 2010 ecological footprint. The research revealed a positive correlation between forest cover and the ecological footprint but a negative correlation involving water coverage and literacy with the ecological footprint. In a study on Middle East and North African countries from 2000 to 2016, Ramezani et al. (2022) examined factors influencing environmental degradation, focusing on per capita GDP, trade openness and financial development. The study revealed that using renewable energy, urbanisation, and democratic quality negatively affect the ecological footprint. In contrast, per capita GDP, trade openness, and financial development have a significant positive effect.

The concept of the ecological footprint was developed through studies conducted in the 1990s. In recent years, as the importance of sustainability has been recognised, the number of studies on this topic has increased, especially those aiming to explain the factors affecting the ecological footprint. Spatial econometric techniques were employed in this study to enhance our understanding of the ecological footprint in the European region, making a valuable contribution to the existing literature. Spatial perception needs to be incorporated into studies investigating ecological footprints in Europe. This study not only analysed ecological footprints across European nations but also integrated spatial effects into the model. The findings revealed that the spatial effect was statistically significant. The presence of spatial impact was tested using the Moran I, Lagrange multiplier, and likelihood ratio tests. The model selection criteria were used to determine the appropriate model. After model estimation, tests were conducted for heteroskedasticity, specification error, and normality assumptions to determine the final model.

3. Methodology

Jean Paelinck, introduced the term “spatial econometrics” in 1970s to describe a subset of regional science research that focuses on the challenges of estimating and testing multi-regional econometric models. Spatial effects, which allow spatial econometrics to be treated as a separate branch of science, are examined at two points: spatial autocorrelation (dependence) and spatial heterogeneity (Anselin, 1988, pp. 7–11).

Anselin (1988) and LeSage and Pace (2009) addressed the construction and application of spatial weight matrices in spatial econometrics. Spatial weight matrices(W) serve the purpose of delineating spatial relationships among observations. Specifically, they assign a value of 1 to indicate adjacency between observations and 0 otherwise. This approach is fundamental in quantifying spatial interactions within econometric models, facilitating the analysis of spatial patterns and dependencies.

According to this, “spatial heterogeneity” refers to the variability of relationships across different points in space. In the broadest sense, anticipate that a distinct relationship may exist for each point in space (LeSage, 1999, p. 7). Spatial autocorrelation can be defined as the covariance and correlation of a variable with its neighbours. If there is a similar relationship in the same direction between neighbouring observation values, it is referred to as a positive spatial autocorrelation. If there is no spatial relationship between the observed values, there is no spatial autocorrelation (Fischer and Wang, 2011, pp. 7–22). A field X(s), (where $s \in S$ is given:

$$\gamma(s_i, s_j) = E\left[\left(X(s_i) - \mu(s_i)\right)\left(X(s_j) - \mu(s_j)\right)\right] \; s_i, s_j \in R^2 \tag{1}$$

The function presented in Equation 2, often referred to as the spatial autocovariance function of the field, is defined. Moreover, the standardised form is given as follows:

$$Q(s_1, s_2) = \frac{\gamma(s_1, s_2)}{\sqrt{\gamma(s_1)\gamma(s_2)}} \quad s_i, s_j \in R^2 \tag{2}$$

The spatial autocorrelation function of the field is defined. For every pair of random variables $X(s_1)$ and $X(s_2)$ within the random field $\{X(s), (\text{where } s \in S)\}$ (Arbia, 2006, p. 41).

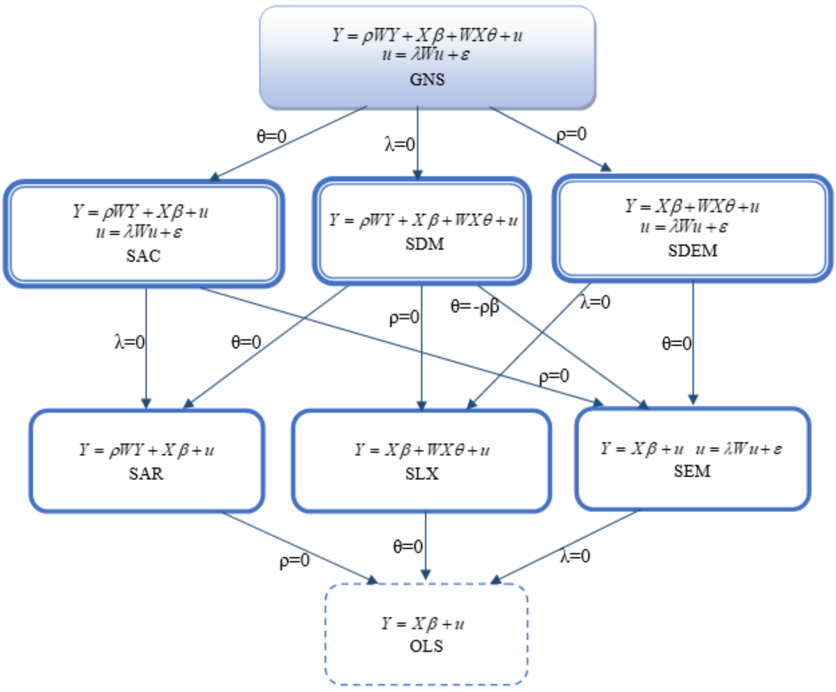
The most common test to test the significance of spatial autocorrelation is the Moran I test (Cliff and Ord (1972) and Hordijk (1974)). The Moran I statistic for a z variable can be calculated as follows:

$$I = \frac{n}{W_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij}(z_i - \bar{z})(z_j - \bar{z})}{\sum_{j=1}^{n} (z_j - \bar{z})^2} \tag{3}$$

The Moran I statistic, denoted by I, is calculated as shown in Equation 3 and takes values between -1 and +1. As the value approaches -1, it indicates a negative spatial autocorrelation, and as it approaches +1, it indicates a positive spatial autocorrelation. In addition, in Equation 3, i and j represent different locations, w_{ij} is the spatial weight matrix, n is the number of observations, w_0 is the standardisation vector, and z_i and z_j represent the variable's value at locations i and j, respectively (Cliff and Ord, 1981, p. 17; Fischer and Wang, 2011, p.23).

In spatial econometrics, models are constructed based on the presence or absence of spatial error or lag for dependent and independent variables, together or separately. As seen in Figure 2; the Spatial Error Model (SEM) involves a spatial autoregressive error term, whereas the spatial autoregressive combined model (SAC) includes a spatial lagged dependent variable along with a spatial autoregressive error term. The spatial Durbin error model (SDEM) includes both a spatial lagged independent variable and a spatial autoregressive error term. The spatial Autoregressive Model (SAR) only consists of the spatially lagged dependent variable, the Spatial Lag of X Model (SLX) includes only the spatially lagged independent variable, the General Nesting Spatial Model (GNS) includes all spatial effects, and the OLS model has no spatial effects. The likelihood ratio (LR) and Lagrange Multiplier (LM) type tests decide the valid model.

Figure 2: Spatial Econometric Models



Source: Yerdelen Tatoğlu F., Spatial Econometrics: Stata Applied, Beta, 2022, Istanbul, p. 58.

Burridge (1980) and Anselin (1988) proposed the LM test. Equations 4 and 5 provide the LM test statistic and the robust LM test statistic, respectively, used to detect the spatial error.

$$LM_{\lambda} = \frac{\left(\frac{\hat{u}'\left(\left(\iota_T \otimes W\right)\hat{u}\right.}{\hat{\sigma}_u^2}\right)^2}{tr\left(WW + W'W\right)} \sim X^2(1) \qquad (4)$$

$$LM_{\lambda}^{*}=\frac{\left(\frac{\hat{u}'(I_T\otimes W)\hat{u}}{\hat{\sigma}_u^2}\right)-\left(\frac{\hat{u}'W_y}{\hat{\sigma}_u^2}\right)B^{-1}tr(WW+W'W)}{tr(WW+W'W)(1-Btr(WW+W'W))}\sim X^2(1) \tag{5}$$

$\hat{u}$: Estimated residuals from a spatial regression model. ι_T : Identity matrix of size T × T, where T is the number of observations. *W*: Spatial weights matrix representing the spatial structure of the data. $\hat{\sigma}_u^2$: Estimated variance of the error term in the spatial regression model. tr(): Trace operator, representing the sum of the diagonal elements of a matrix. $X^2(1)$: Chi-squared distribution with 1 degree of freedom, indicating the distribution of the test statistic under the null hypothesis. Specifically for Equation (5): W_y: A matrix representing the spatially lagged-dependent variable. *B*: A coefficient matrix or parameter related to the spatially lagged-dependent variable.

The Lagrange Multiplier (LM) test and the robust LM test, which are conducted to test the presence of spatial lag, have statistics given in equations 6 and 7, respectively (Anselin et al., 1996, pp. 83–84):

$$LM_{\rho}=\frac{\left(\frac{\hat{u}'WY}{\hat{\sigma}_u^2}\right)^2}{B}\sim X^2(1) \tag{6}$$

$$LM_{\rho}^{*}=\frac{\left(\left(\frac{\hat{u}'Wy}{\hat{\sigma}_u^2}\right)-\left(\frac{\hat{u}'(I_T\otimes W)\hat{u}}{\hat{\sigma}_u^2}\right)\right)^2}{B-tr(WW+W'W)}\sim X^2(1) \tag{7}$$

The likelihood ratio test was also used to assess spatial error, spatial lag, a combination of spatial error and spatial lag, as well as spatially independent variables. The following equations give the test:

$$LR_{\lambda}=-2\left[\hat{L}-\tilde{L}\right] \tag{8}$$

$$LR_{\rho}=-2\left[\hat{L}-\tilde{L}\right] \tag{9}$$

$$LR_{\lambda,\rho}=-2\left[\hat{L}-\tilde{L}\right] \tag{10}$$

$$LR_{\theta} = -2\left[\widehat{L} - \widetilde{L}\right] \tag{11}$$

$\widehat{L}$ is the likelihood function of the restricted model, i.e., the model without the spatial effect. The log-likelihood function of the spatial error model (SEM) is presented in $\widetilde{L}$ (8), while $\widetilde{L}$ (9) provides the log-likelihood function of the spatial lag model (SAR). The log-likelihood function of the unconstrained model (SAC with spatial error and lag) is shown in $\widetilde{L}$ (10), and $\widetilde{L}$ (11) presents the log-likelihood function of the unconstrained model (SDM with spatial lagged independent variables) (Burridge, 1980 pp. 107-108; Yerdelen Tatoğlu, 2022, pp. 139–150).

After selecting the appropriate spatial econometric model, basic assumptions deviation such as heteroskedasticity, non-normal distribution, and specification error should be tested.

4. Data and Analysis Results

This study employs a spatial econometrics methodology to evaluate how certain economic factors will impact the ecological footprint of 34 European countries in 2022. A spatial weight matrix is used to include the spatial effect in the model. This matrix can be created according to the border neighbourhood. In this direction, a study was conducted in 34 countries. In this study, the ecological footprint in 2022 is examined in relation to the lagged effects of trade openness, renewable energy use, and GDP growth rate per capita.

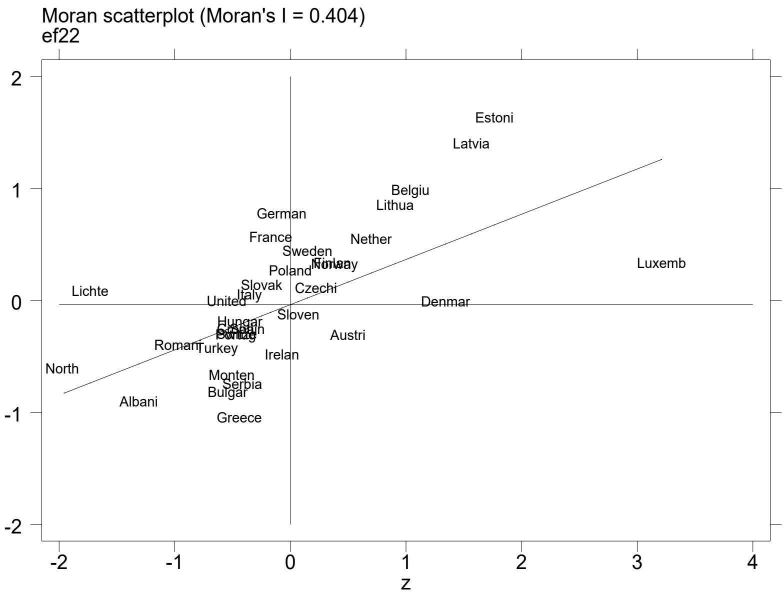
Table 1: Variable Names and Descriptions

Variable Name	Description	Year	Source
GRW	Annual Gross Domestic Product Growth Rate per Capita	2021	World Bank
TRD	Trade Openness	2021	World Bank
REC	Share of primary energy consumption from renewable sources	2021	Our World in Data
FOOTP	The footprint of Consumption (global hectares per capita)	2022	Global Footprint Network

The map below shows the ecological footprint distribution in 2022. The blue colour is used and scaled into four levels, with the highest footprint in the darkest colour. Spatial clustering is evident among different countries. This map shows that the ecological footprint variable has a spatial feature.

Figure 3: Spatial Distribution Map of the FOOTP Variable

Figure 4: FOOTP Variable Moran I Scatter Diagram



In the Moran I scatter diagram, the upper left is low high, the upper right is high high, the lower left is low low, and the lower right is high low. If the observations fall mostly in the low-low and high-high regions, it indicates a positive autocorrelation. If they fall mostly in the low-high or high-low regions, there is a negative autocorrelation. If the Moran I value is positive (if there is positive autocorrelation), it corresponds to a positive slope; otherwise, it will have a negative slope. When the Moran I scatter diagram is examined, it is seen that most of the observations fall in the high high and low low regions. For this reason, the global Moran I value at the top is positive. There is positive Spatial autocorrelation in the ecological footprint. The spatial autocorrelations shown in the scatterplot above can only be interpreted if they are statistically significant. Countries with significant spatial correlation appear in colour in Figure 5.

Figure 5: Spatial Distribution Map of the FOOTP Variable

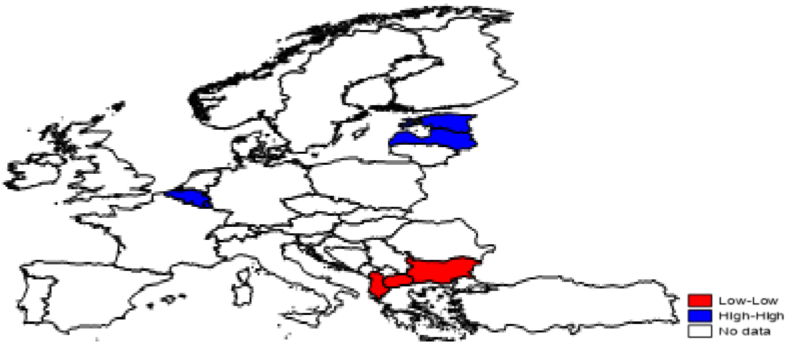


Figure 5 shows the clustering for countries with significant spatial correlation. The red areas (North Macedonia, Albania, Bulgaria) are those with low-low spatial autocorrelation, and the blue areas (Estonia, Latvia, Belgium) are those with high-high spatial autocorrelation. This spatial autocorrelation map, which shows significant movements of the ecological footprint with neighbouring countries, can a priori indicate that models that include spatial lags among spatial econometric models may be meaningful. However, it is still necessary to support this result with tests.

When working with spatial econometric models, LM and LR tests can be performed to separately test the existence of spatial error or spatial lag. The LR test can also test the existence of spatial lag and error together, as well as the spatial effect on the independent variable. After investigating the existence of spatial error, spatial lag, and spatial effect in the independent variable with diagnostic tests, the appropriate model will be estimated, and the assumptions will be tested. Table 2 includes the LM and LR tests to test the presence and type of spatial effects.

Table 2: Diagnostic Test Results

Test	Coefficient	P- value
1. Moran I	2.951	0.003**
2.LM_{ρ} (H_0: ρ=0)	10.926	0.001**
3.LM_{λ} (H_0: λ=0)	5.643	0.018**
4.Robust LM_{ρ} (H_0: ρ=0)	7.048	0.008**
5.Robust LM_{λ} (H_0: λ=0)	1.765	0.184
6.LR_{ρ} (H_0:ρ=0)	25.8615	0.000***
7.LR_{λ} (H_0: λ=0)	0.6389	0.424
8.$LR_{\rho,\lambda}$ (H_0: ρ=λ=0)	34.8695	0.000***
9.LR_{θ} (H_0:θ=0)	6.5102	0.089*

Note: *, ** and *** indicate the 10%, 5% and 1% significance levels, respectively.

The table presents diagnostic test results for spatial dependence, including tests for spatial lag (ρ) and spatial error (λ) dependence. According to the Moran I (1), LM_{ρ} (2) tests and LM_{λ} (3), H_0 is rejected for tests at a significance level of 5%. This indicates that there is spatial lag and spatial autocorrelation. According to the robust LM tests (4 and 5), there is no spatial error, but there is a spatial lag. The LM test results showed that the spatial lagged (SAR) model was more appropriate.

The Spatial Autoregressive Combined (SAC) model output includes tests for spatial lag and spatial error. LR test results (8) indicate the presence of either spatial error or spatial lag. LR test results (6 and 7): For spatial error, H_0 is not rejected. There is no spatial error, but there is a spatial lag at a 1% significance level. The test for the spatial independent variable is included in the SDM model output. According to the test result (9), the spatially lagged independent variables are significant.

Consequently, the test results support the existence of the SDM model. To support the results, the estimations of all the spatial models and the model selection criteria are below.

Table 3: Results of the Model Selection Criteria

Criteria	SAC	SEM	SAR	SDEM	SDM(1)	SDM(2)
$\bar{R}^2$	0.534	0.3648	0.5156	0.6055	**0.6443**	0.6399
AIC	2.0778	2.8322	2.1599	1.8958	**1.7092**	**1.6898**
SC	2.4865	3.3894	2.5848	2.5951	**2.3403**	**1.8524**
HQ	2.2090	3.0111	2.2963	2.1097	**1.9026**	**1.8524**
RICE	2.1475	2.9272	2.2323	2.1345	**1.9249**	**1.8349**
Shibata	2.0286	2.7651	2.1087	1.7726	**1.5986**	1.6064

According to the model selection criteria, the model with the highest $\bar{R}^2$ and lowest information criteria is the appropriate model. The model with the highest $\bar{R}^2$ and the lowest Akaike information criteria (AIC), Schwarz (SC), Hannan Quin (HQ), RICE and Shibata information criteria is the Spatial Durbin Model (SDM). However, in the SDM, the spatially lagged renewable energy use variable was statistically insignificant, so the variable was removed and re-estimated (SDM(2)). This model is also suitable according to the criteria.

Table 4: SDM Model Results

Variable	Coefficient	Standard Error	z
GRW	0.149*	0.083	1.8
TRD	0.018***	0.000	5.67
REC	0.026*	0.014	1.77
wGRW	-0.270**	0.128	-2.11
wTRD	0.012*	0.007	1.66
cons	0.575	0.847	0.68
ρ	0.462**	0.155	2.98
σ	1.020***	0.128	7.97
Wald	60.4706	p-value	0.000
F	12.0941	p-value	0.000
R^2	0.6835		

Test	Statistic	p-value
White Test (H_0:σ_1^2=σ_2^2)	3.6164	0.605
Jarque-Bera LM Test (H_0: S=0, K=3)	0.577	0.749
Ramsey RESET F	3.563	0.069

Note: *, ** and *** indicate 10%, 5% and 1% significance levels, respectively.

According to the White test result, H_0 cannot be rejected, and there is no heteroscedasticity. The Jarque-Bera LM test results show that H_0, which means the normal distribution of the error terms, cannot be rejected. According to the Ramsey RESET test result, H_0 (no specification error) cannot be rejected, so there is no specification error in the model.

Because of the Wald and F Test statistics, the model is significant, the model's independent variables explain 68% of the variability in the ecological footprint. It was determined that the variables of GDP growth rate, trade openness, and renewable energy use positively and significantly affected the ecological footprint.

The findings highlight the importance of accounting for spatial effects in understanding the determinants of the ecological footprint. The negative effect of the spatially lagged GDP growth rate (wGRW) regional economic policies promoting sustainable growth can have cross-border environmental benefits. Conversely, the positive effect of spatially lagged trade openness (wTRD) indicates the potential for trade activities to amplify ecological footprints through spillover effects. Moreover, the significant spatial autocorrelation coefficient (ρ = 0.462) underscores the interdependence of the countries' environmental outcomes, emphasising the need for coordinated regional environmental policies. These results provide valuable insights for policymakers aiming to balance economic growth and environmental sustainability in a globally interconnected context.

5. Conclusion

The findings of this research confirm a significant spatial effect on the ecological footprint among European countries. Specifically, the Moran I scatter plot indicated positive spatial autocorrelation. There is a positive spatial autocorrelation in the ecological footprint variable. According to the diagnostic test results used to determine the correct model, the Spatial Durbin Model (SDM) is the correct model. The spatial Durbin Model revealed that the GDP growth rate, trade openness, and renewable energy use significantly impact the ecological footprint. Additionally, the spatially lagged GDP variable negatively affected the ecological footprint, whereas the spatially lagged trade openness variable had a positive and statistically significant effect.

The ecological footprint increases with the rise in the trade ratio of goods and services to GDP. However, the study notes that trade enables more efficient resource allocation among countries, making the regulation of trade necessary to reduce the ecological footprint. Based on these findings, policies should focus on increasing renewable energy sources, liberalising trade, and sustaining economic growth. Countries must adjust their trade policies with sustainability in mind. Policy recommendations for European countries should include investing in renewable energy, reducing the carbon intensity of goods and services trade, and implementing sustainable growth strategies that consider the environmental impact of economic growth.

The research highlights the necessity of sustainable economic growth. Consequently, countries should reshape their economic growth strategies to prioritise environmental protection and sustainability. Economic growth should be aligned with the sustainable development goals.

In addition, since it was determined in the study that the ecological footprint spreads with spatial effects, efforts should be made to reduce the ecological footprint not only on a country basis but also regionally, including neighbouring countries. These policy recommendations can help reduce differences in the ecological footprint among countries and take steps towards a sustainable future.

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Appendices: Countries Included in the Study

COUNTRIES			
Bulgaria	Italy	Greece	Poland
Switzerland	Lichtenstein	Spain	Portugal
Albania	Lithuania	Finland	Romania
Czechia	Luxembourg	Croatia	Serbia
Belgium	Latvia	France	Sweden
Austria	Montenegro	Hungary	Slovenia
Germany	North Macedonia	Ireland	Slovakia
Denmark	Netherlands	United Kingdom	Turkey
Estonia	Norway		