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Estimating the Main Economic Sectors-Income Inequality Connection for EAGLE Countries: Application of Seemingly Unrelated Regression

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Abstract

The target of this research is to analyze the possible effects of growth in the main sectors of the economy, labor force participation, population growth and human development on income inequality in Emerging and Growth-Leading Economies (EAGLE) countries between the years 1990-2022. The methodology of panel time series analysis was utilized to determine the driving factors of income inequality. In this context, the Seemingly Unrelated Regression (SUR) model, an estimator that takes into account parameter heterogeneity and inter-unit correlation, was used with the slope homogeneity and cross-sectional dependency pre-tests conducted for panel data analysis. While the influence of the agricultural sector, one of the main economic sectors, on income inequality is statistically insignificant, the industrial and service sectors are significant. However, labor force participation rate, population growth and human development also appear to be the driving forces of income inequality. Although literature evidence shows the existence of a connection extending from economic growth to income inequality, the fact that no empirical research has been found that evaluates the impacts of sectoral growth on income inequality and whether labor force participation, population growth, and human development affect income distribution is attributed to the original value of this research.

Keywords

Income Inequality, Main Economic Sectors, Seemingly Unrelated Regression

JEL Classification

O41, C33

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Temel Ekonomik Sektörler-Gelir Eşitsizliği Bağlantısının EAGLE Ülkeleri Tahmini: Görünürde İlişkisiz Regresyon Uygulaması

Öz

Bu araştırmanın amacı, 1990-2022 yılları arasında Yükselen ve Büyüme-Lideri Ekonomiler (EAGLE) olarak nitelendirilen ülkelerde ekonominin temel sektörlerindeki büyüme, işgücüne katılım, nüfus artışı ve insani gelişmenin, gelir eşitsizliği üzerindeki olası etkilerinin analiz edilmesidir. Gelir eşitsizliğinin itici faktörlerini belirleyebilmek amacıyla panel zaman serisi analizine ait metodolojiden faydalanılmıştır. Bu kapsamda panel veri analizine ilişkin yapılan eğitim homojenliği ve yatay-kesit bağımlılığı ön testleri sonucunda, parametre heterojenliğini ve birimler arası korelasyonu hesaba katan bir tahminci olan Görünürde İlişkisiz Regresyon (SUR) modeli kullanılmıştır. Temel ekonomik sektörlerden tarım sektörünün gelir eşitsizliği üzerindeki etkisi istatistiki olarak anlamsız; sanayi ve hizmet sektörlerinin ise anlamlıdır. Bununla birlikte işgücüne katılım oranı, nüfus artışı ve insani gelişmenin de gelir eşitsizliğinin itici güçleri olduğu görülmektedir. Literatür kanıtları, ekonomik büyümeden gelir eşitsizliğine uzanan bir bağlantının varlığını göstermekle birlikte hem sektörel büyümenin gelir eşitsizliği üzerindeki etkilerini hem de işgücüne katılımın, nüfus artışının ve insani gelişmenin gelir dağılımını etkileyip etkilemediğini değerlendiren herhangi bir ampirik araştırmaya rastlanmamış olması bu araştırmanın özgün değerine atfedilmektedir.

Anahtar Kelimeler

Gelir Eşitsizliği,
Temel Ekonomik
Sektörler, Görünürde
İlişkisiz Regresyon

JEL Kodu

O41, C33

1. Introduction

The late 20th and 21st centuries are marked by increases in the inequality of distribution of income and wealth (Beltran & Delgado, 2023). Income inequality is the inequitable and uneven distribution of income among individuals in a society. Fundamentally, inequality arises due to characteristics in various properties like the nature of human capital, natural resources and variations in the demographic structure of each country. This situation is associated with several economic and social problems such as slower economic growth, less intergenerational mobility, more poverty, poor health conditions, human rights violations, undemocratic environment, social conflicts, economic instability, political unrest, even deadly violence. It also triggers increases in crime rates that affect the economic instability of a country. Inequality is a concern in development due to social-ethical and economic reasons. At the same time, research evidence highlights that high economic growth rates cannot enhance the happiness of individuals in a country because of the existence of income distribution inequality. To calculate the extent of income inequality among individuals in a society, different indicators like the Theil index, the percentage shares method, the Gini coefficient and the Dalton-Atkinson measure are preferred. In 1905, Max Lorenz developed a graph covering population and income variables to explain the inequality in income distribution. This method, called the Lorenz curve, later had an important place in discussions of the magnitude

of inequality. This graphical representation has also formed the base of the Gini coefficient, which is one of the most widely utilized method of measuring income inequality. This coefficient is frequently preferred because it is sensitive in explaining the connection between both low-income and high-income population groups (Clark, 2020; Ghifara et al., 2022; Handaulah, 2014; Rauf et al., 2021; Sitthiyot & Holasut, 2016; Topuz, 2017; Wallace et al., 2022).

In historical course, income inequality has been increasing in industrialized and emerging market economies for the past 50 years (Handaulah, 2014). The late 20th century is defined as a period when income inequality increased dramatically for most countries (Clark, 2020). Therefore, income inequality has received more attention in public discourse due to increasing inequalities in many countries. The World Inequality Report (2022) states that income distribution inequality has boosted in almost all countries. It is stated that in 2021, the average adult individual earned €16.700 per year, but this income average disguised wide inequalities both between and within countries. The poorest half of the world's population receives 8.5% of global income, while the richest 10% earn 52%. The average individual in the poorest half of the global income distribution receives €2.800 per year, while an individual in the top 10% receives €87.200 per year. Inequality varies substantially from the most equal region, Europe, to the most unequal region, the Middle East and North Africa (MENA). While the share of total revenue of the richest 10% in Europe is around 36%, this rate rises to 58% in MENA. Inequalities are also seen at different levels outside these two regions. For example, in East Asia, the top 10% earn 43% of total income, while in Latin America the same rate is 55%. However, it is stated that some high-income countries, like the USA, have very high levels of inequality, while in countries such as Sweden, total income is relatively evenly distributed. Similar differences apply to middle- and lower-income countries. For example, some countries, like Brazil and India, have the highest levels of observed inequality, while others exhibit high (e.g. China) or moderate/relatively low levels of inequality (e.g. Uruguay, Malaysia) (Chancel et al., 2022).

The link between income inequality and economic growth has been on the agenda of policy makers and economists for a long time. Kuznets' pioneering article titled 'Economic Growth and Income Inequality', published in 1955, formed the basis for most studies in this field. The article evaluates how changes in economic structure drive economic growth and income inequality. Kuznets stated that in the initial stages of economic development, income inequality increases with economic growth, whereas in the later stages, income inequality decreases. It is envisaged that the

initial stage economic growth rate, supported by the agricultural sector, tends to experience a raise in income inequality, particularly in the beginning stages of the industrialization period. Over time, this path drawn by income inequality in two different stages of economic development follows an inverted-U shaped trend. This hypothesis obtained by Kuznets in his time series research with the data set of Germany, England and the USA has guided many studies. Obtaining different results when the hypothesis is examined under distinctions such as short and long term or developed and developing countries in the research confirms that a consensus on this topic has not been reached yet (Butler et al., 2020; Handaulah, 2014; Rauf et al., 2021; Topuz & Dağdemir, 2016; Topuz & Yıldırım, 2017).

Industrialization and income inequality are critical issues, especially in developing countries. Evidence from studies of developing countries supports that economic growth is generally associated with raises in inequality. The connection between growth and income inequality appears to be non-linear as inequality does not raise consistently with growth. According to this relationship, which is characterized as the 'Kuznets curve', an alteration in income distribution inequality is a consequence of the enlargement of high-income modern sectors of economies into low-income traditional sectors. Income inequality arises owing to employing most of the population in the poor agricultural sector while the rest are employed in the industrial sector. Relative sectoral change and cyclical unemployment point to the inverted-U shaped relationship with income inequality, described as the 'Kuznets hypothesis'. Despite the growing empirical literature and theoretical on the connection between inequality and growth, the consequences are inconsistent. Accordingly, the nature of the intercourse between growth and inequality has been re-reviewed as a causal intercourse from economic growth to income distribution inequality. Therewithal, time series analyses confirm that the Kuznets hypothesis is coherent with the development experiences of most developed countries. In this context, initially, income inequality increases with industrialization due to wage differences between unskilled and skilled labor, afterwards it decreases as most of the labor force moves to high-productivity sectors in after stages of progress (Ghifara et al., 2022; Rauf et al., 2021; Siami-Namini & Hudson, 2019).

In the light of the above explanations, the main target of this research is to underline the different impacts of growth sources on income inequality in leading developing countries, as growth is obtained from different economic sectors. However, the examination of the nexus between income inequality and labor force participation, growth in population size and the Human

Development Index (HDI) constitutes the sub-purpose. Within the scope of the objective, the research is structured as the related literature under subheadings specific to the link between income inequality and explanatory variables, the data set utilized in the empirical analysis and the material, model and method explaining the methodological path, research findings and discussion, conclusion and policy implications.

2. Literature Summary

It is seen in the literature that many researchers examine the characteristics affecting income inequality in various aspects (Acemoglu, 2002; Coady & Dizioli, 2017; Dao, 2008; Furceri & Loungani, 2015). For example, Acemoglu (2002) stated that technological innovations are a critical factor in the enlargement of labor productivity to clarify the determinants of income distribution. Coady & Dizioli (2017) focused on the role of education in income inequality, emphasizing that increases in years of schooling reduce inequality. Dao (2008) stated that income inequality in 35 developing economies is associated with child malnutrition, gender equality in primary and secondary school, maternal and infant mortality rates, income, births attended by qualified health personnel, and primary school completion rates. Furceri & Loungani (2015) found that capital account liberalization reforms in 149 countries between 1970 and 2010 increased inequality in the medium and short term and reduced the share of labor in income.

Since not another study has been found in the literature that uses the variables discussed in this research in an aggregated manner, the relevant literature has been discussed under subheadings such as the impact of economic sectors, labor force participation, population growth and HDI on income inequality. This situation is evaluated as the original value of the research and literature innovation.

3.1. The Nexus of Main Economic Sectors and Income Inequality

Studies conducted by Al Abbasi et al. (2024), Cafri (2017), de Janvry & Sadoulet (2010), Handaulah (2014), Öztürk (2012), Rauf et al. (2021), Siami-Namini & Hudson (2019) are among literature examples for the effects of the main sectors of the economy on income inequality. Al Abbasi et al. (2024) examined the impacts of rural transformation on income inequality in Bangladesh and showed that rural income inequality is positively associated with the share of non-agricultural employment and the share of high-value agricultural outputs. Cafri (2017) investigated the intercourse between the added value of agriculture and service sectors and income inequality

in Turkey in the 1978-2016 time using symmetric and asymmetric causality analysis. The findings indicated that there was no causality correlation between income inequality and the agricultural sector, but a symmetrically unidirectional and asymmetrically bidirectional causality relationship between the service sectors. In addition, while a negative shock occurring in the service sector reduces inequality, an improvement in income distribution negatively affects the service sector. de Janvry & Sadoulet (2010) found that non-agricultural expansion had a significant indirect impact on agricultural expansion in China during the period 1980-2001. It was said that the strength of agriculture stems from its potential to directly reduce poverty and its potential strong growth linkage impacts on various sectors of the economy. In Vietnam, income inequality among agricultural households with lower market access was found to be greater than among households with higher market access. In this direction, it has been pointed out that especially agricultural growth reduces income inequality. Handaulah (2014) analyzed the relationship between inequality and growth in Indonesia and Korea and the factors affecting income inequality in the context of emerging market economies using Theil's T-statistic method. The findings supported that income inequality was driven by the service sector in Indonesia and the financial sector in Korea. Öztürk (2012) used the sectoral dynamics decomposition method for regional inequality for Türkiye in the period 1987-2001. According to the weighted coefficient of variation and Gini index findings, regional inequality is highest in the industrial sector and proportionally lower in the agricultural sector. The decomposition results indicated that the services sector constituted the most important source of regional inequality. It was also emphasized that the agricultural sector does not have a significant role in regional inequality, and the contribution of the industrial sector is secondary. Rauf et al. (2021) analyzed the degree of income inequality in Morowali and Banggai Regency regions of Indonesia using Gini, Williamson and Theil indices. The findings revealed that the mining industry increased regional income inequality, the degree of income inequality between households and regions tended to fluctuate and reached a moderate level, and the manufacturing and mining industries replaced the dominance of the agricultural sector. Siami-Namini & Hudson (2019) focused on the influence of growth in distinct sectors on income inequality and the role of inflation in reducing income inequality in 92 developing countries between 1990 and 2014. The findings indicate that primarily agricultural growth and then industrial growth have a dominant effect on reducing income inequality, while the service sector increases income inequality.

3.2. The Nexus of Labor Market and Income Inequality

In the literature, it is evaluated that the studies examining the influence of the labor market on wage inequality are comprehensive, whereas the impacts on income inequality are more limited. For example, Checchi & García-Peñalosa (2010) argued that personal income inequality depends on labor force participation, wage gap and unemployment rate for 16 OECD countries between 1960 and 2000. Daudey & García-Peñalosa (2007) empirically analyzed the nexus between income inequality and labor force participation on the scale of 39 developed and developing countries during 1970-1994. The findings showed that lower labor force participation share is related with higher Gini coefficient. Likewise, Dao et al. (2017) reached the same findings for a sample of 49 countries, usually developed countries, during the period 1991-2014, and Erauskin (2020) reached the same findings for 62 developed and developing countries during 1990-2015. Jacobson & Occhino (2012) argued that the decrease in the labor force share in the United States was related with increasing income inequality in the period up to 2010. Conversely these findings, Francese & Mulas-Granados (2015) claimed that labor force participation was a determinant of wage inequality, not income inequality, in a sample of 93 countries during 1970-2013.

In more recent research, Elgin & Elveren (2021) provide evidence on the nexus between the inequality and informal sector by considering the feminization of labor in 125 countries between 1963 and 2018. The findings explain that the size of the informal sector is negatively associated with income inequality in high-income countries and positively correlated with income inequality in low-income countries. However, it is noted that higher female labor force participation is related with lower income inequality, but this connection disappears due to the informal sector. Morsy et al. (2023) examine how inequality can be addressed through structural transformation in a sample of 37 African countries between 1990 and 2018. The findings show that inequality across countries is higher when the share of labor employed or providing value added in agriculture is higher, but no relationship is observed for the contributions of industry and services to income or employment. Sauer et al. (2020) demonstrated that the most significant driving force behind the increasing income inequality in 73 countries between 1981 and 2010 was the decreasing labor force participation. Tahsin & Börü (2020) examined the relationships between the structural transformation process and income inequality in Türkiye during the period 2006-2018 using share change analysis and panel data methods. The findings confirmed that the regions underwent a structural transformation towards the service process accompanying the deindustrialization

process, the highest employment increase was experienced first in the services sector and then in the industrial sector, that the power of employment in industry to determine income inequality weakened, but that employment in the service sector increased it. Wallace et al. (2022) chose the power resource theory to investigate the determinants of increasing income inequality in US states during the period 1951-2018. They find coherent evidence that labor and political resources are important in determining income inequality.

3.3. The Nexus of Population Growth and Income Inequality

Literature evidence suggests that population growth increases social heterogeneity and economic complexity, thus creating mostly upward pressure on income inequality. In this regard, Butler et al. (2020), Clark (2020), Rosés & Wolf (2020), Rougoor & van Marrewijk (2015), Sitthiyot & Holasut (2016) have obtained similar findings in their studies. Butler et al. (2020) examined the impacts of rural population growth and diminish on county-level income inequality in the United States during the 1980-2016 period. The findings support the view that both forms of population change have important impacts on income inequality compared to steady growth. Clark (2020) focused on the period after 2000, using 1284 observations in 129 states to examine income inequality. According to the findings, income inequality is mainly shaped by agriculture, industry and services sectors, population growth and tertiary schooling, globalization, state characteristics, gender dynamics and unemployment rate. Rosés & Wolf (2020) examined regional income growth and inequality in 16 European countries in the period 1900-2015. The findings explained the change in the intensity of population and economic activity and the decreasing role of agriculture, the increase and fall of industry, the long-term rise of services and structural change. Rougoor & Marrewijk (2015) combined economic projections with demographic developments and used GDP per worker data to measure income levels. The findings indicated that population growth and differences in population structure increase global income inequality, especially in countries at different development stages after 2030. Sitthiyot & Holasut (2016) introduced the concept of target income inequality level for a certain population size in 69 countries using 2012 data. The findings revealed that the estimates were either too low or too high relative to the appropriate values of the Gini coefficients for most countries.

3.4. The Nexus of the HDI and Income Inequality

For the possible impacts of human development index on income inequality, the studies conducted by Alvan (2009), Castells-Quintana (2019), Ghifara et al. (2022), Hysa (2014), Mikk (2008), Purusa et al. (2025), Sarkodie & Adams (2020), Stanton (2006) are within the scope of the related literature. Alvan (2009) examined the link between HDI and income inequality in 90 countries and pointed out that there was a negative connection and a causal relationship showing a feedback impact between the two parameters. Within this scope, it was stated that when HDI increases, income distribution tends to be more equitable. Castells-Quintana (2019) estimated the nexus between income inequality and HDI and its components in 117 countries in the time 1970-2010. The findings showed a negative and long-term correlation between inequality and HDI and provided empirical evidence for different short-term relationships between inequality and HDI dimensions. However, contradictory findings were reconciled in the literature by determining these relationships might be more pronounced in countries with low development levels. Ghifara et al. (2022) determined the effects of capital expenditures, economic growth and HDI on income distribution inequality between 2012 and 2021 in Indonesia. Empirical evidence showed that HDI has a negative and important influence on income distribution inequality, while capital expenditures and economic growth have an insignificant impact. Hysa (2014) evaluated the impact of HDI on income inequality in the case of Albania and found that lower Gini coefficient values are associated with higher HDI. In the same vein, Mikk (2008) provided empirical evidence of a negative connection between the level of inequality and HDI for the Baltic countries. Purusa et al. (2025) examined the relationships between human development, the addition of the manufacturing sector, population and labor force participation to income inequality by determining the transformation of sectoral contributions to regional GDP in Indonesia. The findings proved that the nexus between the variables in economic development and the transformation of sectoral contributions, the manufacturing sector dominates the contribution to GDP and changes the contribution of the agricultural sector, labor force participation and population growth are negatively associated to income inequality, the contribution of the manufacturing sector positively affects income inequality, and HDI is a central element of economic development. Sarkodie & Adams (2020) focused on the link between electricity access, HDI, political environment, income level and income inequality in Sub-Saharan African countries in the 1990-2017 period. The findings explained that income inequality has a negative influence on access to electricity, while

income level and HDI have a positive effect. Nevertheless, income inequality was found to reduce HDI. Stanton (2006) argued for the importance of inequality in measuring social welfare at the scale of 46 countries, presented an original HDI alternative that included health, education and income distribution for the countries in question, and reported the results of the HDI adjusted for income inequality.

3.5. Research Hypotheses

This research contributes to the existing literature including the EAGLE countries cross-section in the analysis by investigating not only the agricultural sector but also the industrial and service sectors and controlling for the impacts of labor force participation on population growth and human development. The hypotheses of this research, which was created based on existing studies since the theoretical framework and literature review, are as follows:

H1: Main economic sectors have different and important impacts on income inequality depending on the development stages of the development cycle.

H2: Labor force participation has a negative and important impact on income inequality.

H3: Population growth has a positive and important impact on income inequality.

H4: Human Development Index has a negative and important impact on income inequality.

4. Material, Model, and Method

This study target to determine the impacts of main economic sectors, labor force, population and human development on income distribution inequality in the EAGLE countries defined as Emerging and Growth-Leading Economies between the years of 1990-2022.

4.1. Material and Model

The model created in line with the target of the research and empirical literature evidence is as follows:

$$\ln gini_{it} = \partial + \delta_1 \ln agr_{it} + \delta_2 \ln ind_{it} + \delta_3 \ln ser_{it} + \delta_4 \ln lab_{it} + \delta_5 \ln pop_{it} + \delta_6 hdi_{it} + \epsilon_{it} \quad (1)$$

In the model, *gini* indicates income inequality, *agr* indicates the agricultural sector, *ind* indicates the industrial sector, *ser* indicates the service sector, *lab* indicates labor force participation, *pop* indicates population growth, and *hdi* indicates the Human Development Index. Explanations about the variables are in Table 1. The ∂ notation represents the constant coefficient,

$\delta_1, \delta_2, \delta_3, \delta_4, \delta_5$ and δ_6 indicates the parameter coefficients; ϵ shows the error term. In order to prevent excessive differences between variables and to control country and year heterogeneity, logarithms (ln) of all variables except population and human development were taken and the model was established in a semi-logarithmic form. Secondary data for the variables were used.

Table 1

Variable Descriptions

Variables	Abb.	Unit	Data source
Income inequality	<i>gini</i>	%	United Nations University, 2025
Agriculture value added	<i>agr</i>	% of GDP	World Bank, 2025a
Industry value added	<i>ind</i>	% of GDP	
Services value added	<i>ser</i>	% of GDP	
Labor force participation rate	<i>lab</i>	% of total population ages 15+	United Nations Development Programme, 2025
Population growth	<i>pop</i>	Annual, %	
Human Development Index	<i>hdi</i>	Value [0-1]	

The subscript i in model (1) describes the countries China, India, Indonesia, Russia, Brazil, Türkiye and Mexico, and the subscript t describes the period 1990-2022. The temporal trajectory for the period 1990-2022 is visualized in Figure 1 regarding the relationship between dependent and independent variables.

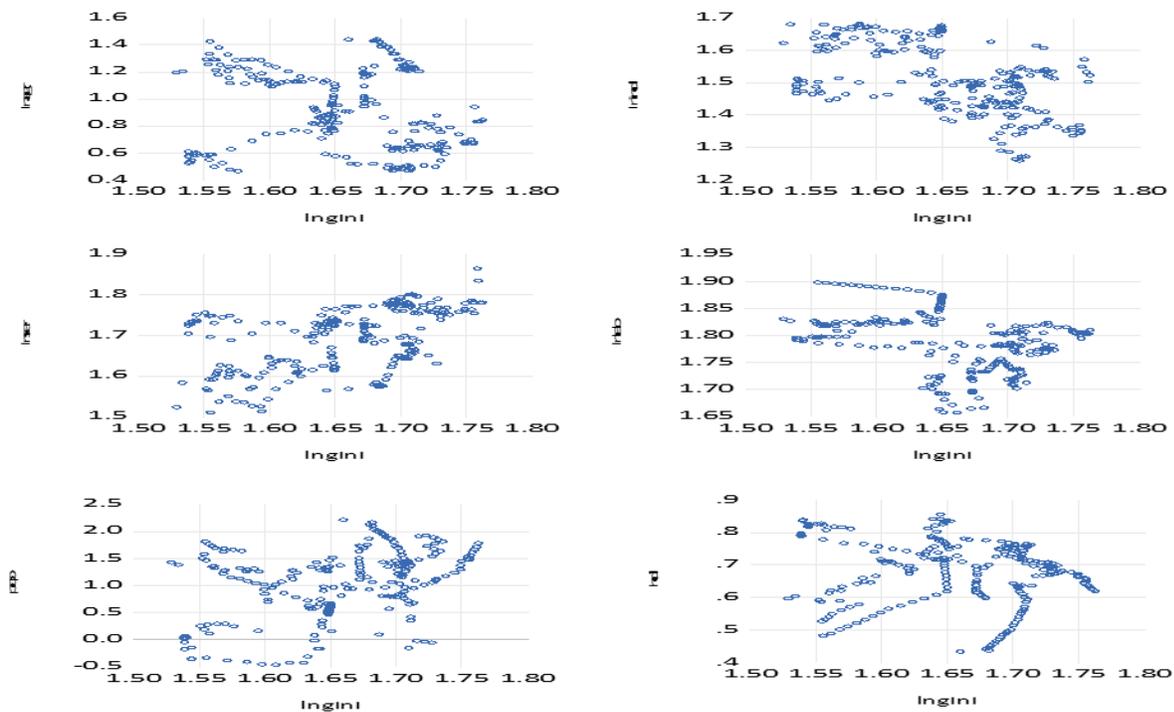


Figure 1. Temporal Trajectory between Dependent and Independent Variables

Table 2 provides the summary statistics of the variables of this study, which was carried out using a balanced panel data structure with 231 (N*T) observations. In this direction, it is seen that the highest average value is in the labor force participation and the lowest average value is in the HDI. In addition, the fact that the standard error values indicating the measure of uncertainty in the test statistics are quite low is interpreted as high reliability.

Table 2

Summary Statistics of Variables

Statistics	<i>lngini</i>	<i>lnagr</i>	<i>lnind</i>	<i>lnser</i>	<i>lnlab</i>	<i>pop</i>	<i>hdi</i>
Mean	1.656209	0.922937	1.507912	1.693469	1.786380	1.049205	0.678342
Std. Dev.	0.060563	0.286995	0.103795	0.075209	0.052208	0.624330	0.097281
Minimum	1.528878	0.466279	1.259797	1.510314	1.658202	-0.460024	0.434000
Maximum	1.762514	1.441895	1.681790	1.865328	1.898561	2.213131	0.855000

Correlation test was performed in terms of the degree of relationship between variables and the findings are reported in Table 3. The correlation coefficient has values varying in the band range [-1 to +1]. The value of -1 represents a perfect negative link, and the value of +1 represents a perfect positive link. The value of 0 (zero) indicates that there is no link between the variables. The relationship level between the variables is defined as so weak [0.00-0.19], weak [0.20-0.39], medium [0.40-0.59], strong [0.60-0.79], and so strong [0.80-1.00] (Alamanda, 2021). The Table explains that the link between the dependent variable and all independent variables is less than 0.60 under statistical significance (except HDI). In this direction, it is seen that the service sector has the highest correlation value with the Gini coefficient, while the agricultural sector has the lowest correlation value.

Table 3

Correlation Test

Matrix	<i>lngini</i>	<i>lnagr</i>	<i>lnind</i>	<i>lnser</i>	<i>lnlab</i>	<i>pop</i>	<i>hdi</i>
<i>lngini</i>	1.0000						
<i>lnagr</i>	-0.1810 ^a	1.0000					
<i>lnind</i>	-0.5282 ^a	0.3334 ^a	1.0000				
<i>lnser</i>	0.5070 ^a	-0.8335 ^a	-0.6223 ^a	1.0000			
<i>lnlab</i>	-0.3400 ^a	0.0219	0.5860 ^a	-0.3391 ^a	1.0000		
<i>pop</i>	0.3788 ^a	0.4118 ^a	-0.0984	-0.1445 ^b	-0.2488 ^a	1.0000	
<i>hdi</i>	-0.1055	-0.8119 ^a	-0.1779 ^a	0.6565 ^a	-0.0877	-0.6157 ^a	1.0000

Note. a and b explain the significance levels of 0.01 and 0.05, respectively.

4.2. Method

In this research, panel time series analysis was utilized to identify the push factors of income inequality. Panel data models is a method that allows econometric analysis of economic issues that are difficult to examine with cross-sectional analysis or time series. The method allows for the control of variables that are unobserved, incorrectly measured, or not included in the analysis (Hurlin, 2018). In addition, due to the comprehensive evaluation of the data, it provides important insights at the collective and individual levels.

Considering Figure 2, depicts the empirical framework of the research, in the first stage it is essential to test the parameter heterogeneity to select the appropriate method before starting the panel time series estimation process. Not taking into consideration parameter heterogeneity causes them to be estimated with deviations. For this purpose, parameter heterogeneity was applied based on Swamy's (1971) S test. After determining that the parameters were heterogeneous, the Breusch and Pagan (1980) Lagrange Multiplier (LM) test, which is established as the null hypothesis $H_0: \rho_{ij} = 0$ and recommended in the case of $T > N$, was realized to test the link between units. The LM test statistic indicated that there was a correlation between units. Consequently, the preliminary tests required for panel data analysis, it was decided to utilize the SUR method, which is an estimator that takes account of parameter heterogeneity and inter-unit correlation.

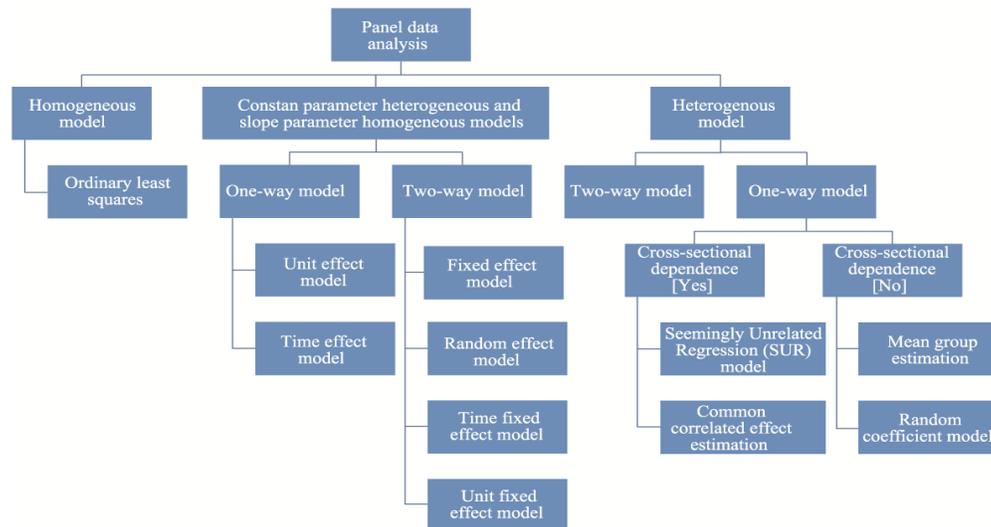


Figure 2. Empirical Framework of Research (Bayramlı & Karımlı, 2024)

The SUR method was developed by Zellner (1962) by applying the Generalized Least Squares (GLS) method to the entire equation system. The SUR model, also known as multivariate

regression or the Zellner method, estimates the parameters of the system, taking into account the simultaneous correlation and heteroskedasticity in the errors between the equations. The method is calculated equation-wise using standard Ordinary Least Squares (OLS). These calculations, while coherent, are mostly not as influential as the SUR method, which stands for Feasible Generalized Least Squares (FGLS), which has a specific body of the variance-covariance matrix. Two significant situations in which the SUR method is equivalent to the OLS method are when each equation involves identical set of regressors on the right-hand side or when the error terms are essentially uncorrelated across equations. In the absence of cross-sectional dependence in the model, the equations are estimated with OLS estimators. If there is cross-sectional dependence, the SUR method using FGLS estimators is asymptotically more effective than OLS estimators. However, effective results are obtained in the method when $T > N$ and especially when the number of units is less than 12 (Khan et al., 2014; Saridoğan, 2021).

The SUR model consists of multiple linear multivariate regression equations that are usually unrelated. Removing a variable from an equation may cause the effect of that variable on the error term to be shown incorrectly. If the removed variable is substantially related to the explanatory variables in other equations, the new relationship or the existing relationship between the error terms is strengthened. The model consists of at least one independent variable and more than one dependent variable. This matrix shows the SUR model with n observations, where each observation corresponds to a dependent variable (y) and an independent variable (x) (Bayramlı & Karımlı, 2024).

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} x_1 & 0 & \cdots & 0 \\ 0 & x_2 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \cdots & x_n \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_n \end{bmatrix} + \begin{bmatrix} \mu_1 \\ \mu_2 \\ \vdots \\ \mu_n \end{bmatrix} \quad (2)$$

$$Y_{it} = \beta X_{it} + \mu_{it} \quad (3)$$

In model (3), β notation is the coefficient of the variables in the equation, and μ notation is the error term. Y_{it} is the dependent variable at time t for the i . country; X_{it} is the independent variable at time t for the i . country. The $\hat{\beta}$ notation represents the coefficient measuring the influence of the independent variable on the dependent variable. μ_{it} shows the error term at time t for the i . country, which captures the impacts of random disturbances and omitted variables.

The GLS method is used to calculate the SUR model by considering the variance-covariance matrix of the error terms. Since the elements of the matrix are usually unknown in apps, Zellner (1962) used the residuals from the OLS estimator to approximate this matrix. Accordingly, the GLS estimator for the SUR method was calculated based on this approach (Bayramlı & Karımlı, 2024):

$$\hat{\beta}_{GLS} = (X'\Omega^{-1})^{-1}X'\Omega^{-1}Y \quad (4)$$

$\hat{\beta}_{GLS}$ in the model is the GLS estimator of the SUR model. Y is the vector of the dependent variable, X is the matrix of independent variables. X' is the transpose of the X matrix; Ω is the covariance matrix of the error terms that takes account autocorrelation and heteroskedasticity. The notation Ω^{-1} shows the reverse of the covariance matrix.

By considering the correlation between the regression used in the SUR method and the residuals of the models, the system can be solved undividedly, and the loss of efficiency can be prevented. Because the estimates made with OLS cause unbiased and consistent, but not sufficiently efficient regression parameter estimates. The GLS method, which involves the correlation between the errors of the equations, increases the efficiency of the estimate. In the SUR method, GLS is generally used as the estimation method (Saridoğan, 2021).

5. Research Findings and Discussion

So as to estimate the model number (1) created for EAGLE countries, firstly the parameter heterogeneity was tested by using Swamy-S test and the findings are reported in Table 4. When the findings were evaluated, it was concluded that the parameters were heterogeneous according to the income levels of the countries since the null hypothesis $H_0: \beta_i = \beta$ was rejected. Therefore, H_0 , which explains that all slopes are homogeneous, is not accepted and it is show that the parameters change from unit to unit.

Table 4

Homogeneity Test Findings

Statistics	<i>lnagr</i>	<i>lnind</i>	<i>lnser</i>	<i>lnlab</i>	<i>pop</i>	<i>hdi</i>
chi2(12)	2599.08	667.67	1675.80	873.16	2586.77	3887.60
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

The findings of the Breusch-Pagan LM cross-sectional dependence are reported in Table 5 which was conducted to test the important of the link among units. In line with the findings, it was

understood that there was a correlation among units since the null hypothesis H_0 was rejected at the 95% confidence level. The findings regarding parameter homogeneity and cross-sectional dependence indicate that the SUR estimation results are reliable for model estimation.

Table 5

Cross-sectional Dependence Findings

Statistics	<i>lngini</i>	<i>lnagr</i>	<i>lnind</i>	<i>lnser</i>	<i>lnlab</i>	<i>pop</i>	<i>hdi</i>
Breusch-Pagan LM	378.9470	442.2774	162.7192	148.9980	76.93279	362.8303	661.0815
Prob	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

According to the SUR model estimation findings in Table 6, in EAGLE countries, the impact of the agricultural sector, one of the main economic sectors, on income inequality is statistically insignificant; however, the industrial and service sectors are significant. In this context, while a 1% raise in the added value of the industrial sector reduces income inequality by 0.04%, it raises it by 0.65%. Accordingly, it is said that the service sector is more effective on income inequality. This situation points to the structural transformation process in EAGLE countries. Moreover, it is seen that the labor force participation, population growth and HDI variables are also the driving forces of income inequality. A 1% raise in the labor force participation decreases income inequality by 0.11%. In contrast, a 1-unit increase in population growth increases income inequality by 0.01%. At the same time, a 1-unit raise in the HDI reduces income inequality by 0.39%. The findings provide information that the services sector has the greatest impact on income inequality, while the least impact is created by population growth. A general evaluation of the independent variables shows that the industrial sector, labor force participation rate and HDI have a decreasing impact on income inequality, while the service sector and population growth have an increasing impact. In addition, the independent variables clarify approximately 89% of the variability in income inequality. The coefficient of determination, which refers the explanatory power of the model, is quite high. The F test also state that the model is statistically significant.

Table 6.

SUR Model Estimation Findings

Variable	Coeff.	Std. Error	t-Stat.	Prob.
<i>lnagr</i>	-0.005553	0.012348	-0.449685	0.6534
<i>lnind</i>	-0.044553 ^a	0.015914	-2.799601	0.0056
<i>lnser</i>	0.648136 ^a	0.050901	12.73332	0.0000
<i>lnlab</i>	-0.105344 ^a	0.036959	-2.850257	0.0048
<i>pop</i>	0.007850 ^b	0.003613	2.172498	0.0309

<i>hdi</i>	-0.389408 ^a	0.027624	-14.09657	0.0000
C	1.074388 ^a	0.145575	7.380288	0.0000
R-squared	0.885817			
Adjusted R-squared	0.882758			
F-statistic	289.6259 (0.0000)			

Note. a and b explain the significance levels of 0.01 and 0.05, respectively.

Sectoral growth is especially important for developing countries in the middle-income phase of development and because the agricultural sector is the basic resource of national income. The agricultural sector creates employment opportunities in rural areas and constitutes the primary source of income in most low-income countries. It also ensures inputs used as raw materials in other economic sectors due to forward and backward connections (Alam et al., 2008; Siami-Namini & Hudson, 2019). However, the findings reached from this research regarding the insignificant effect of the agricultural sector on income inequality is interpreted specifically in the context of the growth-leading countries in the sample group. In this context, when the representation in Figure 1 is investigated, it is observed that the service sector is dominant in the countries in question, followed by the industrial sector. However, according to the World Bank, which divides the world economies into four income groups, Russia is high-income; China, Indonesia, Brazil, Türkiye and Mexico are upper-middle income; and India is in the lower-middle income group (World Bank, 2025b). The heterogeneous feature of the sample group within the income group is explained as another possible reason for the obtained finding. With this, it is thought that other sectors of the economy have changed the dominance of the agricultural sector and explain its decreasing role. The findings support the consequences of the studies conducted by Cafri (2017), Öztürk (2012), Purusa et al. (2025), Rauf et al. (2021), Rosés & Wolf (2020).

The industrial sector is the basic engine of economic growth for developing economies where industrial goods have higher income elasticity. The fastest growing service sector in the 21st century has made important contributions to the economic growth of developing countries. The service sector accounts for approximately two-thirds of global services trade. When evaluating the impacts of sectoral growth, the focus is usually on the distribution of labor income. In this direction, a two-sector economy is assumed as low productivity-low wage and high productivity-high wage. It is stated that when employment, wages or productivity increase in the same proportion in both sectors, income inequality between employees does not modify. It is expected that income inequality will increase if productivity increases in the high productivity sector, whereas income inequality will decrease if it increases in the low productivity sector. However, it is predicted that

the growth impact on employment will be different in both sectors and will occur as the labor force moves from the low-wage sector to the high-wage sector. In the first scenario, different groups change the income difference, while in the second and third scenarios, changes in labor force composition affect income inequality (Siami-Namini & Hudson, 2019). Based on the findings of this study, the influence of the industrial sector on income inequality is negative and the impact of the service sector is positive. Therefore, the industrial sector causes lower income distribution inequality, while the service sector causes higher income distribution inequality. The findings obtained produce similar results to the literature studies conducted by Clark (2020), Handaulah (2014), Öztürk (2012), Siami-Namini & Hudson (2019). It is assumed that income inequality increases due to the high productivity feature of the service sector due to the dominance of the service sector in the later stages of development on the scale of the countries in the sample set. However, the industrial sector is considered as a low-productivity sector in economic growth, and it is stated that inequality decreases due to the wage convergence between skilled and unskilled labor. The findings regarding the effect of the labor force on income inequality support that the raise in the labor force participation decreases income inequality. When the employment composition among sectors is considered, this result is explained by the inequality-reducing impact of the industrial sector. In addition, low levels of occupational differentiation in relatively less diversified small economies lead to decreasing income inequality levels. From the literature examples, Checchi & García-Peñalosa (2010), Daudey & García-Peñalosa (2007), Dao et al. (2017), Erauskin (2020), Jacobson & Occhino (2012), Sauer et al. (2020), Tahsin & Börü (2020), Wallace et al. (2022) have presented similar evidence on the link between labor force participation and income distribution in their studies.

Theoretically, the Gini coefficient takes a value ranging from 0 to 1. In practice, the lowest and highest values it can take are 0 and $\left(\frac{P-1}{P}\right)$ (P is the population number), respectively. Therefore, the theory explain that there should be a nexus between the degree of income inequality measured by the Gini coefficient and the population. At this point, it is seen that for any level of internal inequality explained by the income generation function, a decrease in population size leads to a decrease in inequality measured by the Gini coefficient. In addition, countries with less economic diversity and small populations tend to report lower Gini coefficients. In contrast, a higher Gini coefficient is expected for countries with more economic diversity and large populations (Sitthiyot & Holasut, 2016). Existing literature on demographic relationship of income inequality suggests

that population growth contributes to increasing income inequality by encouraging the diversification and expansion of national economies, occupational differentiation, and growth in employment sectors with less equitable income distribution. According to this argument, as local markets grow and large numbers of rural migrants migrate to cities to pursue low-wage employment opportunities in manufacturing, emerging urban centers experience important economic differentiation. It is stated that while there will continue to be a small number of wealthy and established urban residents, the increasing number of low-skilled and low-wage workers will lead to an increased representation at the lower end of the income distribution, thus contributing to higher levels of income inequality (Butler et al., 2020). In view of the explanations, the findings of this research that population growth increases income distribution inequality are included in the related literature by Butler et al. (2020), Clark (2020), Rosés & Wolf (2020), Rougoor & Marrewijk (2015). Therefore, when the income composition in the countries in the sample group is reckoned with, population growth increases social heterogeneity and economic complexity and creates upward pressure on income inequality.

Based on the findings of this study for the possible impacts of HDI on income inequality, there is a negative nexus between the two parameters. In this direction, it is stated that inequality in income distribution decreases in countries with higher HDI rates. The findings confirm the consequences of the studies conducted by Alvan (2009), Castells-Quintana (2019), Ghifara et al. (2022), Hysa (2014), Mikk (2008), Purusa et al. (2025).

6. Conclusion and Policy Implications

In this research, the impacts of main economic sectors, labor force, population and human development on income distribution inequality in the EAGLE countries in the period 1990-2022 were analyzed. The findings showed that the driving forces of income distribution are the industrial sector, labor force participation rate and HDI, which reduce income inequality, while the service sector and population growth have increasing impacts. The conclusions based on the findings necessitate examining the social effects of the distribution and redistribution processes of differences in income distribution. These requirements include the analysis, examination and evaluation of social policies implemented by states to reduce poverty and inequality (Beltran & Delgado, 2023).

The empirical analysis evidence points to important conclusions. First, it provides evidence for the existence of a nonlinear connection between sectoral growth and inequality in China, India, Indonesia, Russia, Brazil, Türkiye and Mexico. In this regard, it is observed that while growth in the industrial sector reduces income inequality within the population, the increasing impact of the service sector promotes income inequality. A specific observation on the influence of growth in the main economic sectors provides insights into the problem of income inequality. Changes in income inequality are more elastic for growth in the service sector than for growth in the industrial sector. This finding supports the strategies of leading developing countries to promote growth in the service sector.

Considering that traditionally the development processes of the economy go through stages as agriculture, industry and service sectors, it is evaluated that the decreasing role of agriculture does not have an influence on income inequality in the countries in question. The results show that the industrialization process has been largely experienced, the service sector is the engine of economic growth and thus the growth in the service sector creates the traditional first income inequality increase as the economy developments. It is possible that the wage gap increases in the service sector create the largest income gap among workers in the service sector and other sectors. The policy implication contributes to the broader policy objectives of governments in the service sector to ensure justice in income distribution. In this direction, it is recommended that policies that will ensure the convergence of wage gaps in the service sector, which contributes the most to income inequality, be adopted and research on the size of the informal sector be conducted. More comprehensive and additional research is needed at this point.

Another policy implication is that decision makers should count on the widening of sectoral changes in income distribution inequality. Accordingly, social protection policies that minimize income inequality should be developed to reduce vulnerability to poverty. Effectively promoting labor markets and improving the socio-economic capacity to manage unemployment, disability and handicap will reduce income inequality and thus increase human development. The empirical evidence from this research can form a basic framework for promoting inclusive economic development that achieves income equality in EAGLE countries.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement

All authors contributed equally to the article.

Declaration of Researcher's Conflict of Interest

There are no potential conflicts of interest in this study.

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