Various Approaches to Measuring Effectiveness of Tertiary Education*

Józef Dziechciarz, Anna Król and Marta Targaszewska

Abstract The paper aims at assessing selected approaches to measuring effectiveness of tertiary education and their applicability and summarizes various results obtained in the framework of the research project entitled Methods of Measuring the Return on Investment in Higher Education. The goal of the project was to analyse the problem of measuring the effectiveness of investment to tertiary education in its various forms. The applied methods, among others, include classical methods (ANOVA, Mincerian earnings function, correspondence analysis, hierarchical agglomerative clustering), as well as new ideas (application of Wilcoxon Matched-Pairs Signed-Rank Test to determine the significance of differences in incomes before and after reaching the tertiary education). The research is based on the data coming both from Polish (Social Diagnosis, Study of Human Capital), as well as German databases (SOEP). Obtained results support the hypothesis that tertiary education influences the level of incomes. Moreover, the estimated pseudo rates of return to education provide the basis for the evaluation of the effectiveness of private investment in education.

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1 Introduction

Since the year 1998, when the Sorbonne Declaration was signed and European Higher Education Area was established, the development and modernization of higher education have been the priorities of the European Union policies. Both The Bologna Declaration and The Lisbon Strategy, have emphasized the following aims: improving the quality of education, building the knowledge-based society and economy, adapting the education system to the needs of the labour market, lifelong learning, and supporting the acquisition of skills to compete in global environment. According to the strategy presented by European Commission in 2006, the project of Modernization Agenda for Universities (entitled Delivering on the Modernisation Agenda for Universities: Education, Research and Innovation) should be based on three reforms: curricula, governance and funding (cf. European Commission, 2006).

The latest EU strategy - “Europe 2020” - is yet another step of reforming higher education system in Europe. Its main priority is to support the creation of knowledge-based and balanced economy, which favours social inclusion and cohesion. Tertiary education is one of the essential factors in achieving main goals of this strategy. In order to define and realize all the educational aims of the strategy, European Commission issued The Higher Education Modernisation Agenda, which recommends among other measures increasing the number of universities’ graduates, encouraging people from various social groups to undertake studies, increasing quality of tertiary education, adjusting the curricula to labour market needs, directing higher education on financial crisis issues, as well as introducing outcome oriented funding of the universities (output-budgeting).

Moreover, contemporary research and education market with its increasing number of students, globalization, rapid technological development, growing research costs, emergence of specialized university-independent B+R centres, and the increasing significance of commercialization and entrepreneurship poses many challenges for traditional universities and enforces their transformation (cf. Etzkowitz and Peters, 1991; Wissema, 2009; Jongbloed, 2010). In order to ensure the better quality, effectiveness and accessibility of higher education among all EU countries the shift from the traditional Humboldtian university type towards modern entrepreneurial university type is essential. Conventional functioning areas of the university – education and research – should be supplemented by other fields such as research commercialization, application for external grants and projects as well as co-operation with industry.

A significant part of the postulated reforms in the functioning of the universities require changes in the area of funding, in particular encouraging a shift from a centralized input oriented funding mechanisms towards a decentralized outcome oriented financing. All this causes the necessity of measuring the effectiveness of various aspects of higher universities activities, including the education (cf. Dziechciarz, 2011).

This paper aims at assessing selected approaches to measuring effectiveness of tertiary education and their applicability, making use of the data from Polish (Social Diagnosis, Study of Human Capital), as well as German databases (SOEP). It sum-
Various Approaches to Measuring Effectiveness of Tertiary Education\textsuperscript{†} summarizes various results obtained in the framework of the research project entitled \textit{Methods of Measuring the Return on Investment in Higher Education}. 

2 Rate of return to education concepts

One of the concepts used in measuring effectiveness\textsuperscript{3} in the education system is the rate of return on investment to education. The most widely and commonly used approach is the concept of private returns, measured from the point of view of individuals (student), where benefits are increased earnings and costs are foregone earnings, education fees, cost of attendance or other incidental expenses during the period of studies (cf. Psacharopoulos, 1995). The returns to education may also be measured from the social perspective. The costs are in this case the states and the society’s large spending on education and the benefits are based on productivity (cf. Psacharopoulos, 1995). Table 1 presents various types of benefits from both private and social perspectives. The focus of the study is placed on measuring the effectiveness of tertiary education, defined as post-secondary education obtained at both universities and colleges.

### Table 1 Classification of the benefits of education

<table>
<thead>
<tr>
<th>Benefits type</th>
<th>Private</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market</td>
<td>employability</td>
<td>higher productivity</td>
</tr>
<tr>
<td></td>
<td>higher earnings and savings</td>
<td>higher net tax revenue</td>
</tr>
<tr>
<td></td>
<td>less unemployment</td>
<td>less reliance on government</td>
</tr>
<tr>
<td></td>
<td>labor market flexibility</td>
<td>financial support</td>
</tr>
<tr>
<td></td>
<td>greater mobility</td>
<td>technological development</td>
</tr>
<tr>
<td>Non-market</td>
<td>increased happiness</td>
<td>reduced crime</td>
</tr>
<tr>
<td></td>
<td>better personal and family health</td>
<td>less spread of infectious diseases</td>
</tr>
<tr>
<td></td>
<td>better child cognitive development</td>
<td>lower fertility</td>
</tr>
<tr>
<td></td>
<td>greater longevity</td>
<td>better social cohesion</td>
</tr>
<tr>
<td></td>
<td>greater satisfaction from consumption decisions</td>
<td>voter participation</td>
</tr>
</tbody>
</table>

Source: own elaboration based on Psacharopoulos (2009), McMahon (1997).

3 Effectiveness here refers to a relationship between higher education, resources used in education and outcomes - labour productivity and graduates employability (cf. Aubyn et al, 2008, p. 55)

3 Datasets

The described research was based on three datasets: German database Socio-Economic Panel Study (SOEP) (Wagner et al, 2007), and two Polish bases: Social...
The German Socio-Economic Panel Study (SOEP) is an annual wide-ranging representative longitudinal study on private households which started in 1984. The data provide information on households and its members and some of the many aspects include household composition, occupational biographies, employment, earnings, health and satisfaction indicators.

The Social Diagnosis is a panel study investigating households and their members aged 16 and above. The project takes into account all the significant aspects of life, both the economic ones (i.e. income, material wealth, savings and financing), and the not strictly economic ones (i.e. education, medical care, problem-solving, stress, psychological well-being, lifestyle, pathologies, engagement in the arts and cultural events). The first sample was taken in the year 2000. The following one took place three years later, and since then has been repeated every two years. The database is open and may be accessed through the panel internet site (http://www.diagnoza.com/).

The Study of Human Capital in Poland (BKL) is a labour market monitoring project carried out by the Polish Agency for Enterprise Development (Polska Agencja Rozwoju Przedsiębiorczości, PARP) in collaboration with the Jagiellonian University. In the years 2010-2014 the project will trace how the structure of competences is changing in the labour market and seek answers to the key questions related to human capital at both the national and regional level. The project provides access to its results and gathered data without any limitations and fees (http://en.bkl.parp.gov.pl/).

4 Various research approaches to measuring effectiveness of tertiary education

4.1 Application of the Mincer model in the analysis of the influence of tertiary education on the level of incomes

The first approach to measure effectiveness of tertiary education was a two step procedure. In the first step we examine the significance of the influence of education on monthly net incomes. Additionally it was investigated whether factors such as sex, the class of residence, region, study major, occupation, age, tenure of employment, tenure of employment with current employer etc. significantly differentiate the income level among persons with higher education in comparison to those with lower education. In the described research one-way ANOVA was applied\(^4\), except in cases

\(^4\) It is a method used to examine equality of group means for a quantitative outcome. The goal of one-way ANOVA is to verify the hypothesis that the analysed variable is influenced by independent (grouping) variables. In presented method null hypothesis states that all of the group means are equal (cf. Walesiak and Gatnar, 2012, p. 104). The application of one-way ANOVA is limited by...
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of heterogeneous variances in groups of independent variables, in which Welch test was used (cf. Proust, 2009, p. 141). The number of observations for the analysis of the influence of education level on monthly net incomes was 9,756, and 2,022 for the investigation of the influence of additional factors on incomes⁵. The list of the variables used in the research is given in Tables 2 and 3.

Table 2 Independent variables characteristics

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Groups</th>
<th>Number of observations</th>
<th>Mean [PLN]</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>education level</td>
<td>Higher education</td>
<td>2,221</td>
<td>2,331</td>
<td>1,013</td>
</tr>
<tr>
<td></td>
<td>Post-secondary education</td>
<td>409</td>
<td>1,695</td>
<td>548</td>
</tr>
<tr>
<td></td>
<td>Secondary vocational education</td>
<td>2,504</td>
<td>1,761</td>
<td>636</td>
</tr>
<tr>
<td></td>
<td>Secondary general education</td>
<td>789</td>
<td>1,617</td>
<td>570</td>
</tr>
<tr>
<td></td>
<td>Basic vocational education</td>
<td>3,101</td>
<td>1,637</td>
<td>602</td>
</tr>
<tr>
<td></td>
<td>Lower secondary, primary or unfinished primary education and without education</td>
<td>932</td>
<td>1,423</td>
<td>437</td>
</tr>
<tr>
<td>age</td>
<td>working mobile age (18–44 years)</td>
<td>1,408</td>
<td>2,286</td>
<td>987</td>
</tr>
<tr>
<td></td>
<td>working immobile age (females 45–59, males 45–64 years)</td>
<td>614</td>
<td>2,589</td>
<td>1,031</td>
</tr>
<tr>
<td>sex</td>
<td>male</td>
<td>785</td>
<td>2,720</td>
<td>1,089</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>1,237</td>
<td>2,161</td>
<td>891</td>
</tr>
<tr>
<td>the class of residence</td>
<td>big cities (100,000 and more inhabitants)</td>
<td>924</td>
<td>2,567</td>
<td>1,076</td>
</tr>
<tr>
<td></td>
<td>small and medium cities (less than 100,000)</td>
<td>650</td>
<td>2,251</td>
<td>2,251</td>
</tr>
<tr>
<td></td>
<td>villages</td>
<td>448</td>
<td>2,171</td>
<td>2,171</td>
</tr>
<tr>
<td>region⁶</td>
<td>central (without Warsaw)</td>
<td>226</td>
<td>2,298</td>
<td>1,003</td>
</tr>
<tr>
<td></td>
<td>south (without Silesia)</td>
<td>150</td>
<td>2,296</td>
<td>855</td>
</tr>
<tr>
<td></td>
<td>east</td>
<td>392</td>
<td>2,128</td>
<td>909</td>
</tr>
<tr>
<td></td>
<td>north-west</td>
<td>319</td>
<td>2,374</td>
<td>993</td>
</tr>
<tr>
<td></td>
<td>south-west</td>
<td>198</td>
<td>2,436</td>
<td>1,075</td>
</tr>
<tr>
<td></td>
<td>north</td>
<td>329</td>
<td>2,476</td>
<td>1,007</td>
</tr>
<tr>
<td></td>
<td>Warsaw sub region</td>
<td>210</td>
<td>2,778</td>
<td>1,121</td>
</tr>
<tr>
<td></td>
<td>Silesia</td>
<td>198</td>
<td>2,386</td>
<td>942</td>
</tr>
<tr>
<td>tenure of employment⁷</td>
<td>less than 5 years</td>
<td>366</td>
<td>1,964</td>
<td>943</td>
</tr>
<tr>
<td></td>
<td>at least 5 but less than 20 years</td>
<td>959</td>
<td>2,389</td>
<td>987</td>
</tr>
<tr>
<td></td>
<td>at least 20 years</td>
<td>690</td>
<td>2,579</td>
<td>1,026</td>
</tr>
<tr>
<td>tenure of employment with current employer</td>
<td>5 years or less</td>
<td>977</td>
<td>2,240</td>
<td>1,021</td>
</tr>
<tr>
<td></td>
<td>more than 5 years</td>
<td>1,045</td>
<td>2,507</td>
<td>982</td>
</tr>
</tbody>
</table>


the following assumptions: the dependent variable should be normally distributed and the variance should be homogeneous in all group of independent variables (cf. Ntoumanis, 2001, pp. 73, 74).

⁵ Only those respondents which are of working age, and who currently work (according to the variable tenure of employment with current employer), and who declared salaries at least as high as the minimum wage in the year 2009 were chosen. The research also excluded those respondents which declared extreme incomes.
Table 3 Independent variables characteristics (cont.)

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Groups</th>
<th>Number of observations</th>
<th>Mean [PLN]</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>study</td>
<td>education</td>
<td>375</td>
<td>2 137</td>
<td>826</td>
</tr>
<tr>
<td>major</td>
<td>arts, humanities</td>
<td>203</td>
<td>2 272</td>
<td>915</td>
</tr>
<tr>
<td></td>
<td>social sciences, journalism, information sciences, economy and administration, law</td>
<td>717</td>
<td>2 367</td>
<td>1 024</td>
</tr>
<tr>
<td></td>
<td>biological sciences, physics, mathematics statistics, computer sciences</td>
<td>193</td>
<td>2 565</td>
<td>1 105</td>
</tr>
<tr>
<td></td>
<td>technical sciences, production and processing, architecture and engineering</td>
<td>271</td>
<td>2 631</td>
<td>1 035</td>
</tr>
<tr>
<td></td>
<td>agriculture, forestry, fishing, veterinary medicine, public health, health care, social welfare, services for population, transportation services, protection of environment and sanitary municipal services, protection and safety</td>
<td>257</td>
<td>2 434</td>
<td>1 090</td>
</tr>
<tr>
<td>occupation</td>
<td>parliamentarians, high officials and managers</td>
<td>223</td>
<td>2 984</td>
<td>1 078</td>
</tr>
<tr>
<td></td>
<td>specialists</td>
<td>1 080</td>
<td>2 399</td>
<td>947</td>
</tr>
<tr>
<td></td>
<td>technicians and other mid-level staff</td>
<td>336</td>
<td>2 308</td>
<td>1 028</td>
</tr>
<tr>
<td></td>
<td>office workers</td>
<td>156</td>
<td>1 958</td>
<td>8 778</td>
</tr>
<tr>
<td></td>
<td>personal services staff and salesmen, farmers, foresters, fishermen, industry workers, craftsmen, operators and mechanics for machines, simple work staff, armed forces</td>
<td>166</td>
<td>2 054</td>
<td>986</td>
</tr>
</tbody>
</table>


The research was conducted for the data from the Social Diagnosis data set in the year 2009, and all hypotheses were verified with 95% confidence level. The test statistics and significance levels for one-way ANOVA or Welch test are presented in Table 4.

The results of the analysis show that the level of education significantly influences the monthly net income. The highest incomes were characteristic for persons with tertiary education degree, and lowest for persons with at most a lower-secondary education level. Moreover, all independent variables significantly (at the level 0.05 for the post-hoc Games-Howell test (cf. Morgan et al, 2004, p. 152, Field, 2005, p. 341) differentiate personal monthly net income of persons with higher education degree, where the average monthly income is 2 331.16 PLN. The results of research also shows that females achieve lower (on average of 550 PLN) wages than

\[ \text{Warsaw sub region and Silesia were analyzed separately due to higher income levels than observed in other regions in Poland (www.wynagrodzenia.pl/dane_gus.php, [14.11.2012])} \]

\[ \text{Ranges indicated by: Ustawa o promocji zatrudnienia i instytucjach rynku pracy z dnia 20 kwietnia 2004 r. [Dz. U. 2004 nr 99, poz. 1001].} \]

\[ \text{Classification indicated by: Rozporzdzienie Rady Ministrów w sprawie Polskiej Klasyfikacji Edukacji z dnia 6 maja 2003 r. [Dz. U. 2003 nr 98, poz. 895].} \]

\[ \text{Classification indicated by: Rozporzdzienie Ministra Pracy i Polityki Społecznej w sprawie klasyfikacji zawodów i specjalności na potrzeby rynku pracy oraz zakresu jej stosowania z dnia 27 kwietnia 2010 r. [Dz. U. 2010 nr 82, poz. 537].} \]
Table 4 Independent variables characteristics (cont.)

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Statistic</th>
<th>Significance – ANOVA/strong tests for means equality</th>
</tr>
</thead>
<tbody>
<tr>
<td>education level</td>
<td>245.500</td>
<td>0.000</td>
</tr>
<tr>
<td>age</td>
<td>39.193</td>
<td>0.000</td>
</tr>
<tr>
<td>sex</td>
<td>145.514</td>
<td>0.000</td>
</tr>
<tr>
<td>the class of residence</td>
<td>31.126</td>
<td>0.000</td>
</tr>
<tr>
<td>region</td>
<td>8.774</td>
<td>0.000</td>
</tr>
<tr>
<td>tenure of employment</td>
<td>46.358</td>
<td>0.000</td>
</tr>
<tr>
<td>tenure of employment with current employer</td>
<td>35.695</td>
<td>0.000</td>
</tr>
<tr>
<td>major</td>
<td>11.027</td>
<td>0.000</td>
</tr>
<tr>
<td>occupation</td>
<td>31.317</td>
<td>0.000</td>
</tr>
</tbody>
</table>


males. Lower incomes are specific for persons of working mobile age. This could be explained by lower experience of those persons.

There is also a significant difference between the wages of persons living in big cities (number of inhabitants 100 thousands and more) and the persons living in small and medium cities (number of inhabitants less than 100 thousands) or villages, where wages of persons from the first two categories are the highest. In case of variable “region” high income is characteristic for the respondents from the Warsaw sub-region, and lowest for the Eastern provinces (Lublin, Podkarpackie, Podlaskie, Świętokrzyskie).

The next examined variables were “tenure of employment” and “tenure of employment with current employer”. Both of these variables significantly influence achieved income - persons with higher experience (more than 5 years) earn more money. The last two variables – “study major” and “occupation” - are closely related. Conducted research proves that the graduates of educational studies, humanities or art studies obtain lower incomes than graduates of technical and theoretical science studies. Moreover, the average incomes in group of social sciences, journalism and information sciences, economy, administration and law studies are similar to the group which contains studies such as: agriculture, forestry, fishing, veterinary medicine, public health, health care, social welfare, services for population, transportation services, protection of environment, sanitary municipal services, protection and safety. The level of monthly net income is also influenced by occupation, where the highest incomes (800 PLN higher than for other professions) are specific to parliamentarians, high officials and management. Similar earnings are characteristic for technicians, mid-level staff and specialists. For more details on the result of this analysis see Targaszewska (2013).

The obtained results were used to support the process of choosing the appropriate independent variables in the second step of the research - the estimation of the private pseudo rate of return to education using the Mincer’s earning function. Additionally the analysis of the dynamics of influence of education level on the wages was performed. The empirical research for Germany was based on the SOEP
database (years 1995, 2000, 2005, 2010) and for Poland on the Social Diagnosis data set (years 2003, 2005, 2007, 2009, 2011). The description of variables for SOEP data set and summary statistics are presented in the Table 5, whereas the presentation of the variables from the Social Diagnosis data set is given in the Table 6. For the sake of conciseness, the summary statistics for the SOEP data set are presented only for the year 2010 (the most recent of analysed years) and for Social Diagnosis data set only for the year 2009 (the same year as one-way ANOVA and Welch test from the previous step - for comparison purposes). Similarly, the various specifications of the estimated models are presented in details in Tables 7 and 8 only for the selected years (the SOEP data set in year 2010 and the Social Diagnosis data set in year 2009 accordingly), and the Tables 9 and 10 present only the most important results for each year of the study.

Table 5 Description of variables for SOEP data set and summary statistics in year 2010

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Description</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Dataset structure in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGEAR</td>
<td>Hourly gross earnings in [EUR]</td>
<td>16.80</td>
<td>15.01</td>
<td></td>
</tr>
<tr>
<td>YOET</td>
<td>Years of education and training</td>
<td>12.82</td>
<td>2.75</td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>Age</td>
<td>43.70</td>
<td>12.52</td>
<td></td>
</tr>
<tr>
<td>PWE</td>
<td>Potential work experience (PWE=AGE-YOET-6)</td>
<td>25.60</td>
<td>12.18</td>
<td></td>
</tr>
<tr>
<td>HEDU</td>
<td>Higher education 1 if obtained higher education diploma 0 otherwise</td>
<td>26.60</td>
<td>73.40</td>
<td></td>
</tr>
<tr>
<td>MEDU</td>
<td>Secondary education 1 if obtained secondary education diploma 0 otherwise</td>
<td>98.08</td>
<td>1.92</td>
<td></td>
</tr>
<tr>
<td>SEN</td>
<td>Tenure of employment with current employer</td>
<td>11.53</td>
<td>10.57</td>
<td></td>
</tr>
<tr>
<td>FEM</td>
<td>Gender 1 if female 0 otherwise</td>
<td>48.90</td>
<td>51.10</td>
<td></td>
</tr>
<tr>
<td>TYPE</td>
<td>Work position type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APP</td>
<td>(trainee)</td>
<td>12.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPEC</td>
<td>(specialist)</td>
<td>12.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROF</td>
<td>(freelancer/professional)</td>
<td>44.69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAN</td>
<td>(manager)</td>
<td>6.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OTHER</td>
<td>(other)</td>
<td>23.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIZE</td>
<td>Size of current employer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMALL</td>
<td>(less than 20 employees)</td>
<td>31.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEDIUM</td>
<td>(20 - 2 000 employees)</td>
<td>47.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LARGE</td>
<td>(more than 2 000 employees)</td>
<td>21.05</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6 Description of variables for Social Diagnosis data set and summary statistics in year 2009

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Description</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Dataset structure in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNEAR</td>
<td>Monthly net earnings in [PLN]</td>
<td>1350.00</td>
<td>707.72</td>
<td></td>
</tr>
<tr>
<td>HE</td>
<td>Higher education</td>
<td></td>
<td></td>
<td>10.83</td>
</tr>
<tr>
<td></td>
<td>1 for tertiary education</td>
<td></td>
<td></td>
<td>89.17</td>
</tr>
<tr>
<td>ME</td>
<td>Secondary education</td>
<td></td>
<td></td>
<td>36.63</td>
</tr>
<tr>
<td></td>
<td>1 for secondary education</td>
<td></td>
<td></td>
<td>63.37</td>
</tr>
<tr>
<td>YOE</td>
<td>Years of education</td>
<td>11.54</td>
<td>3.31</td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>Age</td>
<td>48.77</td>
<td>18.01</td>
<td></td>
</tr>
<tr>
<td>EXP</td>
<td>Professional experience years</td>
<td>22.36</td>
<td>13.91</td>
<td></td>
</tr>
<tr>
<td>WSEC</td>
<td>Work sector</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>public (PUB)</td>
<td>14.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>private (PRIV)</td>
<td>24.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>own business (ENT)</td>
<td>3.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>other (OTH)</td>
<td>58.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CTYPE</td>
<td>The type of residence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BCITY (more than 100 thousand occupants)</td>
<td>23.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MCITY (less than 100 thousand occupants)</td>
<td>32.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>VIL (villages)</td>
<td>43.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 if female</td>
<td>54.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 otherwise</td>
<td>45.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EAST</td>
<td>Geographical localization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 if eastern Poland</td>
<td>26.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0 otherwise</td>
<td>73.48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


To analyse the dynamics of influence of education level on the wages the commonly applied Mincerian earnings function (cf. Mincer, 1958, 1974) was used in each year separately:

\[
\ln E_{AR_i} = X_i^T \beta + \epsilon_i, \tag{1}
\]

where \( E_{AR} \) - earnings, \( X \) - vector of variables influencing wages, \( \beta \) - vector of unknown parameters, \( \epsilon \) - error term. The elements of \( X \) describe education (represented by number of years of education or dummies for level of education, the latter

10 For categorical and dichotomic variables in the Tables 5 and 6 the percentage for each category is given.
11 Eastern Poland includes the Lubelskie, Podkarpackie, Podlaskie, Świętokrzyskie and Warmińsko-Mazurskie regions in accordance with the division incorporated in the European Operational Programme Development of Eastern Poland. These provinces are considered to have lower living standards, a lower dynamic of economic development, poorly developed and inadequate transport infrastructure and insufficient growth factors, which might be reflected in the earnings of their residents.
providing the estimation of the pseudo rate of return to education) and professional experience, as well as auxiliary characteristics such as gender, region, place of work, position etc. As the dependent variable real hourly gross earnings for SOEP data set and real monthly net earnings for Social Diagnosis data set were used. Afterwards the earnings were transformed to natural logarithms. Applied log-linear functional form proved to be correct in many previous studies (cf. Heckman et al, 2003). In addition, a Box-Cox transformation method which allows to choose between linear ($\alpha = 1$) and log-linear ($\alpha = 0$) specification was used (cf. Box and Cox, 1964):

$$B(EAR_i, \alpha) = \begin{cases} \frac{EAR_i^{\alpha} - 1}{\alpha} & \text{for } \alpha \neq 0 \\ \ln(EAR_i) & \text{for } \alpha = 0 \end{cases}$$

For all tested specifications the parameter $\alpha$ was close to 0 indicating correctness of log-linear specification. Figure 1 presents the results of searching the parameter $\alpha$ which maximizes the logarithm of likelihood function for specification (SOEP4).

Since heteroscedasticity of error term was detected in the large majority of cases (using White’s test (cf. White, 1980)), for model estimation weighted least squares method was applied.

Table 7 presents estimation results of five different specifications of Mincer model in the year 2010 based on SOEP data set (dependent variable $\ln(RHGEAR)$),

\begin{itemize}
  \item[12] Adjustment for inflation led to creation of new variables: $RHGEAR$ and $RMNEAR$ accordingly.
  \item[13] For more detailed analysis and additional information see Król (2014).
  \item[14] In Tables 7, 8, 9 and 10 stars indicate significance level (‘***’ means significance on the level 0.01; ‘**’ means significance on the level 0.05; ‘*’ means significance on the level 0.1), $n$ indicates number of observations used in estimation, $R^2$ indicates goodness-of-fit measure adjusted $R$-squared (adjusted determination coefficient) and AIC indicates Akaike Information Criterion.
\end{itemize}
Table 7: Estimation results of five different specifications of Mincer model (year 2010) based on SOEP data set (dependent variable \( \ln(RHGEAR) \))

<table>
<thead>
<tr>
<th>(SOEP1)</th>
<th>(SOEP2)</th>
<th>(SOEP3)</th>
<th>(SOEP4)</th>
<th>(SOEP5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>0.8636***</td>
<td>1.839***</td>
<td>1.518***</td>
<td>2.207***</td>
</tr>
<tr>
<td></td>
<td>(0.03461)</td>
<td>(0.02436)</td>
<td>(0.07071)</td>
<td>(0.02290)</td>
</tr>
<tr>
<td>YOET</td>
<td>0.08217***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.001909)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PWE</td>
<td>0.05246***</td>
<td>0.05220***</td>
<td>0.05225***</td>
<td>0.02572***</td>
</tr>
<tr>
<td></td>
<td>(0.001943)</td>
<td>(0.002006)</td>
<td>(0.002001)</td>
<td>(0.001813)</td>
</tr>
<tr>
<td>PWE²</td>
<td>-0.0008456***</td>
<td>-0.0008823***</td>
<td>-0.0008815***</td>
<td>-0.0004860***</td>
</tr>
<tr>
<td></td>
<td>(3.867e-05)</td>
<td>(3.916e-05)</td>
<td>(3.912e-05)</td>
<td>(3.522e-05)</td>
</tr>
<tr>
<td>HEDU</td>
<td>0.4192***</td>
<td>0.4148***</td>
<td>0.2231***</td>
<td>0.2229***</td>
</tr>
<tr>
<td></td>
<td>(0.01225)</td>
<td>(0.01226)</td>
<td>(0.01046)</td>
<td>(0.01041)</td>
</tr>
<tr>
<td>MEDU</td>
<td></td>
<td>0.3236***</td>
<td></td>
<td>0.1181*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.06703)</td>
<td></td>
<td>(0.06579)</td>
</tr>
<tr>
<td>SEN</td>
<td></td>
<td></td>
<td>0.02148***</td>
<td>0.02151***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.001403)</td>
<td>(0.001396)</td>
</tr>
<tr>
<td>SEN²</td>
<td></td>
<td></td>
<td>-0.0003143***</td>
<td>-0.0003161***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3.659e-05)</td>
<td>(3.644e-05)</td>
</tr>
<tr>
<td>FEM</td>
<td></td>
<td></td>
<td>-0.1679***</td>
<td>-0.1684***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.008819)</td>
<td>(0.008774)</td>
</tr>
<tr>
<td>APP</td>
<td></td>
<td></td>
<td>-0.3813***</td>
<td>-0.3749***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.02136)</td>
<td>(0.02131)</td>
</tr>
<tr>
<td>PROF</td>
<td></td>
<td></td>
<td>0.2694***</td>
<td>0.2682***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.01036)</td>
<td>(0.01031)</td>
</tr>
<tr>
<td>MAN</td>
<td></td>
<td></td>
<td>0.2893***</td>
<td>0.2881***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.01771)</td>
<td>(0.01765)</td>
</tr>
<tr>
<td>SMALL</td>
<td></td>
<td></td>
<td>-0.2836***</td>
<td>-0.2847***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.01369)</td>
<td>(0.01361)</td>
</tr>
<tr>
<td>MEDIUM</td>
<td></td>
<td></td>
<td>-0.1084***</td>
<td>-0.1081***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.01028)</td>
<td>(0.01021)</td>
</tr>
</tbody>
</table>

| n        | 9 534    | 9 534    | 9 534    | 8 787    | 8 787    |
| R²       | 0.2219   | 0.1711   | 0.1731   | 0.4153   | 0.4172   |
| AIC      | 41 081.68 | 40 710.35 | 40 745.02 | 38 393.00 | 38 289.02 |


starting from the simplest classic Mincer model (SOEP1) describing earnings by number of years of education and experience to the most complex specification (SOEP5). Specification (SOEP5) was chosen for further interpretation, since it has the highest value of goodness-of-fit measure and the lowest value of AIC information criterion, moreover all its variables are statistically significant. The interpretation of results of estimation of the model (SOEP5) shows that in the year 2010 the Germans with higher education could earn about 25% more in comparison to similar (in terms of gender, work experience, work type, size of the company etc.) persons. Women in Germany earned in 2010 on average about 15% less than men on
similar work positions and with similar professional experience. The professionals and freelancers in the year 2010 could earn about 31% more, the managers about 33% more and the trainees about 31% less than regular employees (specialists and other employees). This result proves that labour market requirements extend beyond simple higher education diploma, and that additional qualifications and skills are also important. The differences in earnings in big and small firms may also be observed: employees of small companies in the year 2010 could earn about 24% less and in medium companies about 10% less than employees in big corporations, ceteris paribus.

Table 8 Estimation results of five different specifications of Mincer model (year 2009) based on Social Diagnosis data set (dependent variable ln(RMNEAR))

<table>
<thead>
<tr>
<th></th>
<th>(SD1)</th>
<th>(SD2)</th>
<th>(SD3)</th>
<th>(SD4)</th>
<th>(SD5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.01718)</td>
<td>(0.01060)</td>
<td>(0.01213)</td>
<td>(0.01385)</td>
<td>(0.01437)</td>
</tr>
<tr>
<td>YOE</td>
<td>0.06484***</td>
<td>0.06484***</td>
<td>0.01404***</td>
<td>0.01105***</td>
<td>0.01288***</td>
</tr>
<tr>
<td></td>
<td>(0.00100)</td>
<td>(0.0009639)</td>
<td>(0.0009927)</td>
<td>(0.0008900)</td>
<td>(0.0008705)</td>
</tr>
<tr>
<td>EXP</td>
<td>0.01195***</td>
<td>0.01404***</td>
<td>0.01354***</td>
<td>0.01105***</td>
<td>0.01288***</td>
</tr>
<tr>
<td></td>
<td>(0.0009639)</td>
<td>(0.0009927)</td>
<td>(0.0009839)</td>
<td>(0.0008900)</td>
<td>(0.0008705)</td>
</tr>
<tr>
<td>EXP²</td>
<td>−0.0001213</td>
<td>−0.0002492</td>
<td>−0.0002102</td>
<td>−8.475e-05</td>
<td>−0.001011***</td>
</tr>
<tr>
<td></td>
<td>(1.964e-05)</td>
<td>(2.104e-05)</td>
<td>(2.004e-05)</td>
<td>(1.867e-05)</td>
<td>(1.793e-05)</td>
</tr>
<tr>
<td>HE</td>
<td>0.4807***</td>
<td>0.6024***</td>
<td>0.3470***</td>
<td>0.4699***</td>
<td>0.4699***</td>
</tr>
<tr>
<td></td>
<td>(0.009995)</td>
<td>(0.01068)</td>
<td>(0.009400)</td>
<td>(0.01008)</td>
<td>(0.01008)</td>
</tr>
<tr>
<td>ME</td>
<td>0.2887***</td>
<td>0.2116***</td>
<td>0.2116***</td>
<td>0.2116***</td>
<td>0.2116***</td>
</tr>
<tr>
<td></td>
<td>(0.008038)</td>
<td>(0.007129)</td>
<td>(0.007129)</td>
<td>(0.007129)</td>
<td>(0.007129)</td>
</tr>
<tr>
<td>MCTY</td>
<td>−0.08492***</td>
<td>−0.06582***</td>
<td>−0.06582***</td>
<td>−0.06582***</td>
<td>−0.06582***</td>
</tr>
<tr>
<td></td>
<td>(0.008162)</td>
<td>(0.008016)</td>
<td>(0.008016)</td>
<td>(0.008016)</td>
<td>(0.008016)</td>
</tr>
<tr>
<td>VIL</td>
<td>−0.2194***</td>
<td>−0.1637***</td>
<td>−0.1637***</td>
<td>−0.1637***</td>
<td>−0.1637***</td>
</tr>
<tr>
<td></td>
<td>(0.008138)</td>
<td>(0.008188)</td>
<td>(0.008188)</td>
<td>(0.008188)</td>
<td>(0.008188)</td>
</tr>
<tr>
<td>PUB</td>
<td>0.4295***</td>
<td>0.3852***</td>
<td>0.3852***</td>
<td>0.3852***</td>
<td>0.3852***</td>
</tr>
<tr>
<td></td>
<td>(0.009388)</td>
<td>(0.0099046)</td>
<td>(0.0099046)</td>
<td>(0.0099046)</td>
<td>(0.0099046)</td>
</tr>
<tr>
<td>PRIV</td>
<td>0.3909***</td>
<td>0.3662***</td>
<td>0.3662***</td>
<td>0.3662***</td>
<td>0.3662***</td>
</tr>
<tr>
<td></td>
<td>(0.008321)</td>
<td>(0.008243)</td>
<td>(0.008243)</td>
<td>(0.008243)</td>
<td>(0.008243)</td>
</tr>
<tr>
<td>ENT</td>
<td>0.5190***</td>
<td>0.4745***</td>
<td>0.4745***</td>
<td>0.4745***</td>
<td>0.4745***</td>
</tr>
<tr>
<td></td>
<td>(0.01904)</td>
<td>(0.01881)</td>
<td>(0.01881)</td>
<td>(0.01881)</td>
<td>(0.01881)</td>
</tr>
<tr>
<td>EAST</td>
<td>−0.08472***</td>
<td>−0.08729***</td>
<td>−0.08729***</td>
<td>−0.08729***</td>
<td>−0.08729***</td>
</tr>
<tr>
<td></td>
<td>(0.007100)</td>
<td>(0.006818)</td>
<td>(0.006818)</td>
<td>(0.006818)</td>
<td>(0.006818)</td>
</tr>
<tr>
<td>F</td>
<td>−0.1933***</td>
<td>−0.2138***</td>
<td>−0.2138***</td>
<td>−0.2138***</td>
<td>−0.2138***</td>
</tr>
<tr>
<td></td>
<td>(0.006624)</td>
<td>(0.006485)</td>
<td>(0.006485)</td>
<td>(0.006485)</td>
<td>(0.006485)</td>
</tr>
</tbody>
</table>

| n      | 18 417     | 18 426     | 18 426     | 18 370      | 18 370      |
|        | 18 417     | 18 426     | 18 426     | 18 370      | 18 370      |
| $R^2$  | 0.1904     | 0.1182     | 0.1642     | 0.3330      | 0.3660      |
| AIC    | 77 441.29  | 76 479.20  | 75 850.83  | 77 973.57   | 77 847.24   |

Similarly to the Table 7, Table 8 presents estimation results of five specifications of Mincer model in the year 2009 based on Social Diagnosis data set (dependent variable \(\ln(\text{RMNEAR})\)). Again the most complex specification (SD5) is taken for interpretation and further research. The premium for higher education in Poland in the year 2009 was about 29%\(^{15}\). The difference in earnings between males and females in Poland is bigger than it was observed in Germany. In the analysed period women earned on average about 19% less than man doing similar work in much the same work place. The influence of residence on the level of wages was significant as well. Eastern Polish regions, which are considered to have lower living standards, lower dynamic of economic development and insufficient growth factors, prove to have significantly lower earnings. In comparison to the Central and West Poland the people from eastern provinces earned about 8% less, \textit{ceteris paribus}. Moreover, the residents of small and medium cities earn about 6% and residents of villages about 15% less than the inhabitants of big cities.

Table 9  Estimation results of Mincer model in years 1995, 2000, 2005, 2010 based on SOEP data set (dependent variable \(\ln(\text{RHGEAR})\))

<table>
<thead>
<tr>
<th></th>
<th>SOEP1995</th>
<th>SOEP2000</th>
<th>SOEP2005</th>
<th>SOEP2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>2.421**</td>
<td>2.502**</td>
<td>2.243**</td>
<td>2.090**</td>
</tr>
<tr>
<td>(PWE)</td>
<td>0.02106**</td>
<td>0.001609**</td>
<td>0.03010**</td>
<td>0.02577**</td>
</tr>
<tr>
<td>(PWE^2)</td>
<td>-0.0004066**</td>
<td>-7.616e-07**</td>
<td>-0.0005706**</td>
<td>-0.0004867**</td>
</tr>
<tr>
<td>(HEDU)</td>
<td>0.09978**</td>
<td>0.1385**</td>
<td>0.1826**</td>
<td>0.2229**</td>
</tr>
<tr>
<td>(MEDU)</td>
<td>-0.05301</td>
<td>0.04387</td>
<td>0.02129</td>
<td>0.1181*</td>
</tr>
<tr>
<td>(SEN)</td>
<td>0.01831**</td>
<td>0.02322**</td>
<td>0.02000**</td>
<td>0.02151**</td>
</tr>
<tr>
<td>(SEN^2)</td>
<td>-0.0004006**</td>
<td>-0.0004539**</td>
<td>-0.0003263**</td>
<td>-0.0003161**</td>
</tr>
<tr>
<td>(FEM)</td>
<td>-0.1897**</td>
<td>-0.1899**</td>
<td>-0.1789**</td>
<td>-0.1684**</td>
</tr>
<tr>
<td>(APP)</td>
<td>-0.3114**</td>
<td>-0.4339**</td>
<td>-0.4124**</td>
<td>-0.3749**</td>
</tr>
<tr>
<td>(PROF)</td>
<td>0.2190**</td>
<td>0.2301**</td>
<td>0.2636**</td>
<td>0.2682**</td>
</tr>
<tr>
<td>(MAN)</td>
<td>0.1461**</td>
<td>0.1861**</td>
<td>0.2544**</td>
<td>0.2881**</td>
</tr>
<tr>
<td>(SMALL)</td>
<td>-0.2908**</td>
<td>-0.2744**</td>
<td>-0.2894**</td>
<td>-0.2847**</td>
</tr>
<tr>
<td>(MEDIUM)</td>
<td>-0.1080**</td>
<td>-0.1101**</td>
<td>-0.1202**</td>
<td>-0.1081**</td>
</tr>
<tr>
<td>(n)</td>
<td>7 018</td>
<td>12 423</td>
<td>9 697</td>
<td>8 787</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.3365</td>
<td>0.3474</td>
<td>0.4088</td>
<td>0.4172</td>
</tr>
</tbody>
</table>


Tables 9 and 10 presents the final estimated models for the years 1995 – 2010 for the SOEP data set and for the years 2003 – 2011 for the Social Diagnosis data set. The obtained results allow for the evaluation of dynamics of influence of higher education and other factors on the earnings in Germany and Poland accordingly.

\(^{15}\) Note that in the Social Diagnosis data set the values of variables \(HE\) and \(ME\) for the persons with higher education are 1, whereas in the SOEP data set for the persons with higher education \(HEDU=1\) and \(MEDU=0\).
Table 10 Estimation results of Mincer model in years 2003, 2005, 2007, 2009, 2011 based on Social Diagnosis data set (dependent variable ln(RMNEAR))

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HE</td>
<td>0.5349***</td>
<td>0.4349***</td>
<td>0.4805***</td>
<td>0.4699***</td>
<td>0.4879***</td>
</tr>
<tr>
<td>ME</td>
<td>0.2171***</td>
<td>0.2226***</td>
<td>0.2286***</td>
<td>0.2116***</td>
<td>0.2353***</td>
</tr>
<tr>
<td>M CITY</td>
<td>−0.09271***</td>
<td>−0.07576***</td>
<td>−0.07770***</td>
<td>−0.06582***</td>
<td>−0.04613***</td>
</tr>
<tr>
<td>VIL</td>
<td>−0.2105***</td>
<td>−0.1382***</td>
<td>−0.1452***</td>
<td>−0.1637***</td>
<td>−0.1384***</td>
</tr>
<tr>
<td>PUB</td>
<td>0.4884***</td>
<td>0.4087***</td>
<td>0.4276***</td>
<td>0.3852***</td>
<td>0.4390***</td>
</tr>
<tr>
<td>PRIV</td>
<td>0.4486***</td>
<td>0.3173***</td>
<td>0.3862***</td>
<td>0.3662***</td>
<td>0.3959***</td>
</tr>
<tr>
<td>ENT</td>
<td>0.6216***</td>
<td>0.4372***</td>
<td>0.5128***</td>
<td>0.4745***</td>
<td>0.4716***</td>
</tr>
<tr>
<td>EAST</td>
<td>−0.05617***</td>
<td>−0.05287***</td>
<td>−0.03427***</td>
<td>−0.08729***</td>
<td>−0.07752***</td>
</tr>
<tr>
<td>F</td>
<td>−0.2324***</td>
<td>−0.1882***</td>
<td>−0.2030***</td>
<td>−0.2138***</td>
<td>−0.2219***</td>
</tr>
</tbody>
</table>

| n       | 6 707    | 5 802    | 9 205    | 18 370   | 18 661   |
| R²      | 0.3497   | 0.3028   | 0.3081   | 0.3660   | 0.3545   |


In Germany in the last 15 years we observe quite stable increase in the value of the premium for higher education (from 11% to 25%). The auxiliary factors which influence changed the most are the ones connected with the type of work. For example, the premium for managers increased from about 15% in the year 1995 to about 33% in the year 2010. Another interesting trend observed in the analysed period is the slight decrease of gender-related work discrimination (from about 17% to about 15%).

The analysis of Polish data shows the stabilization of the influence of tertiary education on the level of earnings. In the years 2005 – 2011 the premium for higher education oscillates around the level of 30%. Similarly, the earnings of women in the analysed period remain lower than those of men of about 20%. There is slight improvement in the reduction of regional differences. The difference in earnings of the residents of villages in comparison to the inhabitants of big cities changed from about 19% in 2005 to about 15% in 2011.

4.2 Determination of the significance of differences in incomes before and after reaching the higher education

Another part of our research was to check if there is significant difference in incomes before and after reaching a higher education degree and afterwards to measure the rate of return to education in both groups (cf. Targaszewska, 2014). To achieve those
goals the Wilcoxon Matched-Pairs Signed-Rank Test\(^{16}\) and the classical Mincerian function were suitably applied. The research was based on the group of respondents which declared in The Social Diagnosis to have education at higher level in 2011, which took part in The Social Diagnosis project in previous years (since 2003) and declared a lower than tertiary level of education. Because of the nature of the data some assumptions were made. Firstly, in a situation where over the years, some respondents changed their level of education more than once, the research included the most recent change. Secondly, the variable denoting years of experience in 2011 was estimated\(^{17}\). Lastly, incomes were corrected by inflation indicator (with the base year 2003). Moreover, the cases where incomes were under the minimum wages in each year were removed from the research. In the results 152 cases were taken into account. For beginning a test for dependent samples - namely Wilcoxon Matched-Pairs Signed-Rank Test - was used. The p-value for the executed test was equal to 0E0. It allows to reject the null hypothesis, stating the equality of median difference in paired observations, which means that there is a significant difference in incomes between groups: before reaching higher education degree (“before”) and after reaching higher education degree (“after”). Wages of persons with higher education degree are higher on average of 773 PLN in comparison to persons without this kind of level of education\(^{18}\).

Subsequently, the rate of return to education and rate of return to experience for both groups “before” and “after” were estimated by the classical Mincer model which could be expressed by the formula (cf. Mincer, 1974):

\[
\log(Y) = \alpha + \rho s + \beta_0 x + \beta_1 x^2 + \xi, \tag{3}
\]

where: \(Y\) is earnings, \(s\) is schooling level or years of study, \(x\) is work experience. Parameter \(\rho\) can be interpreted as the average private rate of return to schooling, \(\beta\) is related to the financial return to experience, and \(\alpha\) is related to initial earnings capacity (cf. Polachek, 2008). The estimated model for group “before” is presented in Table 11.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>7.474</td>
<td>0.000</td>
</tr>
<tr>
<td>Years of study ((s))</td>
<td>-0.001</td>
<td>0.943</td>
</tr>
<tr>
<td>Experience ((x))</td>
<td>0.034</td>
<td>0.000</td>
</tr>
<tr>
<td>Quadratic experience ((x^2))</td>
<td>-0.001</td>
<td>0.006</td>
</tr>
</tbody>
</table>


\(^{16}\) It is non-parametric test used to compare two paired (dependent) samples - each of observation of first sample has an unique connection with observation in the second sample. A null hypothesis stating the equality of median difference in paired observation samples have identical distributions (cf. Jackson, 2011, pp. 266, 267).

\(^{17}\) Experience in 2011 is equal to experience in 2009 plus two years.

\(^{18}\) 2453 [PLN] and 3226 [PLN] are means “before” and “after” respectively.
In the presented model the variable indicating the years of study (coefficient 0.001) is not significant at the 5% significance level. It seems to mean that for persons without higher education degree the most important is experience. After rejecting the variable “years of study” the model was estimated once again with the result presented in Table 12.

Table 12 Parameter estimates of Mincer’s model “before” (without “years of study” variable)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>7.458</td>
<td>0.000</td>
</tr>
<tr>
<td>Experience ((x))</td>
<td>0.034</td>
<td>0.000</td>
</tr>
<tr>
<td>Quadratic experience ((x^2))</td>
<td>-0.001</td>
<td>0.006</td>
</tr>
</tbody>
</table>


From the new model for group “before” one can conclude that the rate of return to experience, after 10 years of working is nearly 1.4%. The estimated Mincer earnings function for the group called “after” is shown in Table 13.

Table 13 Parameter estimates of Mincer’s model “after”

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>6.584</td>
<td>0.000</td>
</tr>
<tr>
<td>Years of study ((s))</td>
<td>0.066</td>
<td>0.002</td>
</tr>
<tr>
<td>Experience ((x))</td>
<td>0.031</td>
<td>0.001</td>
</tr>
<tr>
<td>Quadratic experience ((x^2))</td>
<td>-0.001</td>
<td>0.017</td>
</tr>
</tbody>
</table>


For group “after” each of the parameters is significant. The rate of return to education is about 6.6% and rate of return to experience after 10 years of working is as about 1.1%.

4.3 Examination of non-monetary benefits of tertiary education

Our next research step for measuring the effectiveness of education was to capture the intangible benefits of higher education, particularly non-monetary private and social rates of return on investment in education. Empirical studies were carried out on data from the Social Diagnosis 2011. As shown in the Table 1, non-monetary returns are an important part of outcomes of education costs. It is commonly believed that better educated people have a better life. This general opinion can be empirically confirmed in two ways. Firstly, by peoples personal experience and on the other hand by the statements of the respondents concerning their life quality perception and expectations along with their level of education. Figure 2 visualizes the
output of correspondence analysis. A comprehensive description of the algorithm of correspondence analysis, computational details, and its applications can be found in the classic text by Greenacre (1984). Figure 2 shows depicting the coincidence of the respondents’ education level depicting coincidence of respondents education level (1 stands for basic education, 2 - vocational, 3 - secondary and 4 - higher) along with a subjective evaluation of his/her life (1 stands for very happy, 2 - pretty happy, 3 - not very happy and 4 - unhappy). The position of higher education in Figure 2 is close to the most positive assessment of one’s life in the last year. The percent of total inertia described in the two first dimensions is defined in almost 100%, in Figures 2 and 3 first dimension describes in about 98% of inertia. In Figure 2, point very happy is next to high education, and further to the right the education level is lower, and the assessment of life in the last year is also getting worse. Basic education is near to negative assessment. The conclusion is that better education could be associated with a more positive perception of the past. But when respondents were asked to name the three most important conditions for successful and wonderful life, the first five positions were health, children, happy marriage, work and money. The education level was mentioned somewhere between the 13\textsuperscript{th} and 10\textsuperscript{th} place out of 14 possible places (higher position for better educated respondents). Looking into this surprising phenomenon leads to conclusion that that education is associated with higher earnings and better work.

Private non-monetary returns of tertiary education include the impact of education on personal health, ability to enjoy leisure and capacity to make personal
choices. Obviously education tends to improve income which affects health positively. People with a higher education level are more aware of healthy behaviour and demonstrate more tendencies to seek treatment when needed. More results of the analysis of non-monetary benefits of tertiary education can be found in Dziechciarz-Duda and Król (2013).

According to the WHO Regional Office for Europe (2012), the male population in age of 30 with higher education will live on average another 48.5 years. While the male population in age of 30 with primary education will live on average another 36.5 years and for secondary education another 43 years. For women life expectancy is in general longer: for better educated on average 83.2 years and for the least educated 5 years shorter. Moreover, differences in the risk of death related to educational level are greater in the case of men than women for all causes of death (except cardiovascular diseases). Subsequently death rates from all main causes tend to be lower among people with higher education levels. All diseases contribute to shortening the lives of less-educated people when compared with better educated individuals. The cause that is most responsible for shortening the lives of less-educated people when compared with better educated individuals are cardiovascular diseases, external causes and cancer. Numerous research results confirm that higher education contributes to increase longevity and better health in terms of severe and fatal diseases, partly through the increased earnings that enable purchase of better health care and a better diet (cf. WHO Regional Office for Europe, 2012). But moreover education is also associated with feeling of overall well-being.

Fig. 3 Correspondence analysis of education and the frequency of health problems, the Social Diagnosis 2011, sample size: 26 332.
Figure 3 visualizes the output of correspondence analysis for “level of education” of Polish respondents in 2011 (1 stands for basic education, 2 - vocational, 3 - secondary and 4 - higher) and “subjective evaluation of self-well-being” expressed as the frequency of health problems that hinder positive perception of quality of life (1 stands for often, 2 - sometimes and 3 - never). The results support the hypothesis of the positive impact of education on personal health. In Figure 3 the point “often” is next to “basic education” and further, to the right the “level of education” is growing and the assessment of health is better.

4.4 Analysis of employment status and professional profiles of universities graduates

Goal of our last research step was to analyze the professional situation of young people with tertiary education. For this purpose a hierarchical classification method was applied to the data from the Study of Human Capital in Poland 2012. Thereby homogenous classes of university graduates were distinguished as a result of Ward procedure. Based on the histogram graph was isolated eight classes of graduates. The analysis of characteristics of in each class can be a valuable source of information about the factors that have an impact on the level of unemployment in this group. The following variables describing the situation of graduates on the labour market were used: professional status (full-time job, part-time job, unemployed, housework, etc.), the type of university (private, public), (full-time studies, evening studies, extramural studies) the level of studies (bachelor, engineer, master, etc.), as well as the average level of net income.

Fig. 4 Assessment of groups according to the percentage of employed and earnings, Study of Human Capital in Poland 2012.
The analysis of the professional situation and characteristics of the graduates in separate classes allowed for the assessment of how well the representatives of each group cope with the labour market challenges (see Figure 4). The worst groups, in terms of the percentage of employed and earnings level, were the young, out-of-work people with a bachelor’s degree, graduated from private universities (class 5), young people without work and experience (class 8), as well as young people from small towns and villages, graduated from agriculture and service studies (class 2). The level of employment and earnings in class 3 (teachers and humanistic studies graduates) is similar to the average in the whole population. Whereas the situation of the classes 1 (well-paid engineers), 4 (employed economists with significant experience), 6 (working with a bachelor’s degree, graduated from private universities) and 7 (entrepreneurial with a master’s degree) is significantly better. Comprehensive results of the research can be found in Dziechciarz-Duda and Przybysz (2014).

The obtained results support the general opinion of a less favourable situation of the graduates with bachelor degree. The percentage of employment in the group of bachelor degree holders is only 63,8%, whereas for graduates with masters degree it increases to 80,7%. A similar situation may be observed for technical universities graduates - undergraduate engineers employment rate is 76,5%, while in the group of engineers with masters degree 85,3%. The strongest position on the labour market occupy the graduates of engineering and technical studies, as well as mathematics, statistics, physics and medicine grads. The students of most popular majors (economics, pedagogics and social studies) will face the employment rate of about 80% and unemployment rate of almost 15%.

5 Final remarks

This paper summarizes various results obtained in the framework of the research project entitled Methods of Measuring the Return on Investment in Higher Education. The goal of the project was to analyse the problem of measuring the effectiveness of investment to higher education in its various forms. The research approaches, among other, included classical methods (ANOVA, Mincerian earnings function, correspondence analysis, hierarchical agglomerative clustering), as well as new ideas (application of Wilcoxon Matched-Pairs Signed-Rank Test to determine the significance of differences in incomes before and after reaching the higher education). All obtained results support the hypothesis that higher education influences the level of income. Moreover, the estimated pseudo rates of return to education provide the basis for the evaluation of the effectiveness of private investment in education.
Various Approaches to Measuring Effectiveness of Tertiary Education

References


Dear Mr. Dziechciarz,

We would like to inform you about the current state of your submission Various Approaches to Measuring Effectiveness of Tertiary Education to the Archives of Datascience (Online First):

Your submission is undergoing the final copy editing and typesetting.

You will receive a preview of your article as soon as possible.

Sincerely,

Maximilian Korndörfer