# Sustainable development in reflection of the laboratory market


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*Abstract: The purpose of this study is to present a brief analysis of the most important aspects based on the R&D sector's activities, targets and background. Furthermore, the efficiency of the use of Hungarian and EU development resources will be examined as well as the social, economic and ecological analysis of the sustainable development with the supporting cooperation of the industrial laboratory market. In the 20th century, as the result of accelerated growth of production and consumption, the increased utilisation of natural resources and the fast growing of population which exponentially escalated the extraction of resources posing an intensified threat to the sustaining capability of the environment. In this work only the most important aspects based on the Research and Development activities were examined by multivariable statistical methods for sustainable economic development. Naturally, the conceptual scope and extent of this study do not permit all the possible issues to be examined from every aspects, thus it will be endeavored to point out merely the most relevant considerations.*



*Keywords: sustainable development, Economic growth, research and development, importance of Hungarian and EU development resources, statistics*

# 1 Introduction

Social and economic importance of natural resources is unquestionable at all times from the aspect of humanity. „Efforts to satisfy the constantly changing demands for quantitiy and quality accompanied human history as an essential motivational factor.” [1] For decades the reasonable management of natural resources has an emphasized function in the social and economic procedures. In the early periods of economics natural resources were considered as permissible goods exposed unlimitedly to the society. As a consequence of the intensified production and growing consumption in the 20th century, the accelerated pace of population growth increased the utilization of natural resources exponentially and meant more and more enhanced threat to the sustaining ability of the environment. Society and mainly economy intensifies intervention into nature caused irreversible processes in many cases. Economical management of resources against wasteful and careless utilization became an essential topic on corporate, national, regional and global levels. United Nations in its many programs pays particular attention to key questions related to sustainable development such as the decreasing of the emission of greenhouse effect gases, protection of forests, saving and caring of biological diversity [2].

Sustainable development as a concept – following the UN Brundtland report dated in 1987 – became widely popular at the end of the ’90s. The Brundtland report – Our Common Future – defines sustainable development as follows: Sustainable development is a sort of development which ensures the satisfaction of present generation’s demands without the threat of endangering future generations’ chances to satisfy their demands [3].

## 1.1 EU R&D trends

Globalisation and the challenges of a new knowledge-driven economy required radical transformations of the European economy set by the Lisbon Strategy in 2000. R&D fundings is one of the major instruments for steering the science system. In 2002 the European Council defined the objective of 3% of GDP allocated to R&D spending with more focus on economic growth, using guidelines laid out in the Frascati manual, published by the OECD.

An empirical analysis of 2007 working with the database of Eurostat, based on the actual spending on R&D by the main sectors, business, government and higher education as well as the Gross Domestic Expenditure on R&D (GERD: including the private, public and academic expenditure), reveals that none of the EU Member States (EMS) complied with the 3% R&D target set by the Lisbon Strategy, with the exception of the Scandinavian countries, Finland and Sweden. Furthermore, it points out the differentiation among the Western, the Mediterranean and the New Member States. The average GERD expenditure for the Euro zone countries is higher than in the Non-Euro ones, except for the government share of total GDP on R&D, shown in Fig.¬ 1.

| | Euro Zone | Non-Euro Zone |
|---|---|---|
| Over 1% of GDP on private R&D | Finland, Austria, Germany, Belgium, France, Luxemburg | Sweden, Denmark, United Kingdom |
| Under 1% of GDP on private R&D | Netherlands, Slovenia, Ireland, Spain, Portugal, Italy, Greece | Czech Republic, Estonia, Hungary, Malta, Romania, Latvia, Slovakia, Poland Bulgaria, Cyprus |

Figure 1 GDP on Private R&D for Euro- and Non-Euro-Zone
Source: Albu, N. (2011) Research and Development spending in the EU

In analogy to this, the European Union's latest growth strategy, Europe 2020, called 'An European strategy for smart, sustainable and inclusive growth' contains targets for public and private R&D investment in order to provide a stimulus EU competitiveness, as the main objective of country's development, with the key indicator of efficiency set to ensure the strategic goal of 3% of GDP. Several studies have already examined whether these policies are paying off, whether they redeem these hopes. Some of them suggest that globalization, that is to say the global integration of value chains, has had a far greater impact on the knowledge-based progress of the CEE countries' economy than "Europeanization".[14]

According to the publication of Gorzelak (2016) the 2014-2020 period could be the final phase of substantial Cohesion Policy (CP) transfers to the CEE, and this programming period has an increased focus on innovation and R&D support. It was also stated in the work of Gorzelak (2016) that a comparison of thematic shifts in funding from 2007-13 to 2014-20 shows a significant increase in CP allocations to R&D and innovation. It is crucial for CEE Member States that funding is used effectively for sustainable growth. The experience of EU15 countries is that the 'added value' of CP was highest in the third phase of funding.

In the international literature there are many studies which are examining the linkages between R&D expenditure and economic growth. Most of the studies are conducted on developed countries.

Tiryakioglu (2006) analysed the relationship between R&Đ expenditure and economic growth on selected OECD countries by causality analysis since 1970s.

[14] Innovation in Hungary – The Impact of EU Accession and Integration into Global Value Chains
"We contend that globalization (global value chain integration) has more effectively contributed to Hungary's knowledge-based upgrading than Europeanization"

This study reveals that there is causality relationship between them and it emphasizes the importance of technology for economic growth.

Genc et al. (2010) evaluated the linkages between R&D and economic growth for 34 countries using panel casuality model. Findings based on annual data from 1997 to 2008 demonstrate that there is a unidirectional causal relationship running from R&Đ to economic growth.

Gulmez et al. (2012) investigated the long run relationship between R&D expenditures and economic growth in 21 OECD countries from 1990 to 2010 by utilizing the Pedroni and Kao panel cointegration model, Pedroni DOLS and FMOLS Canning-Pedroni causality model. The study presents a strong cointegration relationship between R&D expenditures and economic growth in the long run.

Ozcan et al. (2014) analysed relationship between R&Đ expenditure and economic growth 15 OECD countries over the period from 1990 to 2011 within the framework of panel data model. The results show that R&D has positive effect on economic growth in the selected countries.

Additionally to these studies, Inekwe (2014) analysed the role of R&D spending on economic growth in sixty six developing economies between 2000 and 2009. Countries were grouped into two categories: upper middle income economies and lower middle income economies. The results show that it has a positive impact of R&D spending on economic growth in case of developing countries. The effect of R&D spending on economic growth is beneficial in case of upper middle income economies while insignificant in case of lower middle income economies.

# 2 Materials and methods

The aim of the present thesis work is to examine the presence and role of the laboratory equipments, instruments serving the rapidly changing needs of domestic industrial and clinical laboratories. The laboratory industry is extremely sensitive to ecological problems. The high-tech analytical instruments are mainly responsible for carrying out industrial and chemical tests in the fields of environmental protecion, air pollution, agriculture, food safety, mineral oil industry, water management, biotechnology as well as pharmaceutic.

In the study all available, relevant information, data was gathered concerning sustainable laboratory scientific R&D activities and its necessary adherent background, such as R&D expenditure, researchers' headcount, number of institutes as well as scientific sustainable education.

Research and Development (R&D) spending on innovation, through the measurement of research in laboratory field, based on the impact of science for optimizing laboratory operations. R&D spending, Gross Domestic Expenditure on R&D (GERD) is one of the key Europe 2020 strategy indicators, the ratio of GERD to GDP also known as R&D intensity, which constitutes the source of long run endogenous economic growths. The level of GERD has been increasing modestly since 2006 within the range of 1.76% - 2.04% in EU-28 Member States, set back by the financial and economic crisis (2008-2009) led to deep cuts in funding for scientific research [4]. Scientific research is largely carried out in universities and academics labs, which generally run under heavily constrained state budget. The support level of the research activity varies from country to country. In Hungary, research work is characterized by low state and industrial support and cooperation. The research and development expenditure is below 1,4% of GDP, which is far beyond the average 2,15% in the EU 15 most developed members, shown on Figure 2, not to mention the USA reaching almost 3% of R&Đ costs.

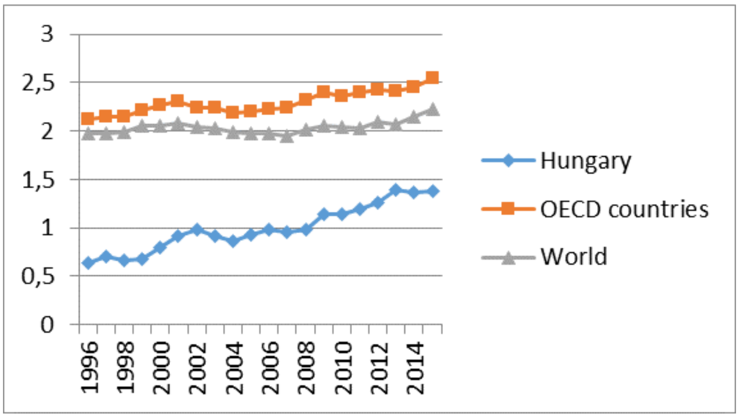


Figure 2 Research and development (R&D) expenditure as a percentage of GDP
Source: own construction based on IMF

According to the main statistical findings GERD stood at EUR 303 billion in the EU-28 in 2016, which showed a slight increase of 0,4% on the year before and 40% higher than 10 years earlier, in 2006, despite the reduction in R&D expenditure in 2009 during the global financial and economic crises. Only in two Member States (Sweden and Austria) were R&D intensity recorded to be over 3% in 2016, while for nine New Member States that joined the EU in 2004 or more recently, level stayed below 1%. The majority of R&D expenditure was generated in the business enterprise sector, where the expenditure rose from 1.12% of GDP in 2006 to 1.32% by 2016. Followed by the higher education, reaching 0.47% of GDP. While the other two remaining sectors, the government sector (0.23% of GDP), and the private non-profit sector (0.02% of GDP) changed slightly throughout the examined period. In 2011, the European Commission presented the 7th framework programme for investing almost EUR 80 billion in research and innovation by announcing Horizon 2020. (Eurostat statistics, 2018 March)

In Hungary, grants paid from EU Structural Funds related to the 'Science and Innovation Program' of the New Szechenyi Plan, co-financing innovation activities was EUR 680 millions over the period of 2010 to 2013. One of the most important components of innovation-specific EU-funds supports higher education institutions' research and research infrastructure development expenditures.

Figure 2. indicates that the amount of support allocated to foster research, development and innovation activities have considerably increased over the surveyed period of 1996 to 2015. Performance by the main input indicator of GERD, definitely started to converge to those of established EU economies (Szalavetz, 2014).

# 3 Methods

The aim of the current study is to highlight the main factors and define the strengh and nature of relation among the main variables in R&D field. In order to fulfill the aim of the research several statistical analysis were being carried out in the field of scientific research.

The work gives an overall survey on the local Hungarian R&D segment by taken the below factors into consideration for a deeper market analysis.

The current paper provides a better picture on the R&D facilities in our local laboratory market, by listing the numbers of institutes divided into sectors.

The increasing numbers of Hungarian research institutes will be calculated by Constant-based dynamic ratio to demonstrate the increasing trend in the period of 1990 to 2016.

$$b_k = \frac{y_k}{y_0} \tag{1}$$

R&D Headcounts were added to number of R&D Institutions in the above mentioned calculation by sectors, inspecting Correlation and Linear Regression among the variables.

Pearson correlation forms the bases of more sophisticated analizes like multiple regression and factor analyses. Performing a Pearson correlation, means that the hypothesis is one variable is associated with another variable and that can be a positive or a negative correlation. Pearson correlation is a method of estimating the association between two variables that are scored at an interval- or a ratio-level.

Furthermore to gain a complex picture of the present status of Hungarian research and development background, Linear Regression was processed in consideration of the strengh of relationship between total R&D staff as a percent of total labour force and R&D expenditure as a percent of GDP.

| Year | Total R&D staff as a % of total labour force | R&D expenditure as a % of GDP |
|---|---|---|
| 1990 | 0,81 | 1,6 |
| 1991 | 0,63 | 1,07 |
| 1992 | 0,57 | 1,05 |
| 1993 | 0,58 | 0,98 |
| 1994 | 0,59 | 0,89 |
| 1995 | 0,54 | 0,71 |
| 1996 | 0,55 | 0,63 |
| 1997 | 0,57 | 0,7 |
| 1998 | 0,56 | 0,66 |
| 1999 | 0,56 | 0,67 |
| 2000 | 0,61 | 0,79 |
| 2001 | 0,59 | 0,91 |
| 2002 | 0,61 | 0,98 |
| 2003 | 0,59 | 0,92 |
| 2004 | 0,59 | 0,86 |
| 2005 | 0,6 | 0,92 |
| 2006 | 0,66 | 0,99 |
| 2007 | 0,66 | 0,96 |
| 2008 | 0,71 | 0,98 |
| 2009 | 0,79 | 1,14 |
| 2010 | 0,84 | 1,15 |
| 2011 | 0,9 | 1,19 |
| 2012 | 0,93 | 1,27 |
| 2013 | 0,98 | 1,39 |
| 2014 | 0,91 | 1,36 |
| 2015 | 0,88 | 1,38 |
| 2016 | 0,82 | 1,22 |

Figure 3 The main ratio on R&D

Source: Own edition based on the Hungarian Statistical Office, Statistical tables on R&D

One of the further scopes of the study is to examine the source of the total R&Đ expenditure's sources in Hungary by the main sectors by Factor Analysis method. Efficiency in itself has not always been in the foreground of public thinking concerning EU fundings. "The European Council and then the European Parliament adopted the regulation on the seven-year financial framework for the European Union on November 17, 2013 [5]. This was a smaller budget in both real and nominal terms than the previous seven-year framework. The reduction of the budget as well as a more stringent spending approach due to the effect of the economic crisis shifted the conditions governing the 2014–2020 framework towards more efficient use.” [6]

EU resources for innovation with a fairly poor level of efficiency can certainly be supported by calculations, and moreover this is deemed the worst among the Central and Eastern European, former Socialist countries.[15] Naturally, by upgrading efficiency, a new consideration came to the fore which, although it was present before, had carried far less weight than it does now.

In order to fulfill the multivariate statistical method concerning the quantitative data by factor analyses to define the observed variables into fictive common groups, correlation as one of the main basic conditions of Factor analyses is to be seen in Correlation Matrix with relatively highly correlated interpreted variables, especially for Foreign, EU fundings sources as well as business sources followed closely by governmental sources.

Depending on the method used the common background variables are called as principal components (principal factors) or factors and it is assumed that they are supposed to be independent).

In the case of factor analysis it is hypothesised that by the help of q<p background variables a considerable part of the variance of the original variables can be explained and the rest of the variance of the observation variables can be considered as a specific effect (Figure 3) (Szelenyi, 2002).

[15] Innovation in Hungary – The Impact of EU Accession and Integration into Global Value Chains
“Hungary is one of the worst performers with respect to the efficiency of public investments in innovation. Montalvo–Moghayer [2011] computed innovation system efficiency indices; that is, input/output ratios of R&D efforts. According to their calculations, Hungary had one of the least efficient innovation systems, while the Czech Republic enjoyed the best performance among CEE economies.” http://real.mtak.hu/18116/

**Model of factor analysis**

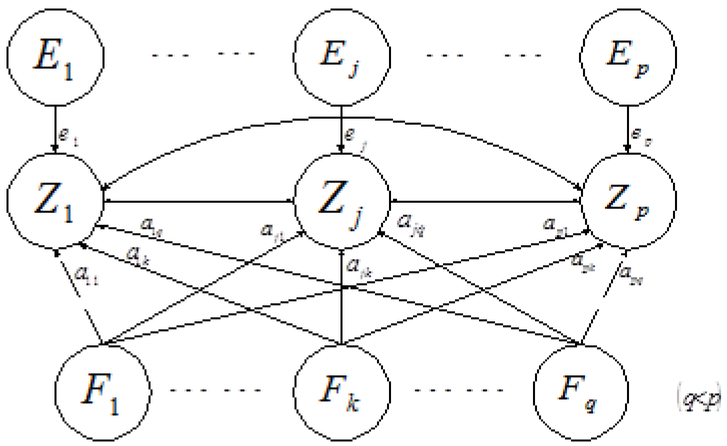


Figure 3 Model of factor analysis
Source: Szelenyi, 2002.

## 3.1 Hypothesis

Hypothesis are being set along the survey to provide wider picture overview of the R&D intensity concerning Hungary in the last decades. Hypotheses are being carried out to determine whether the following statements are veridical or not concerning the context of the topics.

1. Researchers' headcounts have been increasing intensively in the last three decades, since 1990.
   The null (H0)- and H1 hypothesises were ascertained as follows:
   H0= The statement is acceptable. There is only positive relation in all sectors (University, Academic, Business).
   H1= The relation is not positive in all sectors. There can be also negative relation.

2. There is a strong correlation R&D expenditure as a percent of GDP; Total R&D staff as a percent of total labour force.
   H0= R&D expenditure & R&D staff are strongly depending on each other.
   H1= There cannot be found strong correlation between the two variables.

3. The distribution of R&D expenditure is even among the different sectors.
   H0= R&D expenditure is evenly distributed among the sectors.
   H1= The distribution is not even. There are higher and lower sectors concerning R&D expenditure distribution.

# 4 Results

## 4.1 Research Institutions

The growing number of research sites and institutions, founded by university education, could provide a strong background of economic growth. All of them are the basis of innovation technology supporting industrial economic growth for a sustainable welfare for the future. Open Innovation plays a major role in the field of laboratory. The main aim of the laboratory instruments producers and their representatives is to creat more innovation and profitability in the high technology of the equipments. As the laboratory market is a rather highly scientific segment crowdsourcing for products ideas can not be common, rather there is an intensively growing tendency of open innovation collaboration through partnership with other manufacturers. Also a high number of acquisitions can be experienced among manufacturers for open innovation as well as professional associations.

According to Figure 4 the number of research institutes has more than doubled itself since the following year of the regime-change, after 1989, which is also explained by the constantly yearly rising R&Đ expenditure in percentage of GDP, trying to catch up with the world average, shown in Figure 2 to provide basis of innovative technology for R&Đ activities in Hungary.

| Table 4: R&Đ institutes in Hungary (1990-2016) | | | | | |
|---|---|---|---|---|---|
| | y | Of which | | | |
| | No.of R&Đ Institutes | Academic Institutes | Universities Institutes | Business enterprises | Percent of change |
| 1990 | 1256 | 142 | 940 | 174 | 100,00% |
| 1991 | 1257 | 133 | 1000 | 124 | 100,08% |
| 1992 | 1287 | 118 | 1071 | 98 | 102,47% |
| 1993 | 1380 | 124 | 1078 | 178 | 109,87% |
| 1994 | 1401 | 112 | 1106 | 183 | 111,54% |
| 1995 | 1442 | 107 | 1109 | 226 | 114,81% |
| 1996 | 1461 | 121 | 1120 | 220 | 116,32% |
| 1997 | 1679 | 131 | 1302 | 246 | 133,68% |
| 1998 | 1725 | 132 | 1335 | 258 | 137,34% |
| 1999 | 1887 | 130 | 1363 | 394 | 150,24% |
| 2000 | 2020 | 121 | 1421 | 478 | 160,83% |
| 2001 | 2337 | 133 | 1574 | 630 | 186,07% |
| 2002 | 2426 | 143 | 1613 | 670 | 193,15% |
| 2003 | 2470 | 168 | 1628 | 674 | 196,66% |
| 2004 | 2541 | 175 | 1697 | 669 | 202,31% |
| 2005 | 2516 | 201 | 1566 | 749 | 200,32% |
| 2006 | 2787 | 208 | 1552 | 1027 | 221,89% |
| 2007 | 2840 | 219 | 1496 | 1125 | 226,11% |
| 2008 | 2821 | 195 | 1471 | 1155 | 224,60% |
| 2009 | 2898 | 197 | 1394 | 1307 | 230,73% |
| 2010 | 2983 | 190 | 1409 | 1384 | 237,50% |
| 2011 | 3000 | 188 | 1380 | 1432 | 238,85% |
| 2012 | 3090 | 131 | 1376 | 1583 | 246,02% |
| 2013 | 3159 | 130 | 1317 | 1712 | 251,51% |
| 2014 | 2994 | 136 | 1288 | 1570 | 238,38% |
| 2015 | 2801 | 135 | 1253 | 1413 | 223,01% |
| 2016 | 2727 | 125 | 1311 | 1291 | 217,12% |

Forrás: https://www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_ohk002a.html

Figure 4 R&D institutes in Hungary (1990-2016)

Source: Hungarian Statistical Office, Statistical tables on R&D

In the last column the increasing numbers of institutes were calculated by constant-based dynamic ratio method for the period of 1990 to 2016.

The number of research institutes more than doubled with an intensively expanding business sector, became seven times more - like in the United States and Western European countries regulated by free market - since the regime change in Hungary. Unfortunately the governmental non-profit sectors, such as university and academic fields remained around the same level over the examined period due to insufficient governmental and private financial support. Furthermore, it can be stated that the distribution ratio of the researchers' staff in percent of total labor does not indicate such positive difference as it is experienced in the business field and the ratio represents low percent of 0.8% in 2016, which was almost the same in 1990, although we could experience some falls below

0.6% during the nineties. It can be determined that private business industrial sectors should invest more in non-profit sectors in the aim of receiving higher quality research as a mutually beneficial compansation in order to support economic sustainability.

| | | Of which | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | No.of R&Đ Institutes | Academic Institutes | Universities Institutes | Business enterprises | R&Đ headcounts | Academic headcounts | Universities headcounts | Business enterprises HC |
| 1990 | **1256** | 142 | 940 | 174 | **59723** | 19802 | 22787 | 17134 |
| 1991 | **1257** | 133 | 1000 | 124 | **51218** | 16598 | 22607 | 12013 |
| 1992 | **1287** | 118 | 1071 | 98 | **43879** | 13749 | 22296 | 7834 |
| 1993 | **1380** | 124 | 1078 | 178 | **40999** | 11886 | 22029 | 7084 |
| 1994 | **1401** | 112 | 1106 | 183 | **39810** | 9966 | 21765 | 8079 |
| 1995 | **1442** | 107 | 1109 | 226 | **38088** | 9312 | 20699 | 8077 |
| 1996 | **1461** | 121 | 1120 | 220 | **37286** | 11015 | 20085 | 8186 |
| 1997 | **1679** | 131 | 1302 | 246 | **39626** | 10781 | 22434 | 6411 |
| 1998 | **1725** | 132 | 1335 | 258 | **41317** | 10174 | 24750 | 6393 |
| 1999 | **1887** | 130 | 1363 | 394 | **42088** | 9995 | 24411 | 7682 |
| 2000 | **2020** | 121 | 1421 | 478 | **45325** | 11255 | 25972 | 8098 |
| 2001 | **2337** | 133 | 1574 | 630 | **45676** | 10461 | 26543 | 8672 |
| 2002 | **2426** | 143 | 1613 | 670 | **48727** | 11767 | 27532 | 9428 |
| 2003 | **2470** | 168 | 1628 | 674 | **48681** | 11747 | 27769 | 9438 |
| 2004 | **2541** | 175 | 1697 | 669 | **49615** | 11483 | 29262 | 8870 |
| 2005 | **2516** | 201 | 1566 | 749 | **49723** | 11627 | 28702 | 9394 |
| 2006 | **2787** | 208 | 1552 | 1027 | **50411** | 11498 | 27165 | 11748 |
| 2007 | **2840** | 219 | 1496 | 1125 | **49485** | 10429 | 25923 | 13133 |
| 2008 | **2821** | 195 | 1471 | 1155 | **50279** | 9996 | 26240 | 14043 |
| 2009 | **2898** | 197 | 1394 | 1307 | **52522** | 10100 | 25934 | 16488 |
| 2010 | **2983** | 190 | 1409 | 1384 | **53991** | 10293 | 24778 | 18920 |
| 2011 | **3000** | 188 | 1380 | 1432 | **55386** | 10156 | 24404 | 20826 |
| 2012 | **3090** | 131 | 1376 | 1583 | **56486** | 9541 | 23647 | 23298 |
| 2013 | **3159** | 130 | 1317 | 1712 | **58237** | 9309 | 23112 | 25816 |
| 2014 | **2994** | 136 | 1288 | 1570 | **57185** | 9379 | 22447 | 25359 |
| 2015 | **2801** | 135 | 1253 | 1413 | **56235** | 10531 | 21998 | 23706 |
| 2016 | **2727** | 125 | 1311 | 1291 | **54636** | 9318 | 21969 | 23349 |

Figure 5 R&D Institution & R&D headcounts

Source: Hungarian Statistical Office, Statistical tables on R&D

First the number of R&D institutions and Headcounts Means and Standard Deviation information were to gained by Descriptive Statistics. The mean of the institutions is 2266 with a standard deviation of 673, while the number of researchers are 48764 with a deviation of 6634. All variables have positive ratio with the other variable, excepted Academic headcounts, which has negative correlation with all other variables. Among interpretation variables the association are weak, so multicollinearity does not exist.

Hypothesis 1.

Researchers' headcounts have been increasing intensively in the last three decades, since 1990.

Analysis has been carried out whether there is any correlation between the total number of R&Đ institutions and the total number of R&Đ Headcounts in Hungary. It can be stated that there's a strong relationship among R&Đ institutions and their headcounts. Linearity was also assumed therefore graphical visualization has been displayed as well.

Furthermore the influence of the independent variable, the number of R&Đ institutions has been detected on the dependent variables, such as Academics, Universities- as well as Business enterprises R&Đ headcounts by Regression, thus the fit test for the assumped linear relationship among the variables were inspected by Regression Curve Estimation. Strong, positive correlation is inspected among the number of R&Đ institutions and the business enterprises headcounts and slightly positive relationship is detected by the Universities' headcounts, whereas negative correlation is experienced among R&Đ institutions and Academic R&Đ headcounts, which is also corroborated by the the Graph.

### 4.1.1 Results for Business Sector

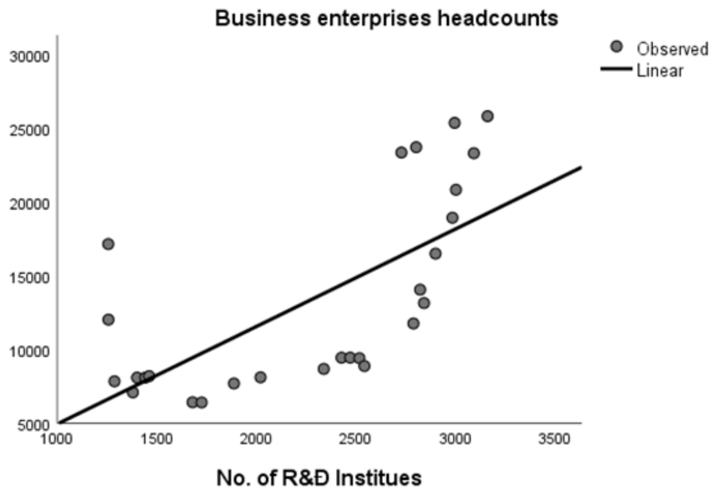


Figure 6 Result of Linear Regression for Business Sector

Source: Own edition, based on Hungarian Statistical Office, Statistical tables on R&D

**ANOVA**

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Regression | 516031863,841 | 1 | 516031863,841 | 21,423 | ,000 |
| Residual | 602195405,121 | 25 | 24087816,205 | | |
| Total | 1118227268,963 | 26 | | | |

Figure 7 The independent variable is No. of R&Đ Institues.

Source: Own edition, based on Hungarian Statistical Office, Statistical tables on R&D

ANOVA is an Analysis method of Variance, investigates the independent variables effect on the dependent variable by comparing means. F-probe is used for testing H0 hypothesis, which states that the categories' means are equal, when

F is 1. F is greater than 1 means, that the independent variables are significantly effect the dependent variable, thus the H0 hypothesis is rejected.

The two basic condition of the variance (ANOVA) analysis is the following:

- Variables are to have normal distribution: unstandardized residuals eaxamination for normality by groups
- Homogenity of groups variance (Levene-test for Homogenity Test)

In the diagram below the alignment of the regression line to the point set is illustrated. Linearity can be observed clearly, which refers to a strong, positive relationship between the variables observed.

In the current examination carried out by ANOVA method, F (the proportion of squares 'Between Groups' and 'Whithin Group') represents 21,423 at 0,00 significancy, which is lower than 0,05 significant-level, thus the null-hypotheses is rejected. The number of R&Đ Institution significantly effected the Headcounts at Business Enterprise R&D sectors. The examination is also significant by the t-test with 4,628 at a 0,00 significant level, lower than 0,05.

**Coefficients**

| | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | t | Sig. |
| No. of R&Đ Institues | 6,620 | 1,430 | ,679 | 4,628 | ,000 |
| (Constant) | -1687,613 | 3375,976 | | -,500 | ,622 |

Figure 8 Coefficients

Source: Own edition, based on Hungarian Statistical Office, Statistical tables on R&D

Regression equation (y=bx+a) can be deduced from the unstandardized coefficients from the above figure.

Headcounts (No.)= -1687+6620*No. of Institution

### 4.1.2 Results for University Sector

Result of Linear Regression for University Secor

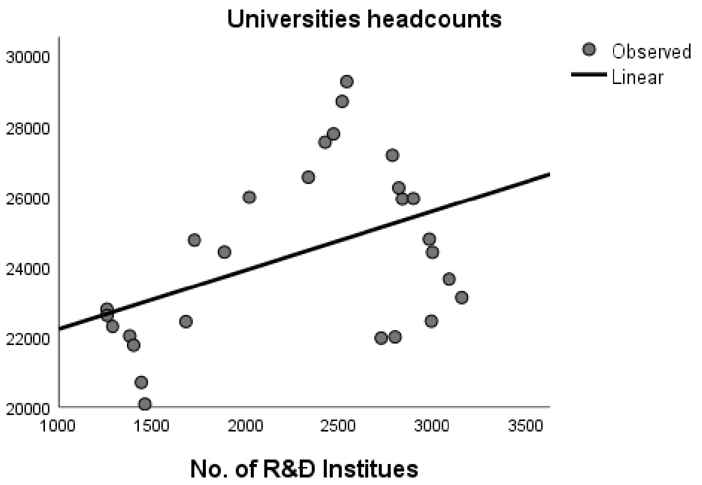


Figure 9

Source: Own edition, based on Hungarian Statistical Office, Statistical tables on R&D

**Model Summary**

| R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|
| ,450 | ,202 | ,171 | 2280,083 |

Figure 10 Result of Linear Regression for Academic Sector

Source: Own edition, based on HSO, Statistical tables on R&D

Pearson correlation coefficient is 45%, while determination coefficient (r2=0,202), which examine the strenth of the relationship, means that the regression equation explains the 20,2% of the total variance.

F-probe, which prove the existance of the relationship, is 6,346 at sig.level of 0,019, p<α (0,05) is significant, so the Nullhypothesis is being rejected. There's significant correlation between the variables. So as T-test with value of 2,519 at a 0,019 sig.level.

### 4.1.3 Results for Academis Sectors

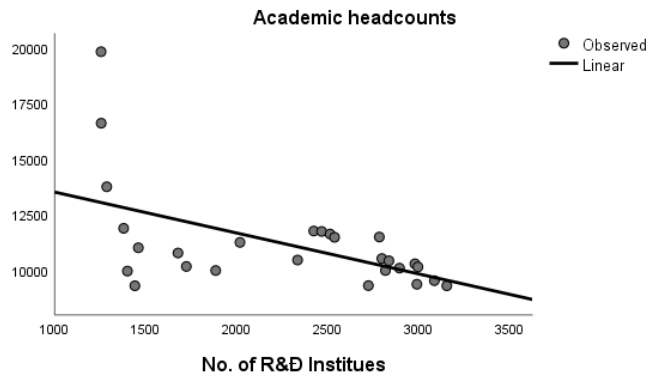


Figure 11 Result of Linear Regression for Academic Sector

Source: Own edition, based on Hungarian Statistical Office, Statistical tables on R&D

Academic Sector has a negative correlation with the number of R&D Institutions. The bad performance of the non-profit sector could be explained by the tendency of brain drain towards the private industrial fields.

Hypothesis 1. Null hypothesis H1 is being rejected taken the negative correlation result of Linear Regression for Academis Sector due to brain drain.

Hypothesis 2. There is a strong correlation R&D expenditure as a percent of GDP; Total R&D staff as a percent of total labour force.

By the increasing amount of R&D expenditure, which means more investment in innovation supporting economic growth, it should be followed by the number of researchers to provide strong research background in the country.

According to Figure 12 the total R&Đ staff is well below 1% as of total labour force in Hungary, hardly reaches 0,8%. It could be an explanation of the low percent of 1,38% of R&D expenditure in percent of GDP. The two database values (R&D expenditure as a percent of GDP; Total R&D staff as a percent of total labour force) have shown strong correlation with a calculated coefficient of r(x,y)=0,857, which indicates that the variables strongly dependending from each other. The examination of the significance of the linear correlation coefficient is the following to define the Hypothesis to be set for the independency of the variables [7].

H0: r(x,y)=0

| n | DF | α | $t_{emp}$ | $t_{crit}$ |
|---|---|---|---|---|
| 26 | 24 | 0,05 | 4,89 | 2,064 |

The empirical result is bigger then then the critical, tcrit< temp so the H0 hypothesis is being rejected, which indicates that stochastical correlation can be stated by the result of the t-test calculation carried out. It was proved that the variables are not independent and strongly correlating to each other.

| Year | R&D units | | | |
|---|---|---|---|---|
| | Total R&D staff as a % of total labour force | Of which: Researchers | R&Đ expenditure as a % of national investment | R&D expenditure as a % of GDP |
| 1990 | 0,81 | 0,39 | 1,27 | 1,6 |
| 1991 | 0,63 | 0,31 | 0,45 | 1,07 |
| 1992 | 0,57 | 0,29 | 0,6 | 1,05 |
| 1993 | 0,58 | 0,3 | 0,56 | 0,98 |
| 1994 | 0,59 | 0,32 | 0,56 | 0,89 |
| 1995 | 0,54 | 0,29 | 0,71 | 0,71 |
| 1996 | 0,55 | 0,29 | 0,4 | 0,63 |
| 1997 | 0,57 | 0,31 | 0,48 | 0,7 |
| 1998 | 0,56 | 0,32 | 0,53 | 0,66 |
| 1999 | 0,56 | 0,33 | 0,52 | 0,67 |
| 2000 | 0,61 | 0,37 | 0,64 | 0,79 |
| 2001 | 0,59 | 0,38 | 0,75 | 0,91 |
| 2002 | 0,61 | 0,39 | 0,74 | 0,98 |
| 2003 | 0,59 | 0,38 | 0,76 | 0,92 |
| 2004 | 0,59 | 0,39 | 0,6 | 0,86 |
| 2005 | 0,6 | 0,41 | 0,72 | 0,92 |
| 2006 | 0,66 | 0,45 | 0,9 | 0,99 |
| 2007 | 0,66 | 0,45 | 0,59 | 0,96 |
| 2008 | 0,71 | 0,48 | 0,62 | 0,98 |
| 2009 | 0,79 | 0,54 | 0,75 | 1,14 |
| 2010 | 0,84 | 0,57 | 0,79 | 1,15 |
| 2011 | 0,9 | 0,61 | 0,86 | 1,19 |
| 2012 | 0,93 | 0,62 | 1,33 | 1,27 |
| 2013 | 0,98 | 0,64 | 1,62 | 1,39 |
| 2014 | 0,91 | 0,64 | 1,15 | 1,36 |
| 2015 | 0,88 | 0,6 | 1 | 1,38 |
| 2016 | 0,82 | 0,59 | 0,96 | 1,22 |

Figure 12 Main ratios of R&D (1990–)
Source: own edition, based on the Hungarian Central Statistical Office

Having the linear regression to be proccess in SPSS, the same Pearson correlation coefficient (r=0.857) result can be experienced as of the classic way of calculating the methods without a research and analyser economical software. Examining the strengh of the relationship with the determination coefficient in the Model Summary table, r2=0,734, which means that 73,4% is explained by the regression equation of the total variance. While the Standard Error of the Estimate is predicting the precision of the forecast analyses.

**Model Summary[b]**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | ,857[a] | ,734 | ,724 | ,07417 |

a. Predictors: (Constant), R&D expenditure as a % of GDP
b. Dependent Variable: Total R&Đ staff as a % of total labour force

Figure 13 Model Summary for variance R&D expenditure as a % of GDP and Total R&Đ staff as a % of total labour force

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | 95,0% Confidence Interval for B | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound |
| 1 | (Constant) | ,199 | ,061 | | 3,285 | ,003 | ,074 | ,325 |
| | R&D expenditure as a % of GDP | ,484 | ,058 | ,857 | 8,312 | ,000 | ,364 | ,604 |

a. Dependent Variable: Total R&Đ staff as a % of total labour force

Figure 14 R&D expenditure as a % of GDP and Total R&Đ staff as a % of total labour force
Source: Own edition, based on Hungarian Statistical Office, Statistical tables on R&D

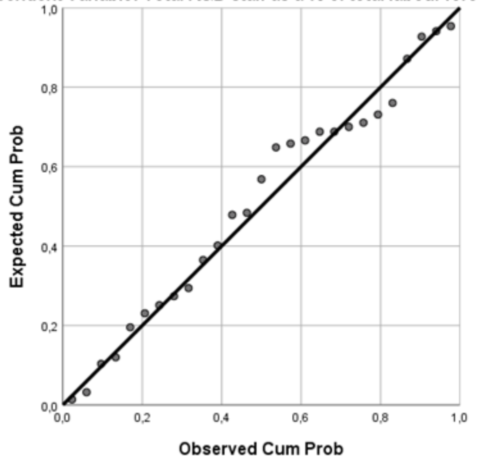


Figure 15 P-Plot of Regression Standardised Residual
Source: own edition, based on Hungarian Central Statistical Office

The condition of homoscedasticity is examined by standardized estimated values and the standardized residual. The distribution of the residual is to be normal according to the basic condition of regression. The normality of the distribution is illustrated by graphical histogram in SPSS.

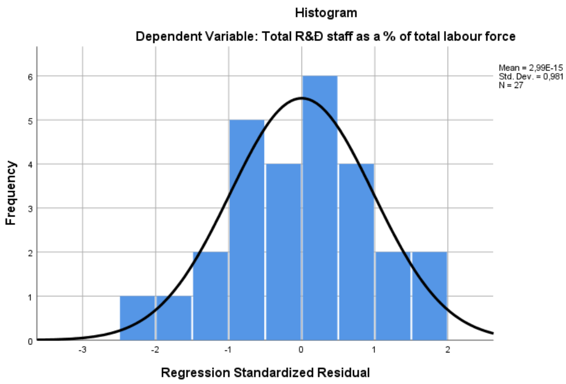


Figure 16 Histogram of Total R&D staff

Source: own edition based on the Hungarian Central Statistical Office

It can be stated that human resource is highly efficient in this scientific market. The main driving force in the laboratory field is high-tech innovation. The most effective tool to enhance competitiveness in the laboratory market is holding scientific seminariums or providing free professional advice to end-users, which explain the needs for well educated professionals. Innovation depends so much on universities' and academics' level of education. Equal access to high education and skills through globalization leading up to race between technology and innovation. Researches executed on high-tech laboratory devices in numerous fields (e.g. environmental protection, food safety, water management, etc.) indirectly support future sustainability.

Hypothesis 2. The statement of H1, alternative hypothesis is acceptable. According to Pearson correlation coefficient: r=0,857, R&D expenditure & R&D staff are strongly depending on each other.

Hypothesis 3. The distribution of R&D expenditure is even among the different sectors.

For the sake of a stable and healthy economic growth, for-profit and non-profit sectors should support and cooperate with eachother for a sustainable future.

Figure 17 indicates that R&Đ expenditure has become four times larger since 2000 in Hungary. According to data collected by the Hungarian Central Statistical Office (herein after: KSH) financial expenditure is mainly represented by private sector through business enterprises as well as foreign sources with a growing amount of EU sources through GINOP and Horizon2020 tenders since 2014. Whereas governmental funding only takes one fourth of the total R&Đ costs, altough it doubled itself in the new century.

| Sources of R&Ð expenditures | | | | | | |
|---|---|---|---|---|---|---|
| | Sources of R&Ð expenditure | Of which: | | | | European Union Tenders |
| | | Business enterprises | Governmental | Other local | Foreign | |
| 2000 | 105388 | 39790 | 52207 | 2189 | 11202 | |
| 2001 | 140605 | 48790 | 75386 | 3317 | 12918 | |
| 2002 | 171470 | 50936 | 100392 | 2369 | 17773 | |
| 2003 | 175773 | 53926 | 102008 | 991 | 18847 | |
| 2004 | 181525 | 67351 | 94049 | 1334 | 18791 | |
| 2005 | 207764 | 81954 | 102666 | 974 | 22171 | |
| 2006 | 237953 | 103040 | 106538 | 1497 | 26877 | |
| 2007 | 245693 | 170769 | 109117 | 1574 | 27233 | |
| 2008 | 266388 | 128683 | 111401 | 1600 | 24704 | |
| 2009 | 299159 | 138892 | 125595 | 2052 | 32620 | 9219 |
| 2010 | 310211 | 146957 | 122030 | 2902 | 38322 | 9206 |
| 2011 | 336537 | 159726 | 128213 | 3331 | 45267 | 11052 |
| 2012 | 363683 | 170503 | 134080 | 3097 | 56003 | 14780 |
| 2013 | 420100 | 196614 | 150728 | 3151 | 69607 | 19382 |
| 2014 | 441092 | 212972 | 147703 | 3046 | 77371 | 15413 |
| 2015 | 468390 | 232869 | 162176 | 3316 | 70030 | 17911 |
| 2016 | 427192 | 241052 | 112118 | 3176 | 70845 | 12733 |
| Source: own construction based on the Hungarian Central Statistical Office, https://www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_ohk004a.html | | | | | | |

Figure 17

Sources: Own edition, based on Hungarian Statistical Office, Statistical tables on R&D expenditures

It is very common that universities, academic and health labs initiate a growing number of lab devices purchase in the frame of tender sources. According to the research of public procurement tenders, 1,905 were written out for laboratory fields of the total number of 38,450 in year 2016. The number represents roughly 5% of all the total procurements, which is low for sustainable R&D activities.

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | ,681 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 114,942 |
| | df | 10 |
| | Sig. | ,000 |

Figure 18 KMO and Bartlett's Test

Source: Own edition, based on Hungarian Statistical Office, Statistical tables on R&D

KMO and Bartlett's Test is significant (0,000) and testing whether the Correlation matrix's items are significantly correlating from zero, but it doesn't test each correlation item separately, but in an overall test. It is testing that the Correlatin Matrix is significantly different than an identity matrix.

Kaiser-Meyer-Olkin (KMO) criteria is determining the appropriateness of the interpreted variables specifying for factor analyses. The current result is acceptable as a medium metrics of 0,681. Bartlett's Test is a correlation test, which examines the independency for variables set in H0 hypothesis. In Factor analyses the variables are dependent and correlated to each other, so H0 has to be rejected with a significant level is smaller than 0,05. So the starting variables are applicable for Factor Analysis. [8]

The Communalities matrix is shown the portion of a variable's variance explained by the total number of factors. Currently the explained portions are extremly high at the business with over 0,9 but also quite high by the governmental sector at almost 0,8 and relatively low at foreign and other sources, non-state sectors, with under 0,5, which means it has hardly any explanatory power.

| | Initial | Extraction |
|---|---|---|
| Source of business sector | 1,000 | ,982 |
| Governmental source | 1,000 | ,798 |
| Foreign source & Other source | 1,000 | ,479 |

Extraction Method: Principal Component Analysis.

Figure 19 Communalities

Source: Own edition, based on Hungarian Statistical Office, Statistical tables on R&D

The examination of Communalities shows, how big part of the total factors explained a variable's variance. Starting the examination of Principal Components, the initial values of communalities are 1. After the Factor Analysis the communalities (Extraction) can be found in the third column. The better the results are, the higher the value of communalities than 0,5, but it has to be at least over 0,25. The Communalities table above shows the high amount of results with strong explanatory value.

| | Component |
|---|---|
| | 1 |
| Source of business sector | ,953 |
| Governmental source | ,893 |
| Foreign source, Other source | ,692 |

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Figure 20 Component Matrix

Source: Own edition, based on Hungarian Statistical Office, Statistical tables on R&D

In the Component Matrix component- or factorloadings can be seen, which tell how strong the relationship is between the component and the item. These are Pearson correlation the item with the component. All of these items load very highly on the component, but the first one, the Source of Business Sector loads the highest (0.953) All items load on a meanful way on the components.

Total Value Explained and Scree Plot, both tables deal with Factor Extraction methods. These two are the most commonly used procedures to decide how many factors should be kept in the solution. Factor Rotated Matrix shows that with only one component to be extracted, the solution cannot be rotated.

According to Kaiser criteria, published first in 1960 Factor Extraction examining Eigenvalue. Only those factors can be taken into consideration, which have Eigenvalue greater than 1. If the Eigenvalue of Factor falls under 1, it contains less information than a variable. Extraction is observed by Scree Plot, illustrating the values of Eigenvalue. Scree plot also help to determine the number of factordimensions. It can be clearly seen that there's only one component is left with Eigenvalue greater than 1. The first component is over 1 with value of 2,4718, explaning the variance by 82,4%. So it means that there is only one component SPSS retained based on the rule. One component explains the relationship among the variables. One component solution accounted for 82,4% of the variance, which is very strong. The total, magniuted of the Eigen value (2.4718) devided by the number of components (3) equal to 0.824 (2.4718/3=0.824).

| | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| Component | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 2,4718 | 82,393 | 82,393 | 2,4718 | 82,393 | 82,393 |
| 2 | ,630 | 12,596 | 94,990 | | | |
| 3 | ,181 | 3,611 | 98,601 | | | |

Figure 21 Total Variance Explained

Source: Own edition, based on Hungarian Statistical Office, Statistical tables on R&D

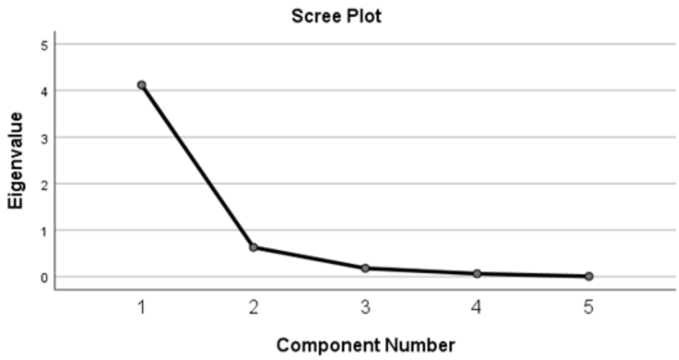


Figure 22 Scree Plot

Source: Own edition, based on Hungarian Statistical Office, Statistical tables on R&D

There is a big drop off to be experienced after the first component, and it flat-lines slowly. Both tables show one component solution.

Hypothesis 3. is being rejected. The distribution of R&D expenditure is not even. Business sector loads the highest.

# 5 Conclusions

The current study is far from beyond the scope of carrying out a full research on a comprehensive overview of the R&D field considering the data availabilty and the time shortness. R&D field in Hungary, but mostly in Europe as well, is a relatively sensitive and narrow segment which can be described mostly with low governmental institution budget. Although the support of R&D through instrument recruitment via proposals has been increasing in the last years.

Previously, there have been no prior attempts in any scientific literatures or publications to examine this scientific research field from this approach. So the current study is trying to fulfill the basic aspects of this ’gap’ by providing a deeper understanding, a better line of sight of the actual sectored laboratory research performance as well as identifying the obstacles towards achieving the desired sustainable economic growth target in a long-run R&D activities based on EU funding.

Hungary has been experiencing significant changes in the field of R&D since 1989, date of the regime change. Concerning the intensively growing number of institutes shown in Figure 4, which indicates the increasing role of the private sector, was increased with one order of magnitude since 1990, currently representing almost half of the existing R&D institutes, whereas the number of academic and universities labs remained stable. Despite the fact, some decrease can be experienced during the period of late nineties and early 2000s which can be explained due to the laborcentralization tendency. More expansive cooperation would be recommended to back up R&D activities through the large industrial business sector supporting sustainable economic growth. Total R&D staff shows very low level of 0.8% comparing to total labor force in the country. There is a huge difference between the number of researchers in for-profit and non-profit fields. It can be explained by the brain drain tendency towards the more profitable industrial sectors. Therefore more cooperation would be needed among the academic institutes and universities with production companies operating on industrial sectors. Also a low number of production enterprices is experienced in Hungary comparing to western European countries, which can be one of the explanation of poor economic sustainability. R&D expenditure and researchers’ headcount infer strong connection between the two. It is advised to grant more opportunities for research on wider platform in a supportive environment from the imondustrial field.

Taken the results of statistical methods carried out on different R&D data in the research into consideration, several conclusions can be drawned. Strong correlation was manifested between R&D expenditure and the number of R&D institutions and headcounts, which has a key role in efficient R&D activities increase. However, Academic sector has been constantly decreasing, while Universities have been stagnated with an intensively growing part of Business sector. Looking at the weak performance of governmental sectors, evolving a more effective way of support system is to be considered. While there is no clear assessment of the effect of EU resources, the available sources of R&D expenditure should be optimalized effectively among the sectors. Nowadays even non-profit organizations such as universities are pushed more and more to earn their budget due to insufficient governmental and private financial support. Evaluating the current surveyed situation of research development, more cooperation would be needed between industrial sectors and universities to back up efficient R&D activities. Also the growing amount of Open Innovation on the laboratory market supports strong background for upgrowth R&D intensity.

Considering the scope of the study further researches covering full range of data are suggested on this field for more extensive results.

Summarizing, it is easily can be stated that the research development supportive laboratory market has a strong influence on the rational resource management and environment protection and by its developing activities it also supports sustainable development. Just like in every other industrial sector also in the laboratory market the importance of the education of sustainability is rising besides the booming pace of technology development and the increasing ecology consciousness.

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