



## Economic and Social Changes in the Demographic Structure of Romania

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**Abstract:** This article aims to capture a series of changes recorded in the demographic structure of Romania as a result of the transition from a centralized economy to a market economy. It is a known fact – which it was started from – that in the pre-1989 time, there was a balanced development strategy for all areas of Romania. A harmonious development of all areas of a country contributes to a balanced capitalization of local potential and, last but not least, to a unitary economic and social development throughout the entire territory of a country. Comparatively, the demographic results recorded in Romania after the transition to a market economy are analyzed in order to detect both the level of concentration of some economic indicators, and the trends recorded by them. This research will be carried out on the basis of a statistical toolkit, combined with graphical analysis. In this sense, the R studio software will be used, whose tools will be incorporated into the content of the article. In this way, it is considered that this article can contribute to the popularization of this particularly useful software in economic research.

**Keywords:** demography; birth rate; migration

**JEL Classification:** F22; J10; J11; J61

### 1. Introduction

The demographic structure reflects the evolution of the population according to age, birth rate, mortality and migration. In Romania, the economic and social changes of the last decades have profoundly influenced the demographic dynamics, determining significant transformations in the way of life of the population and in its territorial distribution.

The transition from a centralized economy to a market economy, integration into the European Union and globalization have had visible effects on birth rate, migration and population aging, shaping new demographic realities.

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## **2. Literature Review**

There is a wide interest in the literature on structural changes. Much of this literature investigates different drivers of structural changes, such as demographic changes, technology - related productivity growth, or income growth. Research has shown that there are a number of countries that are highly urbanized without a significant shift in economic activity in industry or services. Gollin (2014) considered that countries have been identified as natural resource exporters and do not conform to the standard model of urbanization. It is noted that although the development literature often assumes that urbanization is synonymous with industrialization, the models differ significantly across developing countries.

Duarte and Restuccia (2010) investigate the role of sectoral labor productivity in explaining the process of structural transformation - the secular reallocation of labor across sectors - and the time path of aggregate productivity across countries. The authors measure sectoral labor productivity across countries using a model of the structural transformation.

Glaeser (2013) explained the rise of poor mega-cities, contrasting them with historical trends, by modeling how in open economies, desperation (not prosperity) drives urbanization, leading to rapid population growth from natural increase (births > deaths) rather than migration. This paper modeled the connection between urban size and institutional failure and shows that urban anonymity causes institutions to break down. For large cities with weak governments, draconian policies may be the only way to curb negative externalities, suggesting a painful tradeoff between dictatorship and disorder.

Duranton (2008) reviewed the evidence about the effects of urbanization and cities on productivity and economic growth in developing countries using a consistent theoretical framework.

Uy, Yi and Zhang (2013) studied the importance of international trade in structural changes. This framework has both productivity and trade cost shocks and allows for non-unitary income and substitution elasticities.

Sposi, Yi and Zhang (2024) approached a new evidence on deindustrialization and document a new pattern: increasing industry polarization over time. They assess whether these new features of structural change can be explained by a dynamic open economy model with two primary driving forces, sector-biased productivity growth and sectoral trade integration. In this study it is also quoted Rodrik (2016) who pointed out the hump-shaped relationship between industrialization (measured by employment or output shares) and incomes, that has shifted downwards and moved closer to the origin. This means countries are running out of industrialization opportunities sooner and at much lower levels of income compared to the experience of early industrializers.

Dumitru (2025) remarks that official data show that Romania functions as a country with two economies. The West and Center of the country have GDP per capita close to the European average, while the East and South remain at the bottom of the ranking. The capital city and Cluj absorb the largest investments and the gaps are widening. One of the reasons is that big cities push the economy, meanwhile the rural areas remain stuck.

This demographic topic has also been addressed in various European Union projects. Contemporary directions in urban development, economics and technology have changed the way cities interact at local, regional and sometimes national levels and have blurred the boundaries between urban and rural. Addressing issues strictly at the city level is increasingly difficult, as modern metropolises influence areas far beyond their administrative boundaries, while small and medium-sized cities need to cooperate to remain competitive and policymakers need effective comparative methods.

Matthess and Kunke (2020) point out that developing countries have high hopes of compensating for the demographic problem by introducing digital technologies and, at the same time, driving the transformation of the economy towards prosperity. The literature on structural changes considers technology as a determinant of employment shifts across economic sectors, but the underlying mechanisms are often overlooked.

### **3. Analytical Techniques**

This study used both descriptive and econometric data analysis methods.

Descriptive statistics is important in providing insight into the distribution of the data, as well as, explaining some important statistical measures prior to the econometric analysis.

The econometric analysis was carried out with the R studio program in order to research, explore and interpret the results.

The dependence of indicators is a statistical concept based on mathematical and methodological principles that allow the analysis and interpretation of associations between variables, thus facilitating the understanding and explanation of phenomena and behaviors observed in the context of the data under analysis.

### **4. Analysis of the Demographic Structure of Romania**

This study points out the main causes that led to the remodeling of the demographic distribution – that will be analyzed.

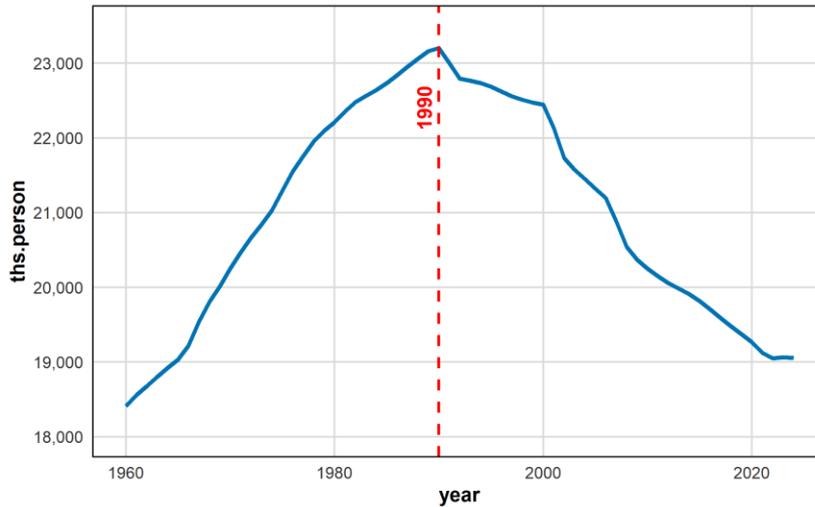
Romania's demographic structure is strictly linked to the demographic crisis, which represents one of the most profound social phenomena of the post-communist time. After 1990, the country's population registered a constant decline, generated by a complex of economic, social and cultural factors.

#### **4.1. The Impact of Birth Rate on Demographic Structure**

In Romania the demographic policies were strongly influenced by restrictive regulations, such as a Decree no. 770/1966 which prohibited abortion, up to 1990 year. This measure produced an artificial increase in birth rate, followed by a sharp decline after 1990, after liberalization of these restrictions. It can be said that the entire demographic growth in the period prior to 1989 was annihilated by the drastic decrease that followed. On the one hand, during 1966-1989, according to official statistics, only as a result of the aforementioned decree, 9,452 women lost their lives, but this number is not real, it must be interpreted as being much understated due to the evil policy of hiding the truth. On the other hand, this legislative framework had a harmful effect as a result of the opposite behavior of the population generated by the freedom of choice, after the democratization of the post-December revolution society.

Another set of factors that influenced the demographic structure were those related to the transition of the economy from a command to a market one, which produced great uncertainty related to the emergence of phenomena such as inflation, the closure of major economic objectives that generated unemployment, as well as other phenomena with a pronounced negative effect.

In order to analyze the population evolution between 1960-2024, it will be used the World Bank database accessible on <https://data.worldbank.org/> and select the SP.POP.TOTL indicator.



**Graph number 1. Evolution of the total population of Romania between 1960-2024**

*Source: Author processing based on World Bank data*

This evolution of Romania's total population, corresponding to this time, can be modeled by a parabolic curve whose parameters are given below:

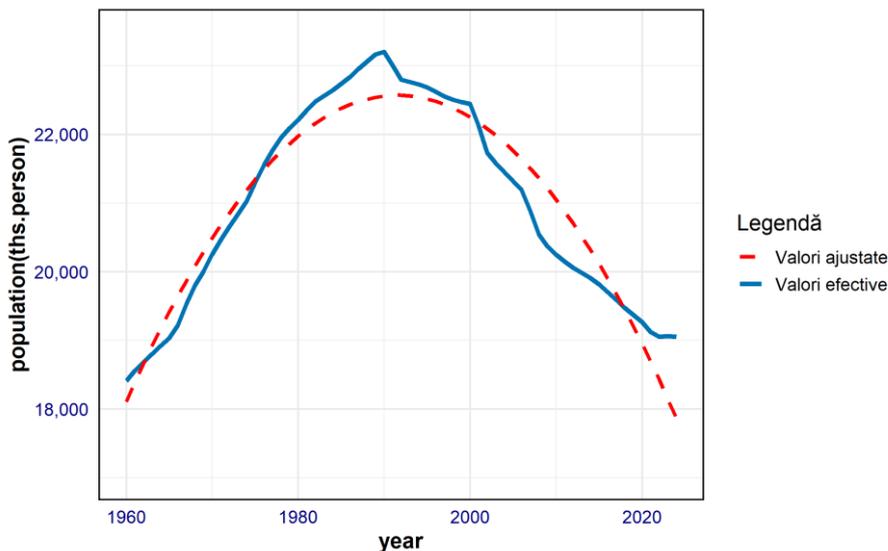
```
Call:
lm(formula = rom_pop_mii ~ time + I(time^2), data = ro)

Residuals:
    Min       1Q   Median       3Q      Max
-845.03 -300.72   68.14  284.27 1201.27

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 17573.5196   164.7856  106.64 <2e-16 ***
time         299.0213    11.5213   25.95 <2e-16 ***
I(time^2)    -4.4740     0.1692  -26.44 <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 429.3 on 62 degrees of freedom
Multiple R-squared:  0.9187
Adjusted R-squared:  0.9161
F-statistic: 350.5 on 2 and 62 DF
p-value: < 2.2e-16
```

It can be seen that the model is significant through its parameters and through the close connection between population evolution and the time factor. The quality of adjustment the evolution of the total population of Romania can also be appreciated visually based on graph number 2:



Source: Author processing based on World Bank data

**Graph number 2: Evolution of Romania's population between 1960-2024**

This model illustrates that the evolution of Romania's total population is downward, fact that would require urgent measures to support the birth rate through economic and social policies.

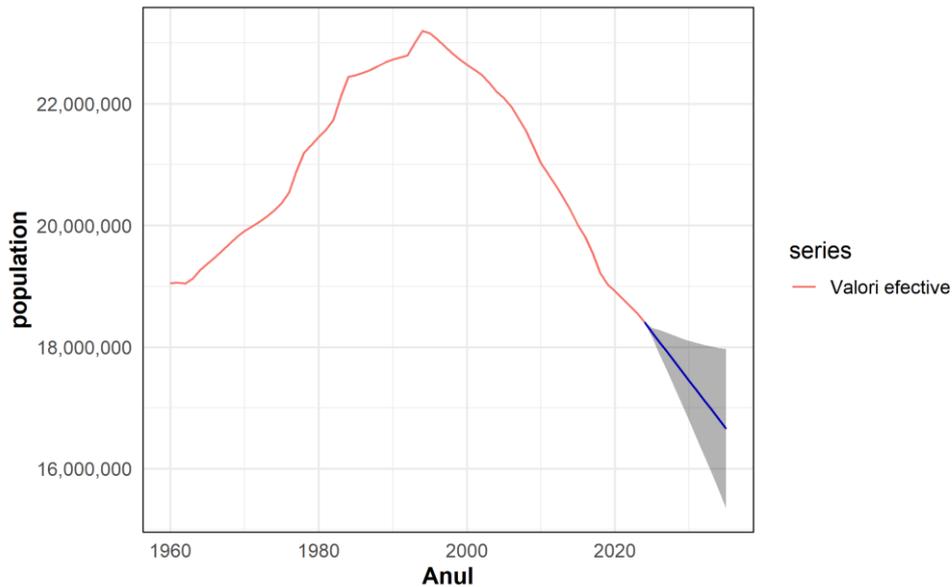
This downward trend of the indicator can also be expressed by approaching an ARIMA model:

```
Series: ro_ts
ARIMA(0,2,3)

Coefficients:
      ma1      ma2      ma3
      0.4547 -0.6768 -0.1927
s.e.  0.1416  0.0932  0.1447

sigma^2 = 3.462e+09: log likelihood = -780.87
AIC=1569.74 AICc=1570.43 BIC=1578.31

Training set error measures:
      ME      RMSE      MAE      MPE      MAPE      MASE
Training set -4719.339 56530.28 38048.69 -0.01746697 0.1783462 0.2715006
      ACF1
Training set -0.02776781
```



Source: Author processing based on World Bank data

**Graph number 3: Evolution of the Romanian population between 1960-2035 (processed with the ARIMA model)**

### Data interpretation

ARIMA Model (0,2,3) Equation:

$$\nabla^2 y_t = c + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \theta_3 \varepsilon_{t-3} + \varepsilon_t$$

- $y_t$  - total population of Romania
- $\Delta^2 y_t$  - second difference (variance of population variance)
- $\varepsilon_t$  - random error (demographic shock)
- $d=2$  indicates a curvilinear trend (accelerated decline)
- $q=3$  indicates the influence of shocks in the last three years.

### ARIMA Model (0,2,3)

The estimated model for the total population of Romania is:

$$\nabla^2 y_t = c + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \theta_3 \varepsilon_{t-3} + \varepsilon_t$$

- $y_t$  - the total population of Romania at  $t$  time
- $\nabla^2 y_t = y_t - 2y_{t-1} + y_{t-2}$  - the second difference, which reflects the variation in population change (i.e. the acceleration or deceleration of the demographic trend)
- $\varepsilon_t$  - random term (demographic shock), representing unexpected factors affecting the population in a year
- $d = 2$  indicates that the series presents a curvilinear trend (second order), specific to an accelerated population decline
- $q = 3$  shows that the current evolution is influenced by the shocks of the last three years, through the moving average component (MA(3)).

The estimated coefficients for the MA terms are:

$$\theta_1 = 0.4547, \quad \theta_2 = -0.6768, \quad \theta_3 = -0.1927$$

They describe the lagged effect of shocks on population change: a positive shock (e.g., an unexpected increase in population) tends to be followed by a negative adjustment in subsequent years, signaling a gradual return to the underlying downward trend.

#### ARIMA Model (0,2,3)

The estimated model for the total population of Romania between 1960–2024 is:

$$\nabla^2 y_t = \varepsilon_t + 0.4547 \varepsilon_{t-1} - 0.6768 \varepsilon_{t-2} - 0.1927 \varepsilon_{t-3}$$

where:

- $y_t$  is the total population at  $t$  time
- $\nabla^2 y_t = y_t - 2y_{t-1} + y_{t-2}$  represents the second difference (to eliminate the second-order trend)
- $\varepsilon_t$  is the random error term (demographic shock).

The ARIMA Model (0,2,3) indicates that the evolution of Romania's population is determined mainly by slow structural changes (curvilinear trend) and the effects of demographic shocks in the last three years.

The positive coefficient  $\theta_1 = 0.4547$  shows that an unexpected positive change in population in one year (e.g., an unexpected increase) tends to be followed by a slight increase in the following year.

In contrast, the negative coefficients  $\theta_2 = -0.6768$  and  $\theta_3 = -0.1927$  suggest that these shocks are quickly corrected, and the positive effects are partially reversed in the next two to three years.

Overall, the model describes a population in a process of adjustment: after each deviation from the main trend, there is a gradual return to the general downward trajectory, specific to the post-1989 time.

The ARIMA Model (0,2,3) suggests that the evolution of Romania's population is influenced by lagged effects of demographic shocks and maintains a long-term decreasing trend.

The economic changes after 1990, combined with the high cost of living, wider access to education and the desire for professional achievement, have led to a drastic reduction in the birth rate. As a result, Romania is facing a very low birth rate, insufficient to ensure the replacement of generations.

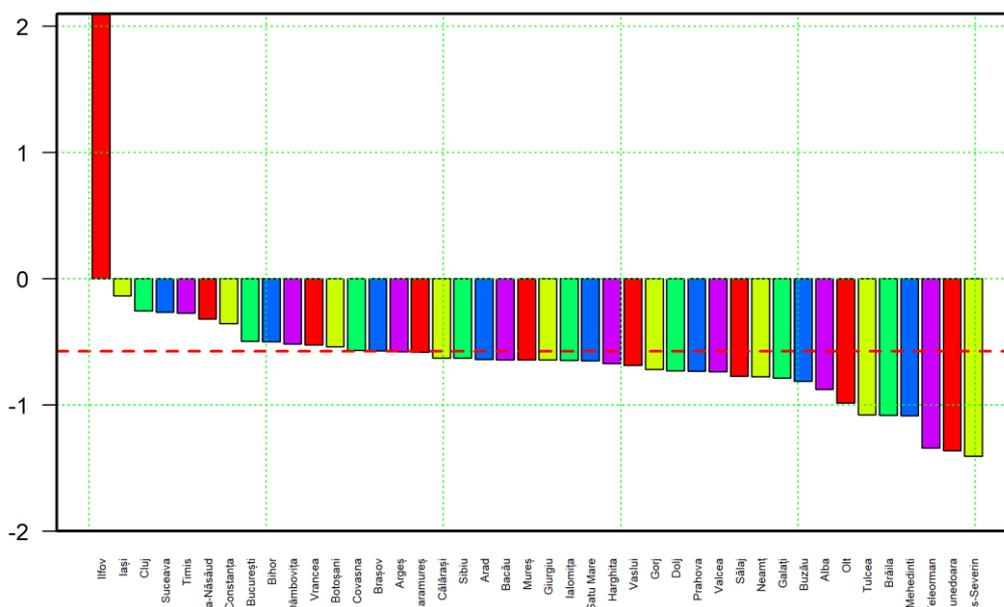
## 4.2. The Impact of External Migration on the Demographic Structure

In addition to the decline of birth rates, external migration has played a key role in population decline. After Romania joined the European Union in 2007, millions of citizens chose to work in other member states, thus contributing to the exacerbation of internal demographic imbalances. Rural areas and less developed regions have also been affected, recording a sharp aging of the population and the depopulation of small towns.

According to data from the National Institute of Statistics and the European ARDECO data-bases, Romania's population has decreased from over 23 million inhabitants in 1990 to approximately 19 million in 2024. This trend is accompanied by an increase in the average age, and a decrease in the share of the active population, with major implications for the labor market, the pension system and long-term economic sustainability.

This population decline trend has recorded different rates at the level of the country's counties. It should be noted that the only city that deviates from the general trend is Ilfov, which recorded an increase of 2.1%, the explanation being that part of the population of Bucharest migrated to less crowded and lower-cost residences.

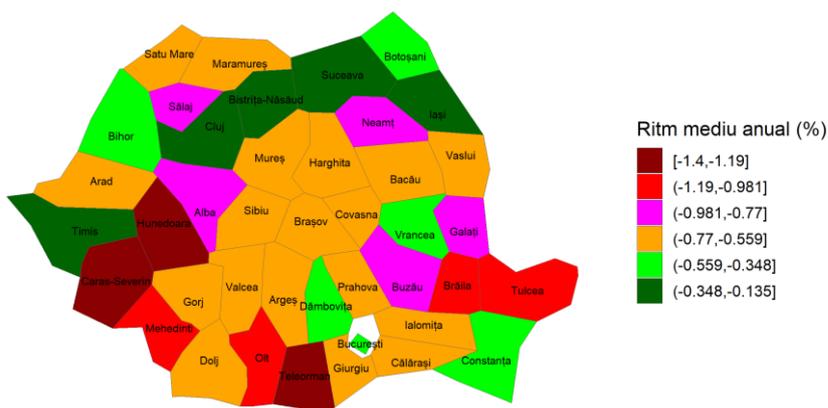
In the following graph, the horizontal line denotes the average annual population reduction of -0.575% compared to the average for the entire country.



Source: author processing based on World Bank data

Graph number 4. Average annual population change rates between 1990-2024

In order to have a better visualization of the population change rates between 1990-2024, it is presented in graph number 5.



Source: ARDECO / SNPTN

Graph number 5. Average annual rate of population changing between 1990-2024

External migration is one of the most powerful social phenomena that have shaped Romania in recent decades. The departure of millions of people to work in other countries has changed not only demographic statistics, but also how the economy works, and further local communities, the families, and even the way of reporting to the future. The consequences of external migration are complex: they

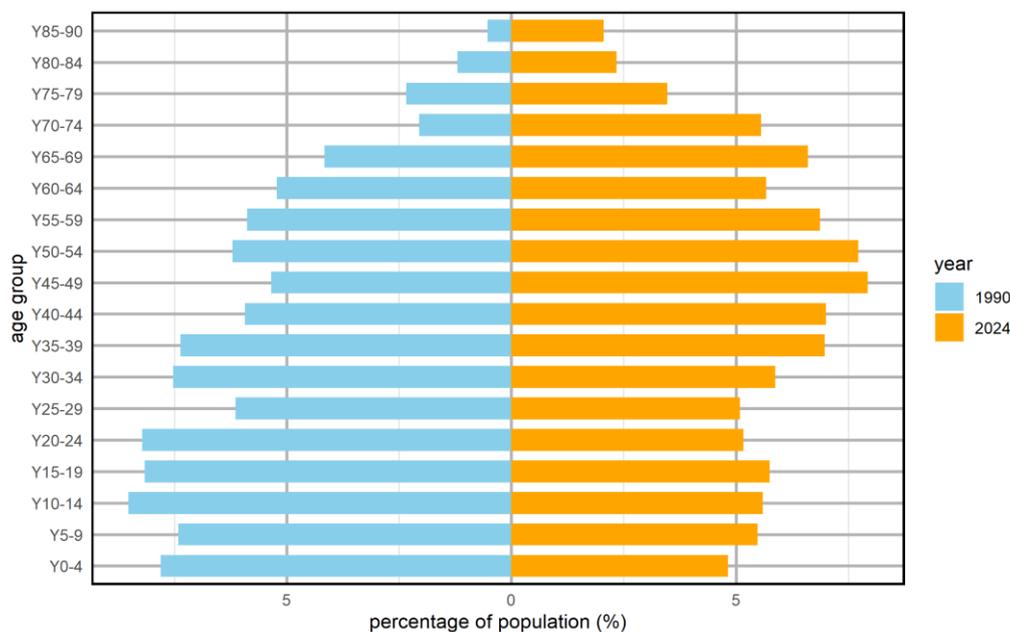
bring real benefits to many households, but also generate long-term costs in society, which are difficult to repair.

### 4.3. The Impact of Population Aging on the Demographic Structure

The evolution of the Romanian population has recorded another negative phenomenon, that is the aging of the population, that can be expressed through the age pyramid.

This still had a vigorous base in 1990, being fueled by numerous young generations - a sign that the birth rate remained relatively high. Meanwhile, up to 2024, the demographic picture has been remodeled: the base has narrowed considerably, indicating a sharp reduction in the young population. There are fewer and fewer children and adolescents and this reflects the decline in the birth rate, the migration of young people and the postponement of the moment to have children.

At the top of the pyramid, however, things swell like a sail caught in a warm wind: the elderly population has visibly increased. This expansion of the over 60–65 years old segment is the result of increased life expectancy, improved healthcare system, and the maturation of the numerous generations born before 1990. The combined transformation - a narrowing base and a widening peak - reflects an aging population. This shift brings economic and social challenges: pressure on the pension system, the need to expand services for the elderly and a labor market that will need ingenious adjustments to maintain the balance between generations.



Source: ARDECO / SNPTZ

**Graph number 6. Age pyramid of the Romanian population in 1990 vs 2024**

The consequences of population ageing are profound for the economy. An older population usually means fewer people in the workforce, and more people dependent on their contributions. There is pressure on companies through staff shortages, on wages through necessary but sometimes difficult to sustain wage increases and on the economy's capacity to grow rapidly. In parallel, a balancing act is becoming more pronounced: the state must simultaneously finance pensions, healthcare and social services for a larger elderly population, with a relatively smaller contributor base. At the European level, Eurostat shows that the dependency ratio between the number of elderly people and the working-age

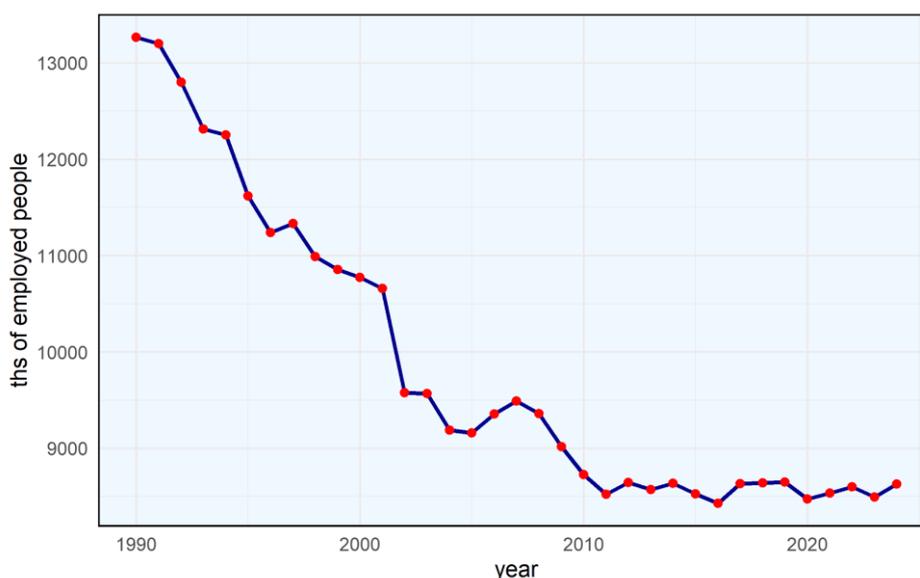
population is projected to increase sharply in the coming decades, suggesting that the pressure will continue both at the European level and for Romania.

#### 4.4. The Impact of the Employed Population on the Demographic Structure

Another important socio-economic change that a country can go through because it produces cascading effects is the decline of the employed population. When population decreases, the impact is not seen in statistics, but also in the pace of development, in the financing of public services, in the life of communities and in people's confidence in the future.

In Romania, the discussion about the decline in the employed population appears against the backdrop of two realities: on the one hand, the employment rate remains relatively modest compared to the EU average and, on the other hand, the demographic base is diminishing.

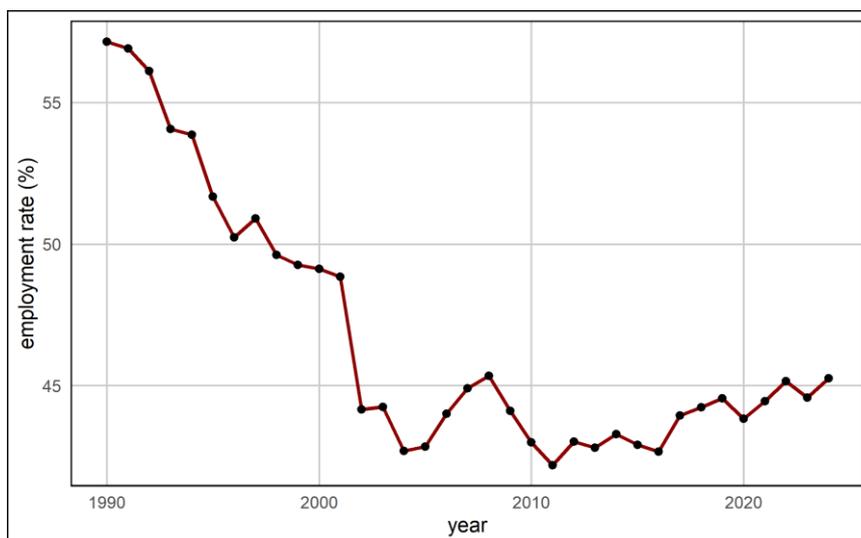
As a direct consequence of these quantitative and qualitative changes in Romania's population from 1990-2024, there was also a sharp decrease in the number of people employed in the economy from 13.2 million to only 8.63 million – ss per the next figure presents.



Source: ARDECO / SNETD

**Graph number 7. Evolution of the number of people employed in Romania between 1990-2024**

The evolution of the percentage of employed population out of the total population, is also significant is, as shown in graph number 8, decreased from 57.15% to 45.25%.



Source: ARDECO / SNPTN and SNETD

**Graph number 8: Employment rate in Romania between 1990-2024**

This trend indicates that the number of people who actually contribute to economic growth and the financing of social systems is decreasing, while the number of dependents – the elderly or inactive people – is increasing.

One of the first consequences is the increased pressure on the public budget. Fewer employees mean fewer contributions to the pension, health and social security budget, while spending on inactive people, especially the elderly, is increasing. This situation can lead to fiscal imbalances, the need to increase taxes or to reforms of social systems.

In economic terms, the decline in the employed population reduces the potential for economic growth. A smaller workforce limits the economy's ability to produce goods and services, affects competitiveness and can discourage investment. At the same time, companies face difficulties in recruiting workers, which can lead to higher wages, but also to lower productivity in sectors with a shortage of personnel.

The social impact is equally significant. A lower proportion of employed people means higher economic dependency: each employee has to support a larger number of people through contributions. This can generate intergenerational tensions, especially in a context where the working population feels fiscal pressure and the elderly population demands increasingly extensive social services.

Last but not least, the phenomenon affects the structure of the labor market. The role of immigration as a solution to the labor shortage is increasing and automation and digitalization are becoming essential for maintaining productivity. At the same time, public policies are needed to stimulate labor market participation – through training programs, support for young people, improving working conditions and making programs more flexible.

As a summary, the decrease in the employed population from 57.15% to 45% has profound effects on the economy and society, generating pressure on the public budget, slowing economic growth and increasing demographic dependence. Managing these consequences requires a coherent strategy of economic, social and demographic policies, capable of maintaining the balance between generations and the sustainable functioning of the economy.

#### **4.4.1. Dependence between Employed Population and GDP/Capita**

The following proposes an assessment of the dependence between the employed population and GDP per capita, in other words, how this decrease in the labor force is reflected on economic growth. In this

line, the dependency at the level of the cities of Romania was chosen, excluding Bucharest which represents a particular case at the level of the year 2024.

```
Call:
lm(formula = log_gdp ~ log_labor, data = my)

Residuals:
    Min       1Q   Median       3Q      Max
-0.62169 -0.17180  0.00476  0.19627  0.54870

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  8.14046    0.47660  17.080 < 2e-16 ***
log_labor    0.27008    0.09284   2.909  0.00596 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2639 on 39 degrees of freedom
Multiple R-squared:  0.1783
Adjusted R-squared:  0.1572
F-statistic: 8.463 on 1 and 39 DF
p-value: 0.005956
```

A log-log model (also called a double logarithmic model is a regression model in which both the dependent variable and the independent variable are transformed with logarithm) was chosen so that it is representative both in terms of parameters and errors. Another advantage of this type of model is that the factor parameter expresses elasticity, in other words, in the present case, a 1% increase in the employed population contributes to a 0.27% increase in GDP per capita. Based on the results, it can immediately proceed to expressing the model in the initial terms, which will be of the following form:

$$GDP = e^{8.14046} \cdot Labor^{0.27008}$$

$$GDP \approx 3416.8 \cdot Labor^{0.27008}$$

```
# Model data
R2 <- 0.1783 # R-squared
n <- 41     # number of observations
k <- 1     # number of regressors
# F-statistic calculation
F_stat <- (R2 / k) / ((1 - R2) / (n - k - 1))
# Calculation p-value
p_value <- pf(F_stat, df1 = k, df2 = n - k - 1, lower.tail = FALSE)
# Display results
F_stat

[1] 8.462578

p_value

[1] 0.005958305
```

```

if (p_value < 0.01) {
  cat("The model is statistically significant at the 1% level.")
} else if (p_value < 0.05) {
  cat("The model is statistically significant at the de 5% level.")
} else {
  cat("The model is not statistically significant.")
}

```

The model is statistically significant at the level of 1%.

### Data Interpretation

The p-value associated with the F-test is approximately 0.006, lower than 1% significance threshold, indicating that the model is statistically significant at 1% level.

Consequently, there is strong statistical evidence that the variable log(Labor) explains a significant portion of the variation log(GDP).

Although the coefficient of determination is relatively low ( $R^2 = 0.1783$ ), the F test confirms that the estimated relationship is not the result of chance, but reflects a statistically significant effect of the labor factor on GDP.

OK: Residuals appear to be independent and not autocorrelated ( $p = 0.184$ ).

OK: Error variance appears to be homoscedastic ( $p = 0.085$ ).

OK: residuals appear as normally distributed ( $p = 0.983$ ).

OK: Simulated residuals appear as uniformly distributed ( $p > .999$ ).

## 5. Conclusions

Economic and social changes have had a major impact on Romania's demographic structure. The decline in birth rates, migration and population ageing represent important challenges for the country's macroeconomic strategy. In order to ensure sustainable development, it is necessary to adopt economic and social policies that support the family, encourage the return of Romanians from the diaspora and ensure a long-term demographic balance.

Economic and social changes not only accompany demographic change, but also shape it, creating a circle of mutual influences between the level of development, migration, fertility and quality of life. In order to limit the negative effects and capitalize on the opportunities, coherent public policies are needed: support for families and birth rates, measures to reduce regional disparities, investments in social and health services adapted to ageing, as well as realistic strategies to manage migration and increase domestic economic attractiveness. Romania needs an integrated approach, in which demography is treated as a strategic indicator of development and social security, not just as a consequence of economic changes.

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