HUMAN RESOURCES IN SCIENCE AND TECHNOLOGY - EVOLUTIONS AND DEPENDENCIES

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Abstract—Human resources in science and technology are an important national resource for any country. Depending on economic policies implemented and of economic developments, its share in the total population on the one hand and in employed population on the other hand, are strengths in the economic development of any country. Based on this observation, the paper examines the evolutions of the human resource in science and technology, its possible implications on share of high-tech exports in total export, and also, the correlations between this, the share of research and development expenditure in GDP and the share of high-tech exports in total exports, in three EU countries with significant results in the field and in some former communist countries in the period 2003-2012.

Keywords—correlation, high-tech exports, human resources in science and technology, statistics

I. INTRODUCTION

IN the present conditions, the global market is characterized by increasing competition, but also, through appropriate policies on competition in the EU [1]. On the other hand traditional societies are transformed more and more into the information societies offering new ways of expression of international trade [2]. In these circumstances the human resource, its quality, becomes an element increasingly important of the national wealth. In this direction, a good strategy influences more than 50% business performance [3], the economic development and social progress depend on the training and education of all citizens [4].

The efficient use of resources requires the design and development of high-tech products, which to have a weight as high as possible in Romania's exports. This is however dependent on the share of the human resources with highly education and skills in high-tech industries.

The paper examines two aspects. The first aspect is the evolution of the share of human resources in science and technology in active population in Romania, some former communist countries and countries with tradition in the field, during 2003-2012. A second aspect is the analyzes of the correlations between the share of exports of high-tech products in total exports from countries analyzed, during 2007-2012.

Methodologically, the paper is based on statistical analysis methods presented in the works of Ouellet [5], Gogonea [6] and Oprea [7]. As IT support in processing and analysis were used SPSS. The data series used were taken from the Eurostat database [8]

II. EVOLUTION OF THE SHARE OF THE HUMAN RESOURCES IN SCIENCE AND TECHNOLOGY IN THE POPULATION BETWEEN 15 AND 74 YEARS

Share of human resources in science and technology [9], both in the total population between 15 and 74 years (HRSTT) and in active population between 15 and 74 years (HRST) with small fluctuations, in the analyzed period, had increasing trends.

Throughout the period, in the analyzed countries HRSTT had an upward trend (Fig. 1). While in France, Germany and the Netherlands recorded values were above the EU27 average, the considered communist countries have evolved below average.

In parallel, there have been processes of convergence and divergence. Thus, if in 2003 the percentages of HRST in France, Germany and the Netherlands were between 27.0% in France and 33.7% in the Netherlands (6.7 percentage points), in 2012 they reduced to 4.2 percentage points (from 34.0% in Germany and 38.2 % in the Netherlands). At the same time in Bulgaria, Czech Republic and Hungary HRSTT recorded a very easy process of divergence, the spread of values increasing from 3.1 percentage points in 2003 (from 18.5% in Hungary and 21.6% in Czech Republic), to 3.4 percentage points in 2012 (between 22.7% in Bulgaria and 26.1% in Czech Republic
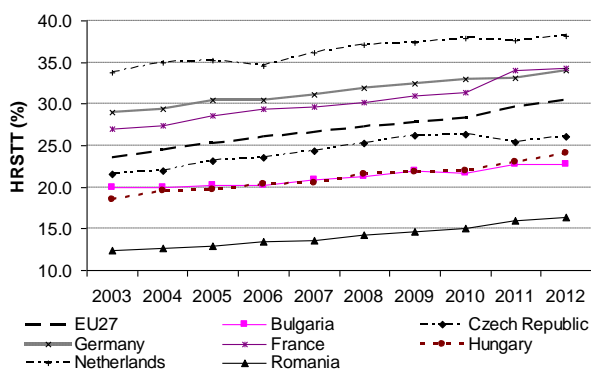
Fig. 1 Human Resources in Science and Technology,
Percentage of total population

In the analyzed period, Romania's HRSTT values were well below values registered in other countries. If in 2003, HRST in Romania was 11.3 percentage points below the EU27 average in 2012 the gap reaches 14 percentage points, marking a significant divergent process.

A situation similar is registered also in terms of the evolution of the percentages of the human resource in science and technology in the active population between 15 and 74 years (HRSTA). The convergence processes recorded by France Germany and the Netherlands, and the relative divergence recorded by Bulgaria, Czech Republic and Hungary are maintained, at least until 2010 (Fig. 2). Note that the recorded values of HRSTA in 2012 compared to 2003 were increases in all examined countries , but compared to the EU27 average (7.2 percentage points), with the

exception of France where the increase of HRSTA is 8.9percentage points, in all the other countries the values are much lower.
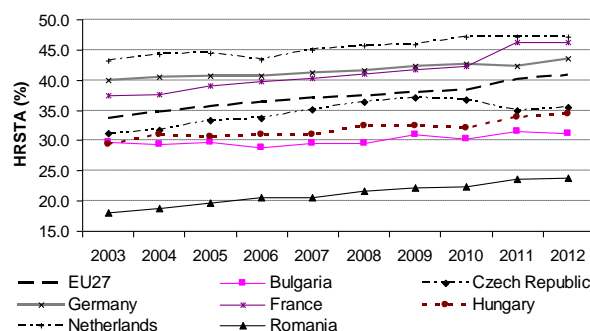

Fig. 2 Human Resources in Science and Technology,
Percentage of active population

At first view, on one hand, with an increase of 5.8 percentage points in 2012 compared to 2003, and with an average annual growth of 3.15% on HRSTA value, Romania would be the first places. This is, however, relatively. The obtained results are due to the very small values registered by HRSTA in Romania. Eg a 1% increase in the value of HRSTA, registered in Romania in 2011 corresponds to an increase of 0.165 percentage points, while a 1% increase in the value of HRSTA registered in France in the same year corresponds to an increase of 0.469 percentage points in HRSTA. On closer analysis, it is found that the gap between the EU27 average and HRSTA values recorded in the former communist countries, analyzed in this chapter, are increased (Table I).

TABLE I
EVOLUTION OF THE GAPS BETWEEN THE HRSTA VALUES REGISTERED IN FORMER COMMUNIST COUNTRIES AND THE EU27 AVERAGE

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Bulgaria	4.0	5.4	5.8	7.4	7.5	8.0	7.1	8.2	8.6	9.8
Czech Republic	2.5	3.1	2.3	2.7	1.9	1.2	1.0	1.7	5.2	5.4
Hungary	4.4	3.9	4.9	5.3	6.1	5.0	5.5	6.3	6.4	6.5
Romania	15.7	16.0	15.9	15.7	16.4	15.9	15.9	16.0	16.5	17.1

Unfortunately, in this regard, Romania is still in last place with a lag almost double that its recorded for Bulgaria where in 2012 HRSTA records 31.1% while in Romania the value recorded is only 23.8%.

III.   HUMAN RESOURCES IN SCIENCE AND TECHNOLOGY AND HIGH-TECH EXPORTS

Normally, human resources in science and technology is an important element in the design, the implementation, production and export of High Technology. Reference [10] defined High Technology "as the sum of the following products: Aerospace, Computers-office machines, Pharmacy, Electronics-telecommunications, Scientific instruments, Electrical

machinery, Chemistry, Non-electrical machinery, Armament."

Based on these observations, we present a brief analysis of the evolution of the share of exports of all high technology products of total exports (HTE) and of the correlations between it and share of human resources in science and technology in active population (HRSTA), in the analyzed countries. The evolutions of HTE, in the period 2007 -2012, are shown in Fig. 3.

A first important observation is that, unlike those presented in the previous chapter, this indicator, in two of the four former communist countries analyzed (Hungary and Czech Republic), the HTE values exceed the EU27 average, inclusive values registered in countries with

tradition in the field.

Thus, while the HTE average in the EU27, registered the values from a minimum of 15.4% in 2008, and a maximum of 17.1% in 2009, in Hungary, HTE registered values from a maximum of 22.2% in 2009 and a minimum of 17.3 % in 2012, outpacing in the period 2007-2011, all the other analyzed countries. The HTE values over the EU27 average, in the entire period, were also recorded in France and the Netherlands.
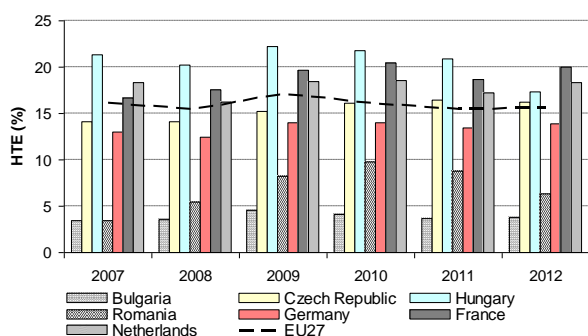

Fig. 3 Evolution of High-tech exports % of exports

In terms of this indicator, Romania was the last but one, with a period of significant growth of 6.3 percentage points from 3.5% in 2007 to 9.8% in 2010, followed by a period of decline, reaching in 2012 to 6.3% (a gap of 9.3 percentage points compared to the EU27 average, compared to 12.9 percentage points in 2007). It should be noted that unlike Bulgaria, with whom usually we share the last places, the efficiency of the use of human resources in science and technology, in high-tech industries in Romania is far superior. For instance, in 2010 in Bulgaria to a value of HRSTA of 30.2% , HTE was 4.1%, while in Romania to the HRSTA value of 22.4%, HTE was 9.8% (2.4 times more). Unfortunately, if we compare ourselves with the Czech Republic or Hungary, the situation is different.

A second observation relates to how the economic crisis has affected exports of high technology products. While in countries such as Hungary and Bulgaria the decline occurred by the end of 2009, in France, Netherlands and Romania, it occurs at the end of 2010. Special cases are found in Germany, where in the period 2009 - 2012, the HTE values are maintained approximately constant (about 14%) and in Czech Republic where HTE registered an increasing trend from 14.1% in 2007 to 16.2% in 2012.

Taking account of the evolutions of the HRSTA and HTE values, were tested the possible correlations between they during the period 2007-2012, the period that includes the economic crisis. A graphic representation of the dependencies of the HTE and HRST is shown in Fig. 4
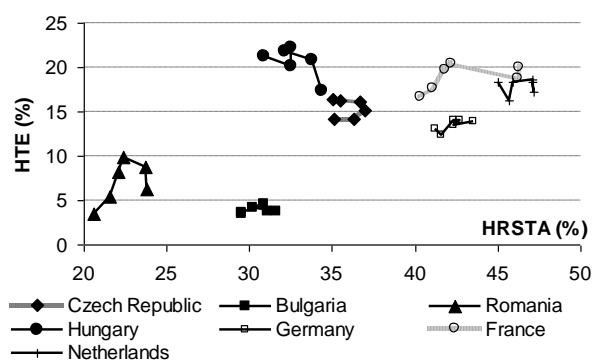

Fig. 4 Testing dependence between the share of High-Tech Exports in total export and the share of Human Resources in Science and Technology in Active population

.As can be seen, after the point cloud shape, in the case of Bulgaria, Czech Republic, and Netherlands, the correlations between HTE and HRSTA are very weak. In their case, the values of Pearson correlation coefficients are 0.358 for Bulgaria, -0.078 for Czech Republic, respectively, and 0.129, in the case of Netherlands

A very special situation is recorded in Hungary As can be seen in Fig. 4, between the two indicators is a reverse relation of medium intensity (r = -0.68), which means that the reducing of the share of human resources in science and technology in the active population, increases the high-tech export share in total exports, which is nonsense. We believe that the influences of the other factors on the evolution of the two indicators were much stronger and therefore their exclusion affects the conclusions of the analysis.

TABLE II
CORRELATION COEFFICIENTS BETWEEN HIGH-TECH EXPORTS IN TOTAL EXPORT AND THE SHARE OF HUMAN RESOURCES IN SCIENCE AND TECHNOLOGY IN ACTIVE POPULATION

Country	Pearson Correlation	Nonparametric Correlations	
		Kendall	Spearman
Romania	0.590	0.467	0.600
Sig. (1-tailed)	0.109	0.094	0.104
Germany	0.756	0.500	0.691
Sig. (1-tailed)	0.041	0.087	0.064
France	0.488	0.600	0.714
Sig. (1-tailed)	0.165	0.045	0.055

For further analysis, for Romania, Germany and France, have been determined, both the Pearson correlation coefficient (r) and the values of the nonparametric correlation coefficients , Kendall and Spearman (Table II). For significance level $\alpha = 0.1$ (probability 90%) were tested, for each factor, the following hypotheses:

H_0: Value of coefficient is not statistically significant.

H_1: Value of coefficient is statistically significant.

Because normally, the correlation between HTE and HRSTA must be a positive one, in the sense that the increasing of the share of human resources in science and technology in the active population, should increase the

share of high-tech exports in total exports was chosen the right one-sided test.

In Romania, the values of correlation coefficients indicate a direct correlation of low intensity. Of these, only to the Kendall coefficient, because $Sig.(1-tailed)=0.094<\alpha=0.1$ the null hypothesis (H_0) is rejected and is accepted the alternative hypothesis (H_1), the Kendall correlation coefficient (0.467) being statistically significant. On the other hand, due to the significant reduction of the HTE value with 2.4 percentage points in 2012 compared to 2011, while the value of HRSTA remained approximately constant, for the chosen significance level could not be identified a valid econometric model.

For Germany, all three values of correlation coefficients are statistically significant (in all cases the hypothesis H0 is rejected). It follows that, in Germany, during the analyzed period between HTE and HRSTA there was a relatively strong direct correlation (r=0.756). Taking this into account, using the F test (Fisher) and the method of least squares was deduced the model:

$$HTP = -12.1158 + 0.6053 \cdot HRSTA + \varepsilon \qquad (1)$$

Given that, for the model (1), $Sig.F=0.08<0.1$, the null hypothesis (H_0) is rejected and it is accepted the alternative hypothesis (H_1), the model being valid. The confidence interval for the coefficient of HRSTA is $[0.0459, 1.1646]$. This means that with a probability of 90%, one percentage point increase in human resources in science and technology in the active population increases the share of high-tech exports in total exports with a value between a minimum of 0.0459 and a maximum of 1.1646 percentage points.

For France, both nonparametric correlation coefficients, Kendall and Spearman are statistical significance (in both cases the hypothesis H0 is rejected), with values of 0.6 and, respectively, 0714. Taking into account their values, between HTE and HRSTA there is a direct relationship by medium intensity. But, on the other hand, under the circumstances, the Pearson correlation coefficient is not statistically significant. Moreover, due to the gap recorded in 2011, between the two indicators is not possible to identify with existing data, a regression model, statistically valid.

IV. CONCLUSION

Economic and social policies implemented in the last decade and the economic crisis triggered in 2009 made that gap between Romania and EU27, both in terms of the share of the human resources in science and technology in the active population, and the share of the high-tech exports in total exports, to widen, placing Romania, along with Bulgaria on the last places.

The effects of the economic crisis on high-tech industries have been significant. Except for Germany, the economic crisis has affected the share of the exports in total high-tech exports in all other countries, which did not allow identification of valid econometric models to describe the dependencies between the two analyzed indicators.

To overcome this handicap, on the one hand, the technical education in Romania must try a full approach, by resorting both to the system of the classical didactic methods, and to the learning strategies and techniques which favors the students' understanding [11] and, as all organizations, the universities must activate in direct collaboration with their stakeholders [12], to process knowledge in educational, technological and social instruments for business performances in high-tech industries.

REFERENCES

[1] M. Văduva, *Considerations on the concept of competition*, in *Annals of the „Constantin Brâncuşi" University of Târgu Jiu, Economy Series*, Issue1/2014, p. 219

[2] I. G. Radulescu, *Export – a major provocation for companies,* in International Conference "*Educaţie şi creativitate pentru o societate bazată pe cunoaştere*", ed. II, Editura Universităţii Titu Maiorescu, Bucureşti, November 20-21, 2008

[3] D. Ulrich, W. Brockbank, *The HR Value Proposition*, Harvard Business School Press, Boston, Massachuseetts, 2005, p.223.

[4] M. Zaharia, D. Enachescu, *Considerations on the Evolution of Attention Paid to Education in Romania Compared to EU, in the 1998-2010 Period*, in *Proceeding of 36th International Convention*, MIPRO 2013, Opatija, Croatia, pp.667-672.

[5] G. Ouellet, *Méthodes quantitatives en science humaines*, Les éditions Le Griffon d'argile, Québec, Canada, pp.171-206

[6] R. M. Gogonea, *Statistica. Metode si tehnici aplicate in turism*", Editura Universitara, Bucuresti, 2006

[7] C. Oprea C., M. Zaharia , "*Elemente de analiza datelor si modelare utilizand Excel*", Editura Universitara, Bucuresti, 2011, pp.27-118

[8] http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/searc h_database, accessed on March 14, 2014

[9] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=hrst_st_ncat&lang=en, accessed on March 14, 2014

[10] http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tin00140 , accessed on March 14, 2014.

[11] S. Neacşu, Si. Suditu, C. Popescu, *Modern Teaching Instruments for the Establishment of the Thermodynamic Values of Real Gases in the Training of Engineer Students* in WSEAS Transactions on Advances in Engineering Education, Issue 11, Vol. 7, November 2010, pp. 347-358.

[12] I. Teodoreanu, *Engineering education for sustainable development – a strategic framework for universities* in *Annals of the Oradea University, Fascicle of Management and Technological Engineering* Volume XXII (XII), 2013/1, p.414.