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Predictive modeling and analysis of changes migrations in Poland

Monika Nawrocka

The Jerzy Kukuczka Academy of Physical Education in Katowice,
72A Mikolowska Street, 40-065 Katowice, Poland

E-mail address: monika.nawrocka@centrumstatystyczne.pl

ABSTRACT

The development of the research in economy has shown that conducting mathematical modeling and statistics is an effective instrument for diagnosing the progress phenomenon of socio-economic. It provides the information about the dynamics of result changeability in different periods of time. Additionally statistical analysis allows determining the prediction for periods of future and past years. Migrations is characterized by the quality of being measurable because it includes quantitative data. In recent years, demonstrate high dynamics. Conducting the analyses and calculations based on methods and statistical instruments will result in the opportunity to compare, group, analysis variables, specify trends and designate the diagnoses of achieved sports results with the implementation of the optimum vector of variables of independent variable of migrations. An analysis of the dynamics migration variability was carried out on the basis of data from the website of the main statistical office, in this article. Used the statistical methods and the testing of interdependencies. Additionally, the models of time series have been used for the sake of the analysis. The most significant aim of the analysis of the dynamics is the designation of predictions. The use of the model of time series has the task of the specification of the change of the phenomenon level in time.

Keywords: dynamics migration, exponential smoothing, forecasting

1. INTRODUCTION

For many years there has been dynamic changes in the migration of women and men in Poland. It was found that the dynamics of immigration in men and women is higher than

emigration and was noticed a larger cardinality emigration of both gender. It has been proved that the cause of these changes is to rush in the direction of the west of Europe for commercial purposes (Fierla 2007).

Indicators volatility of migration were tested at an angle of positive or negative balance. Noticeable anomaly in the changes of migration up of the years 1946 when it reached a negative balance value of -654.8 thousand. After 1950, international migration stabilized at -4.4 to 5.8 thousand.

Unfortunately, after 1960 years the migration balance again returned to negative values, and is maintained to this day. In truncating the period 1946-2013 only in 1955-1956 and in 1959 was read positive international migration balance in Poland. This is somewhat problematic socio-demographic phenomenon.

Study included a list of the migration of Poles in the years 1946-2013. The study material consists database of international migration of women and men obtained from the website of the Central Statistical Office of Poland and EUROSTAT.

Based on theoretical and empirical formulas referenced in analysis of this research to calculate the moving average for each of the analyzed phenomenon under which were determined predictive values in the time frame: 1990-2023 year. The work has two main stages pertaining to optimization of migration rates a function of time, 1990-2013 and designation forecasts for future of 10 periods in the form of time series.

Research was targeted also in order to obtain answer the following research questions based on character analytical:

- What is the direction of the trend and the dynamics of the changes of the emigration and immigration for women and men?
- What is the prediction of the changes in migration in the case of both gender?
- Whether in the coming years will accelerate or deceleration of emigration and immigration for women and men?

2. THEORETICAL BACKGROUND

Socio-economic phenomena are part of the discipline of economics, which is characterized by measurability. Means that the all processes can be subjected to mathematics and statistics analysis. Any empirical data can be compared and classified. Having a data of input and knowledge of the dynamics variation of mass phenomena of a quantitative can provide in different ways their forecast with curves marked trend indicators. From the above whereas follows that for predictive testing and analysis of variance, designed to detect changes and to determine their dynamics in function of time, the most appropriate method is to analyze these results in suitably long period (Brandt 1998; Maszczyk 2013; Nawrocka 2014). Latest methods of realizing such assumptions are modern computer tools and statistical and mathematical software (Krzysztofiak, Urbanek 1981).

The problem of migration issue in Poland has enormous scientific achievements. Beginning with statistical yearbooks processed by the Central Statistical Office of Poland after the a rich literature of Polish economists. However, selectively is conducted the analysis. Few studies include an analysis of the variability in the values of indexation not to mention the models of exponential smoothing Holt's linear trend method. All works prognostic are created on regression models with lower quality results (Luszniewicz, Słaby 1990; Żurada,

Barski, Jędruch 1996; Osowski 2000). In this situation, it should be noted that any economic phenomenon should seek to maximize namely designation most optimal models, or variables. Therefore the problem of selection of appropriate research methods and tools is particularly important for the credibility of estimated forecasts. Lacking work discussing simultaneously the variability of immigration and emigration in comparative analysis of for women and men with regard to the prediction models.

2. 1. Method of data collection and analysis

Mathematical modeling occupies a key element of socio-economic studies. The analyzes conducted were based on a function of time. Immigration and emigration of highest values were the predictors. All analyzes were performed by using the exponential smoothing and estimate of variance.

Forecasts were determined using Holt's linear trend method on the basis of formulas (Iwanejko, Bajer 2012):

$$F_t = \alpha * y_t + (1-\alpha) * (F_{t-1} + S_{t-1})$$

$$S_t = \beta * (F_t - F_{t-1}) + (1 - \beta) * S_{t-1}$$

where:

α , β – parameters of smoothing from the interval [0,1]

As can be seen model consists of two equations. The first equation F_t smooths forecasted variable values $\{y_t\}$. In turn, the equation S_t smoothed growth trend. Minimizing the mean square error is obtained by adopting values for $F_t = y_1$ and $S_t = y_2 - y_1$. Forecasts for the times $T < n$ is determined as:

$$\widehat{y_{t+1}} = F_t + S_1$$

Therefore, the forecasts of the number times smaller than the number of words time series are called expired . Forecasts for $T > n$ is determined as:

$$\widehat{y_T} = F_t + (T - n)S_1$$

Application of the Holt's linear trend method usually provides a good fit to the empirical data, which indicates the reliability of obtained estimates. To analysis was adopted parameter values: $\alpha = 0,1$ and $\beta = 0,9$.

To minimize the error was performed estimate of variance the exponential smoothing model of trend Holt to achieve precise quality forecasts.

3. ANALYSIS

Began by the presentation of the characteristics of the results of empirical data for each subclass of migration of the volatility in the period from 1990 to 2013 years. In the next

sequence, presents an analysis of time series based on the input data emigration and immigration for women and men, with linear trends. Graphically were compared curves time series with input data. According to the results of analyzes and comparisons of predictive values were determined with forecasts for the future 10 periods. Predictions discussed in terms of the factors affecting the dynamics of the volatility of migration. It is known fact that emigration rates significantly outweigh indicators of immigration in both gender.

3. 1. Emigration

The first, presented comparative characteristics data emigration of men and women in the period 1990-2013 (Table 1). Illustrates the analysis undertaken distribution and optimization results, along with forecasts for the graphs (Figure 1, 2 and 3).

Table 1. Empirical data of emigration for men and women as a function of time 1990-2013.

Gender	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2013
Women	9600	13039	12453	10415	10570	13259	12121	9161	19699	13978	9385	11249	17229
Men	8800	13305	13451	10882	11607	13740	12411	9716	27237	16162	7975	9951	14874

Source: own elaboration based on data from the Central Statistical Office of Poland, <https://stat.gov.pl/>

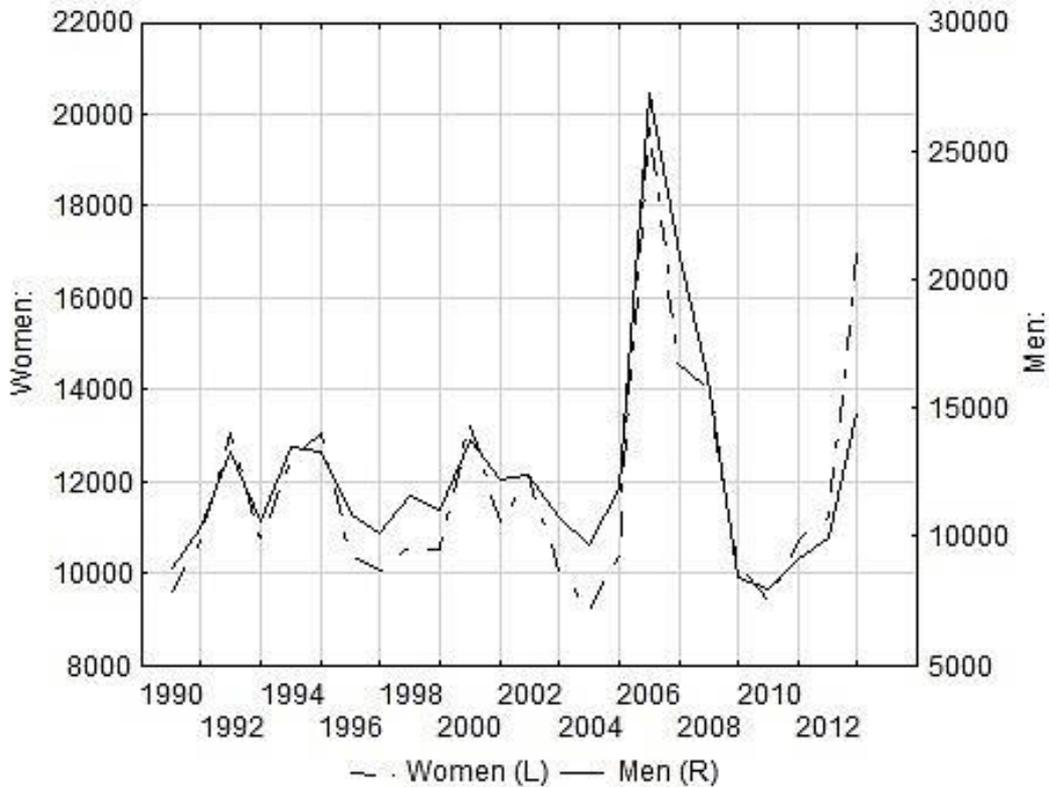


Figure 1. Empirical comparison of the emigration for women and men.

Source own elaboration

The analysis shows that the sum of emigration is higher for men a larger years. Only over the years 1990-1994 and 2010-2012 women achieved higher results. Highest incidence rates were achieved in women in 2013, with a value of 17229, which is 31.24% more than the average (11845) over the period. For men, the highest values were observed in 2006, with a value of 27237, which is 48,48% more than the average (14033).

The dynamics of variation in both gender differs significantly from the trend line and show large fluctuations. The largest decreases the variability of results over the entire period for women was recorded in 1993 (-17 per cent), 1996 (-20 per cent), 2001 (-16 per cent), 2003 (-17 per cent), 2004 (-9 per cent), 2007 (-26 per cent) 2009 (-27 per cent) 2010 (8 per cent). For men, declines were relatively small values and recorded in the years: 1993 (-20 per cent), 1996 (-21 per cent), 1998 (-36%), 2007 (-23 per cent), 2008 (-23 per cent), 2009 (-48 per cent).

The other hand the largest increases in the volatility of emigration for women was recorded in the years: 1992 (22 per cent), 2000 (26 per cent), 2006 (90 per cent), 2,013 (53 per cent). The dynamics of variation largest increases for men determines the extent of years: 1992 (29 per cent), 1994 (126 per cent), 2000 (25 per cent), 2005 (22 per cent), 2006 (129 per cent) 2013 (49 per cent).

The phenomenon of emigration on the basis of exponential smoothing Holt's linear trend method and estimate of variance discussed in the following table (Table 2 and Table 3). Transformation exponential smoothing curve in relation to the trend of growth variability of input data is illustrated in figures (Figure 2 and Figure 3).

Table 2. Emigration analysis and prediction for women using exponential smoothing Holt's linear trend method and the estimation of variance.

Years	1990	1995	2000	2005	2010
Exponential smoothing	9766	11894	12813	13062	14169
Years	1990	1995	2000	2005	2010
Estimation	9928	11421	12962	13707	14501
Prediction					
Years	2014	2015	2016	2017	2018
Value	13966	13819	14322	14451	14581
Years	2019	2020	2021	2022	2023
Value	14710	14840	14969	15098	15228

Source own elaboration

Table 3. Errors model Holt and transformation (estimation of variance) the emigration of women.

Error	Model	
	Holt's linear trend	Transformation (estimation of variance)
ME	-842,83	-1,8364
MAE	2261,66	144,7962
SSE	185735954	2199589
MPE	-10,75	0,02
MAPE	19,66	1,11

Source: own elaboration

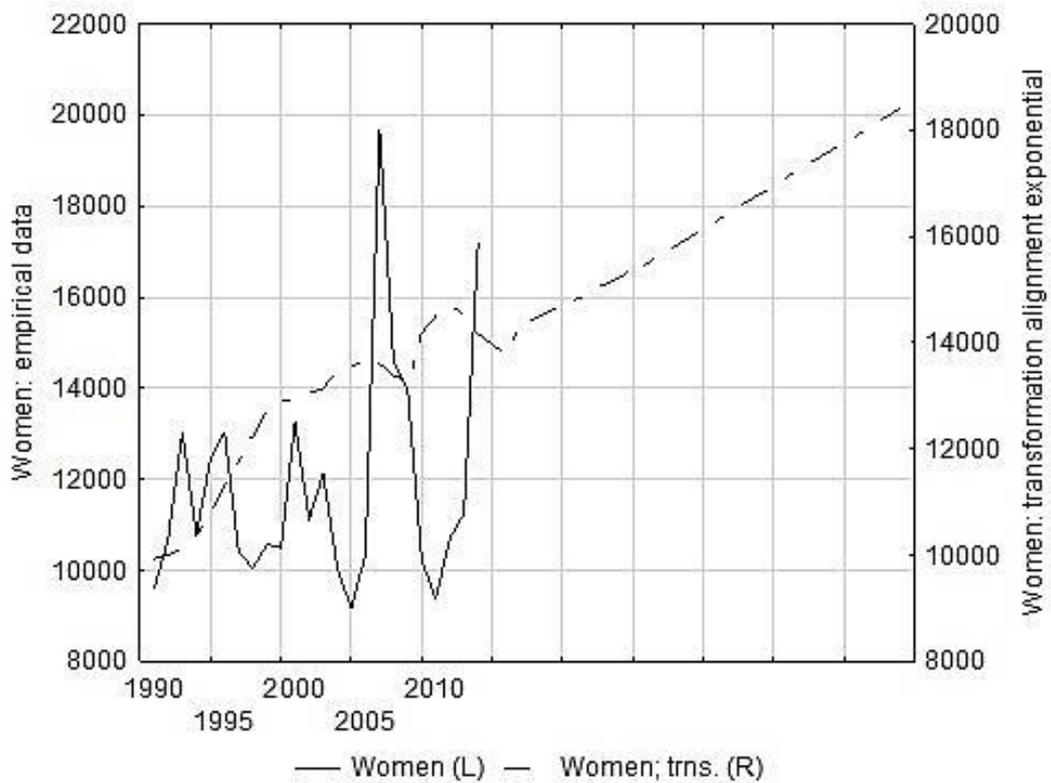


Figure 2. Emigration prediction for women using by transformation exponential smoothing in function of time 1990-2013.

Source own elaboration

In forecasting the emigration of women, the initial value of Holt smoothing model was $S_0 = 111,5$, and for the transformation of the model gave $S_0 = 112,1$. The average forecast of the Holt model is deflected by 19.66 per cent from the actual value, and it is not valuable result. However the information that the transformation of the model by estimating variance with average deviation of forecast of 1.11 per cent of the actual values is a valuable forecast for the emigration of women.

Table 4. Emigration analysis and prediction for men using exponential smoothing Holt's linear trend method and the estimation of variance.

Years	1990	1995	2000	2005	2010
Exponential smoothing	8932	11231	12653	13401	16140
Years	1990	1995	2000	2005	2010
Estimation	9151	10690	12650	13977	16642
Prediction					
Years	2014	2015	2016	2017	2018
Value	15569	15192	15347	15489	15632
Years	2019	2020	2021	2022	2023
Value	15774	15917	16059	16202	16345

Source: own elaboration

Table 5. Errors model Holt and transformation (estimation of variance) the emigration of men.

Error	Model	
	Holt's linear trend	Transformation (estimation of variance)
ME	-506,355	-2,47
MAE	3069,11	203,09
SSE	485696949	5735446
MPE	-12,3478	0,05
MAPE	26,13	1,44

Source: own compilation

In forecasting the emigration of men, the initial value of Holt smoothing model was $S_0 = 111,2$, and for the transformation of the model gave $S_0 = 111,9$. The average forecast of the Holt model is deflected by 26.13 per cent from the actual value, and it is not valuable result. However the information that the transformation of the model by estimating variance with average deviation of forecast of 1.44 per cent of the actual values is a valuable forecast for the emigration of men.

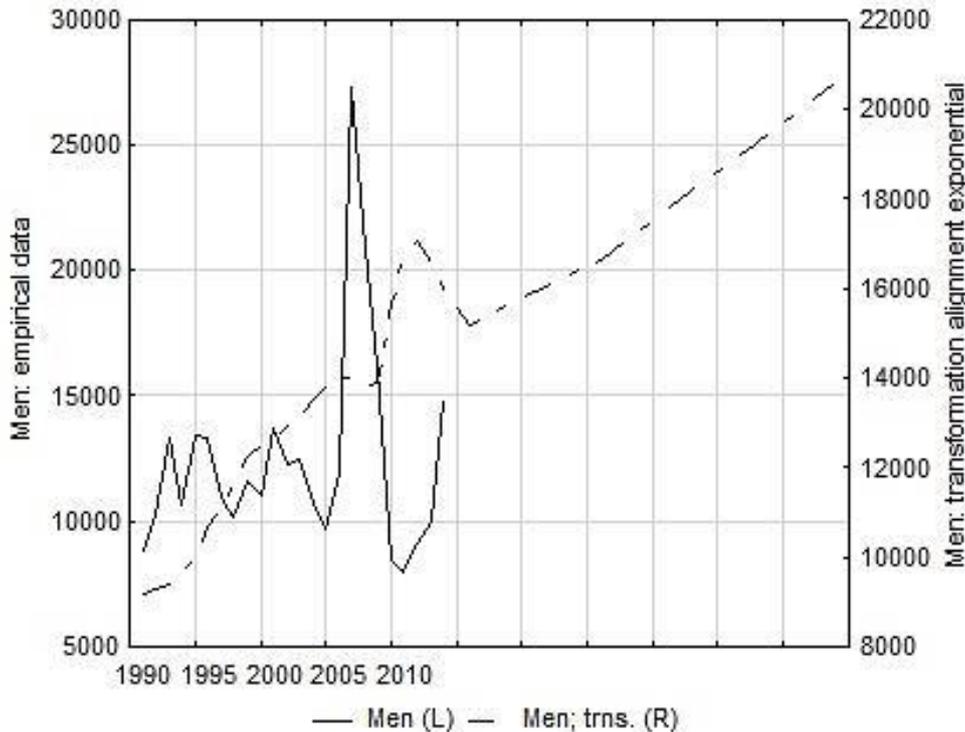


Figure 3. Emigration prediction for men using by transformation exponential smoothing in function of time 1990-2013.

Source: own elaboration

Prediction results indicates growth emigration of men in the next 10 years. Record maximum values were for men, not women. Even so, recognizes the maximum value emigration in men, not in women. Nonetheless, it is not a determinant the overall analysis, where are visible similar values for both gender. Trend Holt for men is only 0.8 per cent higher than for women.

Sequentially given the analysis prediction by using modeled neural made prediction of emigration on the basis of time series. This allowed the estimate of the future ten years.

3. 2. Immigration

As a second step of the analysis was to assess and comparing immigration of women and men. Predictive values were determined for both gender throughout the analyzed period. Subsequently, based on the linear trend Holt determined forecast of immigration on the future 10 periods. Compare the empirical data shown in following table (Table 6) and figure (Figure 4).

Table 6. Empirical data of immigration for men and women as a function of time 1990-2013.

Gender	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2013
Women	1100	3800	3338	4021	4516	3438	3058	4695	4864	6291	6235	6477	5345
Men	1500	4321	3569	4165	4400	3893	3529	4800	5938	8984	9011	8106	6854

Source: own elaboration based on data from the Central Statistical Office of Poland, <https://stat.gov.pl/>

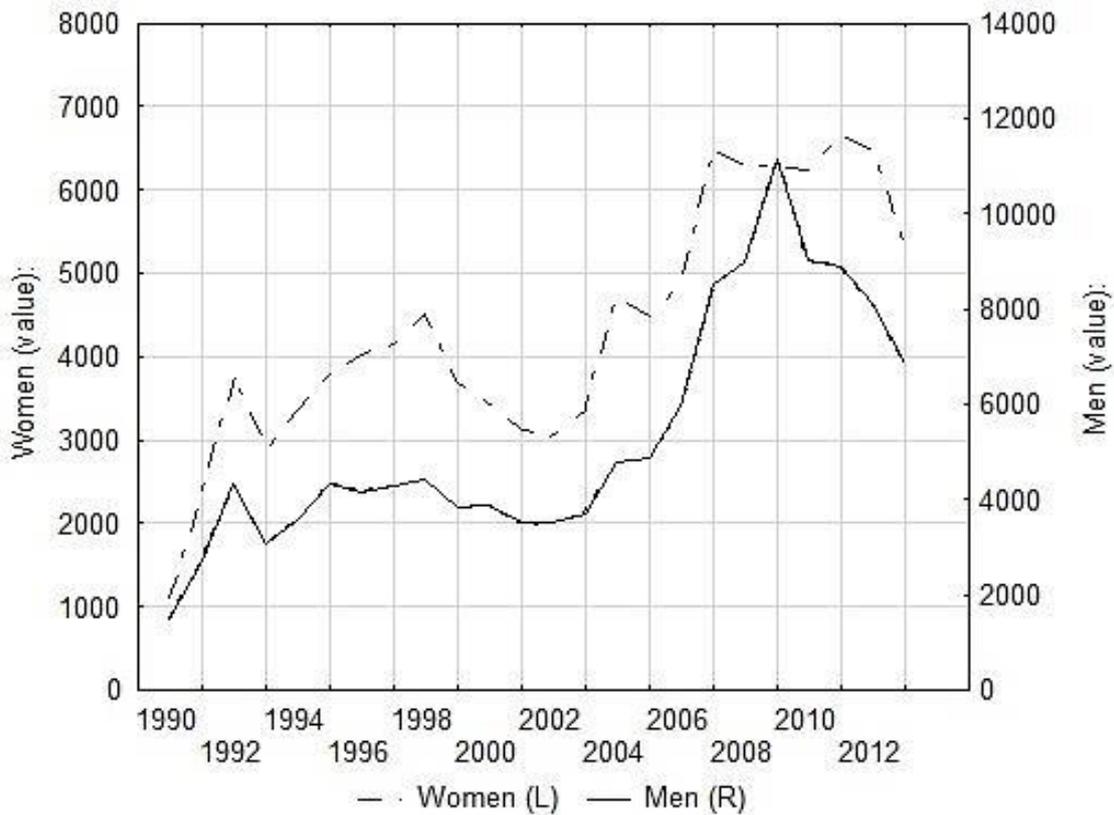


Figure 4. Empirical comparison of the immigration for women and men.

Source: own elaboration

Over the whole period demonstrated that the sum of immigration is higher for men. Highest incidence rates were achieved for women in 2011, with a value of 6661, which is 34.72 per cent more than the average (4348) over the period. For men, the highest values were observed in 2009, with a value of 11145, which is 52.2 per cent more than the average (5328) over the period.

The dynamics of variability immigration in both gender after 2000 shows an upward trend until 2012, after which there was a decrease in 2013. Declines indexation variability of the results were significantly lower than in emigration. The largest for women was recorded in

1993 (-24 per cent), 1999 (-19 per cent). For men, declines were recorded in the years: 1993 (-29.5 per cent), 1999 (-12.5 per cent), 2010 (-19 per cent).

In contrast, the largest increases volatility of emigration for women was recorded in the years: 1991 (109 per cent), 1992 (65 per cent), 2004 (41 per cent), 2007 (33.5 per cent). The dynamics of variation largest increases for men determines wide range years, namely: 1991 (80 per cent), 1992 (60 per cent) and 1995 (21 per cent), 2006 (22 per cent), 2007 (43 per cent), 2009 (24 per cent).

Values of analysis and prediction immigration by linear trend Holt and estimation of variance shown in following tables. (Table 7 and 9). Transformation exponential smoothing curve in relation to the trend of growth variability of input data is illustrated in figures (Figure 5 and 6).

Table 7. Immigration analysis and prediction for women using exponential smoothing Holt's linear trend method and the estimation of variance.

Years	1990	1995	2000	2005	2010
Exponential smoothing	1192	2711	4311	4945	5916
Years	1990	1995	2000	2005	2010
Estimation	1308	2616	4322	4970	6148
Prediction					
Years	2014	2015	2016	2017	2018
Value	7110	7170	7384	7597	7810
Years	2019	2020	2021	2022	2023
Value	8023	8237	8450	8663	8876

Source: own elaboration

Table 8. Errors model Holt and transformation (estimation of variance) the immigration of women.

Error	Model	
	Holt's linear trend	Transformation (estimation of variance)
ME	119,5521	-3,42
MAE	790,2923	67,15319

SSE	21858874	249316,9
MPE	2,27	0,08
MAPE	21,08	2,01

Source: own elaboration

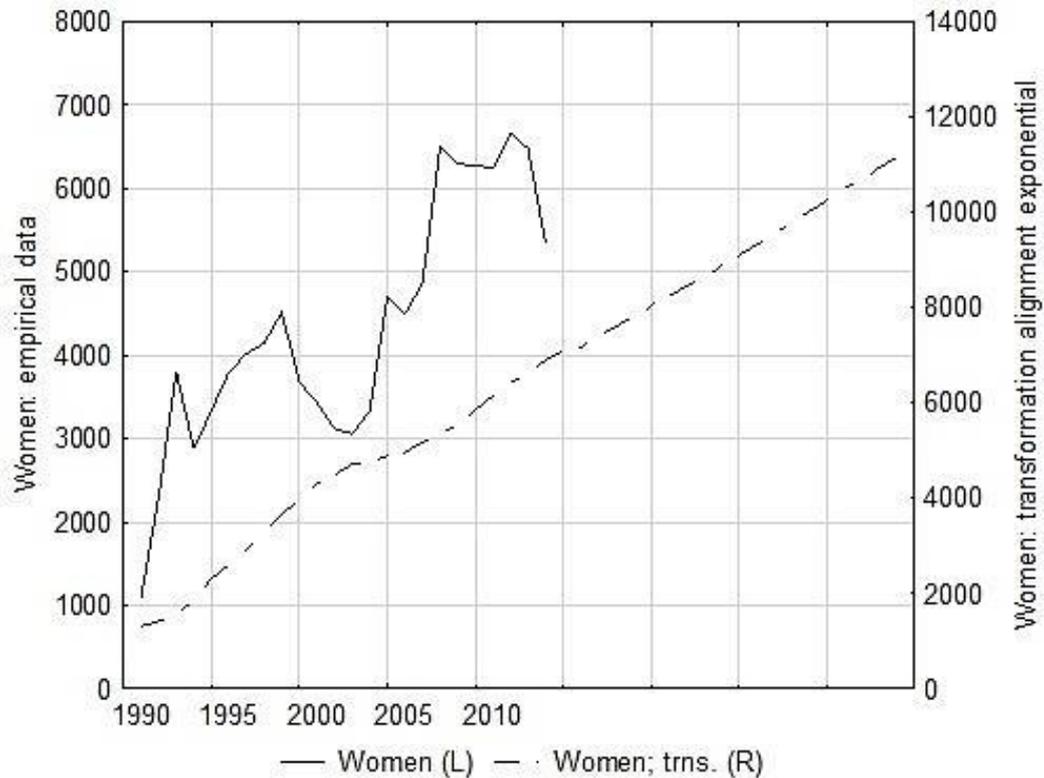


Figure 5. Immigration prediction for women using by transformation exponential smoothing in function of time 1990-2013.

Source: own elaboration

Table 9. Immigration analysis and prediction for men using exponential smoothing Holt's linear trend method and the estimation of variance.

Years	1990	1995	2000	2005	2010
Exponential smoothing	1616	3281	4828	5455	7651
Years	1990	1995	2000	2005	2010
Estimation	1770	3254	4928	5587	7219

Prediction					
Years	2014	2015	2016	2017	2018
Value	9124	9241	9554	9866	10179
Years	2019	2020	2021	2022	2023
Value	10492	10804	11117	11430	11742

Source: own elaboration

In forecasting the immigration of women, the initial value of Holt smoothing model was $S_0 = 110,3$, and for the transformation of the model gave $S_0 = 110,8$. The average forecast of the Holt model is deflected by 21.08 per cent from the actual value, and it is not valuable result. However the information that the transformation of the model by estimating variance with average deviation of forecast of 2.01 per cent of the actual values is a valuable forecast for the immigration of women.

Table 10. Errors model Holt and transformation (estimation of variance) the immigration of men.

Error	Model	
	Holt's linear trend	Transformation (estimation of variance)
ME	332,994	-4,51503
MAE	1153,768	93,52
SSE	54611074	629992,2
MPE	2,00701	-0,37289
MAPE	21,64	1,97

Source: own elaboration

In forecasting the immigration of men, the initial value of Holt smoothing model was $S_0 = 110,4$, and for the transformation of the model gave $S_0 = 110,9$. The average forecast of the Holt model is deflected by 21.64 per cent from the actual value, and it is not valuable result. However the information that the transformation of the model by estimating variance with average deviation of forecast of 1.97 per cent of the actual values is a valuable forecast for the immigration of men.

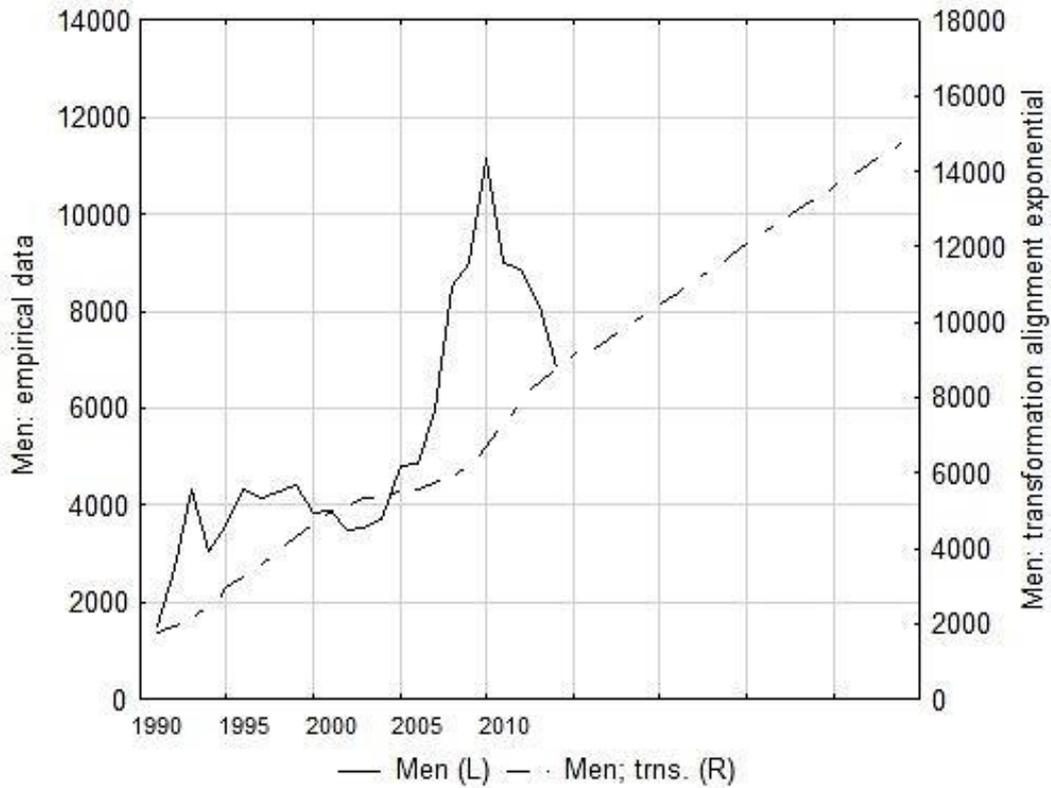


Figure 6. Immigration prediction for men using by transformation exponential smoothing in function of time 1990-2013.
Source: own elaboration

During the whole period sees surplus immigration of men over women. Based on the time series growth dynamics of frequencies the is similar (7-8 per cent) in both gender.

4. CONCLUSIONS

Presentations of research results the volatility and forecast of Polish migration in the period from 1990 to 2023 years have shown large fluctuations. In terms of analysis prediction by means of time series at an angle of immigration and emigration anticipated increase. However, the growth rate of immigration is higher than emigration. In an appeal to the dynamics of migration changes achieved by men and women not been shown large differences chasm. However, the growth dynamics of immigration is higher than emigration. In general, the forecasts for the years 1990-2023 immigration men 59 per cent and women 41 per cent, which means that 18% more men than women in Poland will immigrate. Also, in the percentage of migration greater men (52 per cent) compared to women (48 per cent). It is anticipated more volatility dynamics of migration for men.

In the light of these values include men more wanes than women. Likewise, seen from influx of population, which proved that the future will be more men than women emigration. Confirmation of the use of mathematical models are research papers Wojna (2007) already been proven to that includes a set of methods classified as operations research, optimization

and management decision-making in the economic and social phenomena. All models include sections: linear and non-linear, discrete, dynamic, etc. Holzer and Groblewska (1989) obtained the quantifiable results of predictive modeling in demography.

Linear trend extrapolation is very widely used in various scientific disciplines. Excellent performance linear trend methods discuss Makridakis and Hibon (2000), Assimakopoulos and Nikolopoulos (2000) i Hyndman and Billah (2003). Hyndman, Maxwell, Pitrun and Billah (2005) noted that the restricted parameter space for Holt's method has not resulted in noticeable deterioration in forecast performance.

Developed forecasting models confirmation of their reach in analysis of forecasting records of the Treasury in research Mills and Pepper (1999).

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