Magisterarbeit

Titel der Magisterarbeit

"Education and Wages: Empirical Evidence from Poland"

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Magistra der Sozial- und Wirtschaftswissenschaften (Mag.rer.soc.oec.)

Wien, im Juni 2008

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Introduction

This master thesis looks at micro determinants of investment in education. The main assumption is that any investment is undertaken to maximize the resulting stream of future receipts. I shall present two approaches that try to explain the positive influence of education on wages. The first one is that education increases the productivity of an individual who is then paid according to the value of his marginal product. The second one is that the amount of education serves as a signal of some characteristic of a potential worker.

In my opinion these two alternative approaches are a good economic explanation. I would like to argue that they do not exclude one another. Job market signalling can be a useful extension of human capital theories. Mincer assumed that the conditions of perfect information are present both on the worker and the employer side, which is a realistic assumption. Thus, signalling extension can be useful to reflect the labour market.

I consider education as a kind of investment in human capital. Thus, I found it useful to approximate the return on such investment to see if it is positive and how high it is.

I shall attempt to find the return on education using the example of Poland. To estimate the return on investment in education I will use the data gathered by the Institute for Social Studies of the University of Warsaw. Polish General Social Survey (PGSS) is created on the basis of individual surveys and its main points of interests are situation on labour market, wages, but also voting patterns, religion.

More precisely, I will investigate the role of investment in education on earnings in Poland in 1999 and 2005.I have chosen these two years because based on the available literature, I assume that the return on education might have changed slightly after joining the European Union.

Using disaggregated income data and OLS methods I will examine the impact of the number of years of schooling on wages, also controlling for the influence of socio-demographic factors. Based on the literature I predict that my estimated of the return on education in Poland will be between 7 and 10%.

My motivation to choose this particular topic is determined by the strong belief that sometimes micro incentives and economic selfishness have broader economic consequences. This is the case when it comes to investment in education. The benefits of education can be divided into private, both tradable and non tradable, and social. Private tradable are the main topic of my dissertation- these are the abilities gained during schooling as well as the

possibility to signal these abilities. Private non tradable benefits include job satisfaction or better health of an individual and their family.

Hartog and Oosterbeek (1998) analyzed the influence of education on health and the feeling of happiness. They found that this relation is statistically significant. People with secondary education are on average healthier and happier than other groups[1]. When it comes to health, Sander (1995) noticed that educated people are more likely to stop smoking[2]. Moreover, more educated individuals can adapt to new conditions and consumption possibilities more easily. For example, Wozniak (1987), using the sample of farmers, proved that education positively influences the probability of adapting new, profitable investment opportunities[3].

However, I would like to emphasize the importance of social consequences of educational choices. Human capital is thought to be one of the key determinants of GDP growth. Mankiw, Romer and Weil (1992) pointed that education is an additional input in the production function. Romer (1986) said that education influences the level of the technology and the rate of technological progress. Stimulating technological progress through higher human capital level may be associated with higher per capita production growth.

Moreover, some authors claim that generating social capital is also one of the aggregate effects of education[4]. High level of social capital usually means political stability, lower crime and high voter turnout. For all the reasons mentioned above, I found that the problem of investment in education is worth studying.

The thesis is structured as follows: in the introduction I will pose hypotheses, present the goals and motives of my work.. Chapter I is devoted to the analysis of the theoretical basis. In the first subsection, detailed literature review is presented. Second subsection introduce the human capital approach. I shall pay attention to the compensating difference model as well as to the Mincerian accounting-identity model. The next subsection will be devoted the to presentation of an alternative approach to job market signalling (Spence (1973)). Last subsection of Chapter I gives comparison of models and implications for wage regressions. Data and methodology will be presented in Chapter II. Definitions of variables and the source of the data will be described in the first subsection. Second subsection gives an overview on

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[1] Hartog J., Oosterbeek H., Health, Wealth and Happiness: Why Pursue a Higher Education?, Economics of Education Review, Vol. 17, No. 3, 1998, pp. 254.

[2] Sander W., Schooling and Quitting Smoking, The Review of Economics and Statistics, Vol. 77, No. 1, (Feb., 1995), pp. 195.

[3] Wozniak G. D., Human Capital, Information, and the Early Adoption of New Technology, The Journal of Human Resources, Vol. 22, No. 1, (Winter, 1987), pp. 102.

[4] For example Fukuyama (1999), McMahon (1999).

used methodology In Chapter III the results will be presented. In the first subsection I will present the results of estimations, in second results will be compared with the results from literature. The last part of my thesis concludes

Chapter 1. Theoretical analysis

Education is a process of learning new things, accumulating information and skills. According to the economic approach, it is a kind of investment in the so called human capital, which is defined as individual's embodied skills above their raw labour ability[5]. Moreover, it is believed that the bigger the human capital, the higher productivity of the worker. Education, as a form of investment is undertaken in hopes of getting positive return in the future.

However, the reward of education is very complex and contains financial as well as no pecuniary gains. More educated people are regarded as better worker. Therefore, they can enjoy higher probability of finding a job and a shorter period of unemployment. Moreover, prestige and social status are also important. When it comes to pecuniary aspects, the most visible and straightforward gain is the increase in the future income.

To study the link between investment in education and labour market, two alternative approaches are commonly used. The first one is based on the model developed by Jacob Mincer (1974). Its main assumption is that individuals maximize their future stream of income taking into consideration that an additional year of education raises their future earnings but also makes the period of labour activity shorter.

The other approach was developed by Michael Spence (1973). Spence suggested that productivity of individuals is given and education is a way of communicating the abilities to the potential employer. The absence of perfect information is of key importance here. I would like to argue that this approach can be used as a kind of extension of the schooling model presented by Mincer.

1.1. Literature review

The discussion about the importance of education was partially provoked by inquiries about the reasons of income inequality among people. The problems, such as poverty and income distribution have always been the subject of research of economists. Becker and Chiswick (1966) came to the conclusion that the distribution of earnings is the determined by distribution of investment in human capital and on its return[6].

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[5] Belfield C. R., Economic principles of education. Theory and evidence., Cheltenham, Glos. [u.a.]: Elgar , 2000, pp. 1.
[6] Becker Gary S., Chiswick Barry R., Education and the Distribution of Earnings, The American Economic Review, Vol. 56, No. 1/2. (Mar. - May, 1966), pp. 368.

According to Mincer (1958), individuals choose the optimal schooling length. They maximize the present value of their earnings considering the fact that longer training is connected with higher annual earnings but also with postponement of receipts to a later age[7]. He also remarked that earnings significantly differ with age.

However, not only schooling is important. Thus, Mincer (1962) studied the importance of investment in manpower[8]. Formal schooling is not a sufficient method of training the labour force. In the literature there were also some efforts made to estimate the optimal level of investment in training and its the rate of return on training. Post school investment is a significant component of the total investment in human capital.

Ben-Porath (1967) posited that human capital cannot be bought as a final good. The individuals' characteristics, such as abilities, affect the production function of education[9]. This has some important implications for the choice of optimal path of investment and thus for life cycle of earnings. In the thesis, education is studied in the framework of dynamic modelling and the role of production function and costs are precisely described. The validity of Ben-Porath (1987) model's insights was confirmed by Mincer (1997).

Spence (1973) pointed out that individuals undertake education to signal the abilities and productivity to potential workers[10]. The same approach was advocated by Weiss (1995). He summarized both human capital and the signalling models and presented several doubts connected with human capital models that can be easily explained using the signalling approach[11].

There were numerous evidences for sorting versus human capital models and vice versa. Groot and Oosterbeek (1994), Kroch and Sjoblom (1994) may be given as an example. None of the arguments is persuasive since different methods of testing the same hypothesis are applied. And it is hard to decide which is the best one. Grubb (1993) suggested for example, that the fact that self employed and highly educated people often have very high wages is the evidence that the signalling hypothesis is wrong. On the other hand Altonji (1995) estimated that coefficient on particular courses in wage regression are often very small, sometimes

[7] Mincer J., Investment in Human Capital and Personal Income Distribution, The Journal of Political Economy, Vol. 66, No. 4. (Aug., 1958), pp. 284.

[8] Mincer J., On-the-Job Training: Costs, Returns, and Some Implications, The Journal of Political Economy, Vol. 70, No. 5, Part 2: Investment in Human Beings. (Oct., 1962), pp. 50-79.

[9] Ben-Porath Yoram, The Production of Human Capital and the Life Cycle of Earnings, The Journal of Political Economy, Vol. 75, No. 4, Part 1. (Aug., 1967), pp. 352.

[10] Spence Michael, Job Market Signaling, The Quarterly Journal of Economics, Vol. 87, No. 3, (Aug., 1973), pp. 358.

[11] Weiss Andrew, Human Capital vs. Signalling Explanations of Wages, The Journal of Economic Perspectives, Vol. 9, No. 4, (Autumn, 1995), pp. 133-154.

negative or insignificant[12]. This discredits human capital models and supports a sheepskin effect. Sheepskin effect suggests that the obtaining diploma or certificate has positive and significant effect on wages. Some authors suggest that it is responsible for positive correlation between earnings and schooling. The existence of sheepskin effect was confirmed by paper written by Hungerford and Solon[13].

Nevertheless, many researches attempt to estimate the return on various types of education. The rate of the return is the percentage growth in earnings associated with an additional year of schooling or graduating from given level of education. An important and detailed paper was written by Psacharopoulos (1985)[14]. The main conclusions from his research are as follow: firstly, the gain from education decreases with the level of education. Relatively high return on primary education is connected with high productivity increase as well as with low cost. Secondly, the return on education is lower in developed countries[15]. In developing countries high skilled people are relatively more rare.

Similar results, but on the family level were also found by Land (1993) and Card (1995). They both showed that the return on education is higher for people from poor families. The third Psacharopoulos' (1985) finding says that private return on education is higher than social[16].

Card (1999) associates an additional year of education with 6-11% percentage premium in remuneration. Acemoglu and Angrist (1999) estimated individual and social gain on education at about 7.5% level annually. Brunello, Coni and Lucifora (2000), using Italian data, obtained 6.2% for men 7.7% for women. Simirally, Harmon, Oosterbeeck and Walker (2002) estimated return for 15 European Union countries as 6.5 %.

There were also some estimations that used some Polish data. However, the results are ambiguous. Nevertheless, all of them showed that more years of education are connected with a rise in earnings. Obtaining a university diploma increases earnings by 28.5% - 73.1% (Kot (1999) and Bedi (1998)).

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[12] Altonji J.G., The Effects of High School Curriculum on Education and Labor Market Outcomes, The Journal of Human Resources, Vol. 30, No. 3, (Summer, 1995), pp. 421-427.
[13] Hungerford T., Solon G., Sheepskin Effects in the Returns to Education, The Review of Economics and Statistics, Vol. 69, No. 1, (Feb., 1987), pp 177.
[14] Psacharopoulos G., Returns to Education: A Further International Update and Implications, The Journal of Human Resources, Vol. 20, No. 4 (Autumn, 1985), pp. 583-604.
[15] Psacharopoulos G., Returns to Education: A Further International Update and Implications, The Journal of Human Resources, Vol. 20, No. 4 (Autumn, 1985), pp. 588.
[16] Psacharopoulos G., Returns to Education: A Further International Update and Implications, The Journal of Human Resources, Vol. 20, No. 4 (Autumn, 1985), pp. 587.

It is worth remarking that there are also papers suggesting a negative coefficient between this rate and the average years of schooling in a given country. Coen Teulings and Thijs van Rens (2002) showed that the increase in average length of schooling causes that wages of lower educated increase, whereas. because of the greater supply of high skilled labour force their salaries are not higher.

This mechanism reduces the return on human capital. Empirically, they showed a strong negative correlation between the supply of human capital and return on education. One additional year of education is connected with a rate lower by 2%[17]. It means that it is profitable to be highly educated but is more profitable have higher educational level as compared to the average.

The influence of the cost on investment decision is also worth mentioning. This branch of studies emphasizes the importance of, for example, the height of tuition fees, grants, scholarships on the average educational level. This kind of subject was described, for example by Card (2000), McPerson, Schapiro (1991), Kane (1995) or Frederiksson (1997).

1.2. The basic human capital model

The model presented by Mincer (1958) was designed to explain the inequality of income. Neither stochastic nor ability based models provided any satisfactory explanation that would reflect the observed variation of wages. Abilities are thought to be normally distributed, whereas income is sharply skewed. On the other hand, stochastic models lacked deep economic interpretation. The next paragraphs will present the logic of the model introduced by Mincer.

Mincer started his analysis of investment on education with the belief that the personal income must be a consequence of an individual's rational choice. However, formulating a simple human capital model requires more meaningful assumptions. Firstly, it is assumed that all individuals in the economy have identical abilities. Secondly, there are several occupations that require different amount of training. Thirdly, individuals act in the conditions of perfect information, also concerning possible wages (there is no uncertainty). Moreover, credit markets are perfect[18].

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[17] Coen N. Teulings, Thijs van Rens, 2002. "Education, Growth and Income Inequality," Tinbergen Institute Discussion Papers 02-001/3, Tinbergen Institute, revised 05 Mar 2003, pp. 25.

[18] Mincer J., Investment in Human Capital and Personal Income Distribution, The Journal of Political Economy, Vol. 66, No. 4. (Aug., 1958), pp. 284.

The schooling costs consist of two elements- opportunity costs and direct costs. The opportunity costs are associated with forgone earnings while in school. Each year of schooling reduces the earning life exactly by one year so schooling is full time activity. The direct costs, such as tuition and other educational services costs seem to be substantial in some countries. What is more, according to the key economic assumption, the resources that are available are scarce. In other countries, education of an individual is financed either by the state or by family, which reduces direct costs. For simplicity, Mincer (1958) considered these educational services costs to be zero.

The original model uses a principle of compensating differences. It means that the wage difference between occupations with required high level of education and these that require a lower level must fully compensate the costs connected with forgone earnings.

Let V_n be the present value of the future earnings. The present value of an individual's lifetime earnings at the start of schooling is equal to the discounted stream of earnings for a person with given s years of education. Following notation from Mincer (1974), it can be written in following way:

$$V_s = Y_s \sum_{t=s+1}^{n} \left(\frac{1}{1+r} \right)^t$$

if the discounting process is discrete and as

$$V_s = Y_s \int_s^n e^{-rt} dt = Y_s \frac{e^{-rs} - e^{-rn}}{r}$$

for continuous discounting process, where Y_s is the annual earning available for an individual with s years of education, r is the discounting rate, n is the length of working life and schooling.

Using this logic, the present value of lifetime earnings of an individual with s-d years of education can be written as

$$V_{s-d} = Y_{s-d} \int_{s-d}^n e^{-rt} dt = Y_{s-d} \frac{e^{-r(s-d)} - e^{-rn}}{r}.$$

It can be observed that there two contradictory effects. Firstly, annual earnings of a person with s years of education are higher than earnings after only s-d years of education ($Y_s > Y_{s-d}$). Secondly, the employment period is shorter.

The ratio $k_{s,s-d}$ of annual earnings after s years to earnings after s-d years of schooling is then equal to

$$k_{s,s-d} = \frac{Y_s}{Y_{s-d}} = \frac{V_s r(e^{-r(s-d)} - e^{-rn})}{V_{s-d} r(e^{-rs} - e^{-rn})} = \frac{V_s (e^{-r(s-d)} - e^{-rn})}{V_{s-d} (e^{-rs} - e^{-rn})}.$$

However, since there is an assumption that future earnings must fully compensate the cost of studying, an individual must be indifferent between various occupation choices. In other words, each person invests up to a point in which the present value of earnings with additional d years of education is equal to the present value of earnings without this additional investment. So, it can be assumed that $V_s = V_{s-d}$. Then, the ratio can be found.

$$k_{s,s-d} = \frac{(e^{-r(s-d)} - e^{-rn})}{(e^{-rs} - e^{-rn})} = \frac{e^{r(n+d-s)} - 1}{e^{r(n-s)} - 1}.$$

Mincer (1974) pointed out that this ratio is larger than 1,0 which means that, in fact, annual earnings of a person with more education are higher than for a person with less education. Secondly, $\frac{\partial k}{\partial r} > 0$, $\frac{\partial k}{\partial n} < 0$ and $\frac{\partial k}{\partial s} > 0$. The higher rate of return to schooling, the higher the wage difference. The length of working plus the schooling period have negative influence on the wage ratio. If n is very large, there is much time to compensate for investment and, consequently, annual earnings do not have to differ a lot. Moreover, the ratio of earnings is a negative function of the years of schooling. Therefore, the wage difference would be greater for two people that have, for example, 14 and 12 years of schooling than for two people with 8 and 6 *ceteris paribus*.[19]

If we add the additional assumption that n is fixed, then, each person has the same life horizon, videlicet, the length of working plus the schooling period. Under this assumption, the value of the future stream of earnings can be denoted as:

$$V_s = Y_s \int_s^{n+s} e^{-rt} dt = Y_s \frac{e^{-rs} - e^{-r(n+s)}}{r} = Y_s \frac{e^{-rs}(1 - e^{-rn})}{r},$$

and similarly:

$$V_{s-d} = Y_{s-d} \int_{s-d}^{n+s-d} e^{-rt} dt = Y_{s-d} \frac{e^{-r(s-d)} - e^{-r(n+s-d)}}{r} = Y_{s-d} \frac{e^{-r(s-d)}(1 - e^{-rn})}{r}.$$

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[19] Mincer J., Schooling, Experience and earnings, NBER, New York, 1974, pp. 10.

This assumption can be made, for example, when the age of retirement is fixed. Then, the ratio becomes a bit simpler and has the following form:

$$k_{s,s-d} = \frac{e^{-rs}\left(1-e^{-rn}\right)}{e^{-r(s-d)}\left(1-e^{-rn}\right)} = e^{rd}.$$

Since we defined $k_{s,s-d}$ as the ratio of earnings of person with s years of schooling to the earnings of person with s-d ears, then the ratio of annual earnings after s years of education to the earnings without schooling is equal to

$$k_{s,0} = \frac{Y_s}{Y_0} = e^{rs}.$$

Taking logs yields

$$\ln\frac{Y_s}{Y_0} = \ln e^{rs}$$

which is equivalent with

$$\ln Y_s - \ln Y_0 = rs.$$

It can be concluded that the logarithm of earnings of a person with completed s years of education is equal to $\ln Y_s = \ln Y_0 + rs$, so it is proportional to the time spent at school. However, more detailed conclusion can be drawn form this simple equation, namely, the percentage increment in earnings is the linear function of years spent in school.

In reality, it is very hard to observe the Y_s. People do not stop investing in their human capital after completing school. Qualifications are raised during the whole working life. Investment takes the form of training, courses and internships. Moreover, also the learning by doing process must be taken into the consideration.

Learning by doing is an important concept in economics. It says that workers are able to improve their productivity by repeating the same activities. A well known illustration of this process is the liberty ships example provided by Rapping (1965). The speed of building these ships in the U.S.A. was increasing very fast with the number of ships built[20]. To be more precise, the more ships were built, the less time workers needed to build an additional one. Thus, it can be concluded that the productivity rose because of repeating the same actions.

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[20] Rapping L., Learning and World War II Production Functions, The Review of Economics and Statistics, Vol. 47, No. 1, (Feb., 1965), pp. 81-86.

Different types of training and process mentioned above showed that human capital and productivity of a worker can be increased also after the end of their formal education. If we add an assumption that people are paid according to their productivity, then we end up with the conclusion that Y_s may be observed only just after completing school. The amount of later earnings is a combined effect of both formal education and professional training.

Taking into account the existence of training learning by the doing process, Mincer (1974) showed a slightly different approach which is now widely applied and called the accounting-identity model. The notion of potential earnings has been introduced to underline the fact that the earnings profiles that are observed are just the net earnings. To be more precise, Y_t (observed earnings at time t) is equal to potential earnings minus the investment in training. Mincer (1974) assumed these cost to be some fraction of potential earnings[21]:

$$C_t = k_t \cdot P_t.$$

Potential earnings in year t can be written then as the sum of potential earnings plus the return on investment in education made in a previous year[22], so:

$$P_t = P_{t-1} + r_{t-1}C_{t-1} = P_{t-1} + r_{t-1}k_{t-1}P_{t-1} = P_{t-1}(1 + r_{t-1}k_{t-1}).$$

By recursion:

$$P_t = P_{t-1}(1 + r_{t-1}k_{t-1}) = P_{t-2}(1 + r_{t-2}k_{t-2})(1 + r_{t-1}k_{t-1}) = P_0(1 + r_0k_0) \cdot \ldots \cdot (1 + r_{t-1}k_{t-1}).$$

Periods of investment in education can be divided into two groups- years of schooling and years when an individual is active on the job market. The main difference between these two periods is that in the first investment in education is a full time activity. All potential earnings are sacrifices to invest in human capital so k is equal to 1 then. Moreover, Mincer (1974) assumed that the return on investment is constant during s year of studying and is not equal to the return to training. It can be summarized in the following way:

$$P_t = P_0(1 + r_0k_0) \cdot \ldots \cdot (1 + r_{s-1}k_{s-1})(1 + r_sk_s) \ldots \cdot (1 + r_{t-1}k_{t-1}) = P_0 \prod_{j=0}^{s-1}(1 + r_jk_j)\prod_{j=s}^{t-1}(1 + r_jk_j) =$$

$$= P_0\prod_{j=0}^{s-1}(1 + r_s)\prod_{j=s}^{t-1}(1 + r_0k_j) = P_0(1 + r_s)^s\prod_{j=s}^{t-1}(1 + r_0k_j)$$

Or in a logarithmic form:

[21] Mincer J., Schooling, Experience and earnings, NBER, New York, 1974, pp. 19.
[22] In next few paragraphs notation from Heckman J. J., Lochner L. J., Todd P. E., Earnings Functions, Rates of Return, and Treatment Effects: The Mincer Equation and Beyond, NBER Working Paper Series, Working Paper 11544, 2005 will be followed.

$$\ln P_t = \ln P_0 + s\ln(1+r_s) + \sum_{j=s}^{t-1} \ln(1+r_0 k_j).$$

Using the property that $\ln(1+x) \approx x$ for x being small the above expression can be rewritten as[23]:

$$\ln P_t \approx \ln P_0 + sr_s + \sum_{j=s}^{t-1} r_0 k_j = \ln P_0 + sr_s + r_0 \sum_{j=s}^{t-1} k_j.$$

It was assumed that k during s years of schooling is equal to one. Now, I shall concentrate on this ratio in later periods to elaborate on how people invest in those periods. It is known that the observed earnings Y_t equal the potential earnings in period t minus the investment undertaken in this period. Then the annual increment of earnings can be denoted as:

$$\Delta Y_t = Y_{t+1} - Y_t = (P_{t+1} - C_{t+1}) - (P_t + C_t) = (P_t + r_t C_t - C_{t-1}) - (P_t - C_t) =$$
$$= r_t C_t + C_t - C_{t-1} = r_t C_t - (C_{t-1} - C_t)$$

A positive increase in the observed earnings will be observed if the net investment is positive. Mincer (1974) pointed out that rational allocation requires most education to be taken in early stages of a person's life. That is why, k was assumed to be 1. To put it simply, the cost of education in the model is the forgone earnings and all year earnings are forgone when schooling is assumed to be full time activity. It should be pointed out that this general statement that more investment is taken in the early stages of people' lives, continues after completing school- in the training period (assuming that lifetime is certainly finite).

At this point, it would be useful to explain where the assumption of declining investment comes from. Mincer (1974) listed the reasons after Becker (1964)[24]. Firstly, because of finite lifetime, the later investment is undertaken, the shorter is the period when these investment pays return. Secondly, the postponement of investment reduces the net gains. Thirdly, one of the consequences of investment is the fact that the value of the time for a given individual increases since alternative cost increases.

The next important question is why not all education is undertaken at the young life stage if it is more beneficial. The answer relies on the analysis of human capital production function made by Ben-Porath (1967). He assumed that the marginal cost of production is upward sloping within each period. Moreover, from the reasons mentioned above, marginal

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[23] This is deducted from a second order Taylor approximation.
[24] Mincer J., Schooling, Experience and earnings, NBER, New York, 1974, pp. 13.

benefits shift down with age. The choice of optimal investment in education in a given period can be treated as production problem where the optimal level of production must be chosen as it is presented through figure 1.

Figure 1. Production of human capital
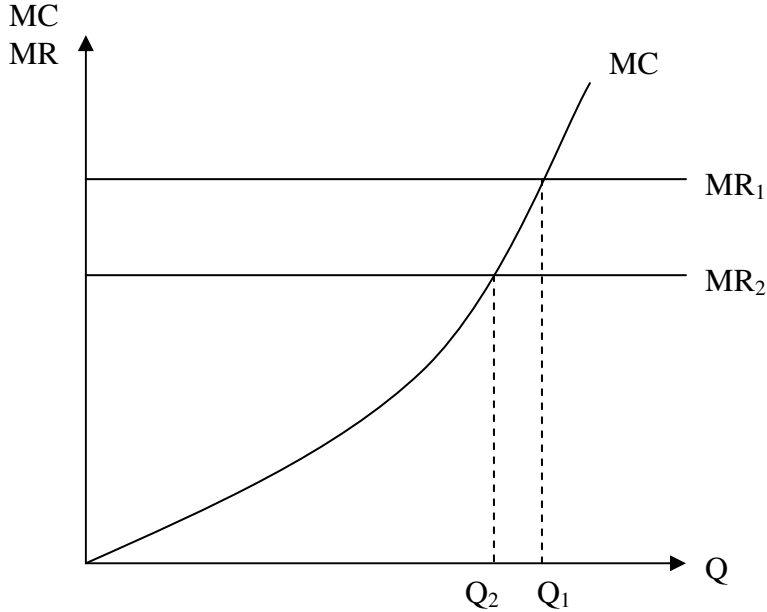
Source: Mincer J., Schooling, Experience and earnings, NBER, New York, 1974, pp. 15.

How an individual makes the choice of investment in two periods is presented through the figure X. In one period, marginal revenue is equal to MR_1. Thus, individuals choose the optimal level- Q_1 by equating marginal costs with MR_1. In the other period, marginal revenue shifts down. The reasons for this shift were listed above. Then, the optimal investment level is equal to Q_2. This very simple illustration shows that investment is declining over the life cycle. Moreover, some authors suggested that this process is even stronger if the marginal cost curve shifts up with age.

It can be simplified that the ratio of investment in education to the potential earnings is a linear function of work experience

$$k_{s+x} = K\left(1 - \frac{x}{N}\right)$$

where x denotes experience, K is a parameter, and N is the sum of schooling and working age. Now, the potential earnings can be written as[25]

$$\ln P_{x,s} \approx \ln P_0 + sr_s + r_0 \sum_{x=0}^{t-1-s} K(1-\frac{x}{N}) = \ln P_0 + sr_s + r_0\left[x(K+\frac{K}{2N}) + x^2(\frac{K}{2N})\right] =$$

$$= \ln P_0 + sr_s + x(r_0K + \frac{r_0K}{2N}) + x^2(\frac{r_0K}{2N}).$$

Finally, observed earnings that are the potential earnings minus the cost equal

$$Y(s,x) = P_{x+s} - C_{x+s} = P_{x+s} - k_{s+x}P_{x+s} = P_{x+s}(1-k_{x+s})$$

$$\ln Y(x,s) = \ln P_{x+s} + \ln(1-k_{x+s}) = \ln P_{x+s} - k_{x+s} = \ln P_{x+s} - K\left(1-\frac{x}{N}\right) =$$

$$= \ln P_0 + sr_s + x(r_0K + \frac{r_0K}{2N}) + x^2(\frac{r_0K}{2N}) - K\left(1-\frac{x}{N}\right) =$$

$$= \ln P_0 - K + sr_s + x(r_0K + \frac{r_0K}{2N} + \frac{K}{N}) + x^2(\frac{r_0K}{2N}).$$

According to the last expression, the logarithm of the observed earnings is a linear function of years of schooling. However, it is also a function of experience and experience squared since some training is also taken after completion of studies. This formulation is known as the Mincerian wage equation.

Nevertheless, it must be also added that other authors argued many times if wage should be really the function of the whole life experience or only an experience in a given firm. Experience in a given job or in a given firm is a kind of firm specific experience. It consists of the knowledge of a know how of the firm, its rules, clients and the technology used there. Probably, both types of experience have positive influence on wages, but the influence in a given job is stronger.

Firm specific knowledge can be one of the most important resource in some industries. It can be shown on the example of NASA[26], a company that in 2000 faced a serious problem of retirement of their most experienced scientists. The headquarters realized that the company had no information sharing culture and something must be done to transfer implicit knowledge to the less experienced workers.

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[25] $\sum_{x=0}^{t-1-s} K(1-\frac{x}{N}) = K + K(1-\frac{1}{N}) + \cdots + K(1-\frac{t-1-s}{N}) = K\left[(t-s) - \left(\frac{1}{N} + \cdots + \frac{t-1-s}{N}\right)\right] =$

$= K\left[x - \frac{1}{N}(1+2+\ldots+(t-1-s))\right] = K(x - \frac{1}{2N}(x-1)x).$

[26] Leonard D., Kiron D., Managing Knowledge and Learning at NASA and the Jet Propulsion Laboratory (JPL), Harvard Business School, Case study no. 9-603-062, Rev . October 29, 2002.

Implicit or tacit knowledge is hard to transfer since it is based on experiences and, of course, also on failures. NASA's idea was to introduce Lesson Learned Information System (LLIS) that was designed to improve two important processes connected with the transformation of knowledge- socialization[27] and internalization[28] the skills of retiring scientists. The example of NASA shows the importance of the job training for the company. It rises both human capital of the worker and organizational knowledge. Thus, the positive correlation between the tenure and wages is reasonable.

The next paragraph is devoted to arguing that not all available research confirms the human capital approach to post school education. Schleifer and Summers' (1998) finding was that senior workers suffered most after hostile takeover[29]. Also Gibbons and Katz (1991) confirmed this prediction in the case of plants closing and layoffs. They summarized that the dismissed people with a long tenure that should be valued also by other firms in the same industry, were offered relatively low wages[30]. Sometimes senior workers are paid high bonuses to induce them to earlier retirement[31].

Shleifer and Summers (1998) and Gibbons and Katz (1991) seem to be in contradiction with the human capital approach. Senior workers should be valued most since they on the job training is the longest. Moreover, these workers have the biggest firm specific skills.

1.3. Job market signalling model

The human capital model is one possible way of explaining investment in education. An alternative approach was presented by Spence (1973). The main assumption of his model is that education does not upgrade the human capital of the student. It is only a way of signalling its level to the potential employer. More generally, it assumes that asymmetric information is present on the labour market.

According to the job market signalling model, all workers are dichotomized into two groups that have different levels of abilities. Thus, the productivities of both groups are not

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[27] Process of transfer the knowledge from implicit to implicit (Hatch M. J., Organization Theory (2006), pp. 314-315).
[28] Process of transfer the knowledge from implicit to explicit (Hatch M. J., Organization Theory (2006), pp. 314-315).
[29] Shleifer A., Summers L., Breach of trust in hostile takeovers., in: Auerbach A., ed., Corporate takeovers: Causes and consequences., Chicago, University of Chicago Press, 1988, pp. 33-56.
[30] Gibbons R., Katz L., Layoffs and lemons, Journal of Political Economy, October 1991, pp. 351-380.
[31] Lumsdaine R., Stock J., Wise D., Efficient windows and labor market reduction, NBER Working Paper No. 3369, 1990.

equal. Let the marginal productivity of low (high) ability group be MP_l (MP_h). In the absence of asymmetric information workers are paid according to their marginal productivity:

$$W_l = MP_l \text{ (wage of low ability workers)}$$

$$W_h = MP_h \text{ (wage of high ability workers)}.$$

It is clear that the wage of high ability workers should be higher than low ability workers ($W_h > W_l$).

However, job market employers are usually not sure of the productive capacities of the potential worker at the time they employ workers. Employers are not able to differentiate between the types. The fact that the actual abilities of a worker are not known to employers, makes the decision of hiring the decision under uncertainty- such investment becomes the lottery in the technical sense[32].

Then, they can offer all workers an average wage equal to the expected productivity:

$$W_a = (1 - p)MP_l + pMP_h,$$

where p is the share of high ability workers in the economy. Importantly, the average wage W_a is lower than the wage that should be offered to high ability workers W_h, so they may be unwilling to accept it.

According to Spence (1973) model, even if the information on the market is not complete, the employer receives some amount of information about the applicant. These include characteristics, such as sex, race, education, previous work, etc. Moreover, based on previous experience, the employer has a conditional probability assessments over productive capacity, given various combinations of applicants' characteristics.

A risk neutral employer would take into the consideration the employee's profile to offer them a wage equal to their expected productivity:

$$W_i = p_i MP_h + (1 - p_i)MP_l,$$

where $p_i = p(sex_i, education_i, ...)$ is a conditional probability that applicant i belongs to a group with higher productivity.

All the variables that characterize the person that are fixed, for example sex, race etc. are called indices and all other like attire and education are regarded as signals. The applicant can manipulate the values of the signals, and thus change the probability of being regarded as a

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[32] Spence Michael, Job Market Signaling, The Quarterly Journal of Economics, Vol. 87, No. 3, (Aug., 1973), pp. 356.

"better" or "worse" candidate. The applicant is no longer passive. He or she can choose the signal to maximize the difference between the future wage and the cost of the signal.

It is important to note that that education is a very important signal here. One may ask why the employer cannot test the abilities of the worker on their own. However, it is not defined how this test should look like. Moreover, according to Weiss (1995), a firm that substituted the test for education as an employment criterion would have monopsony power over the workers. Let us suppose that an individual quits education to take the test. However, after some time he is dismissed from work for some reasons not connected with his bad performance. Then, no other firm would recognize his abilities since the future employer would not know the test results[33]. Education is a good solution to this problem. Thus, taking into consideration availability and that education is recognized by different employers, individuals prefer to use education as a signal. Weiss concludes that testing for abilities is an out of equilibrium move and it would be difficult to predict responses to such move.

When it comes to education, an individual chooses how much they should invest in their education to maximize:

$$\max_{e_i}\{W_i - C_i\} = \max_{e_i}\{p_i MP_h + (1 - p_i)MP_l - C_i(e_i)\} =$$
$$= \max_{e_i}\{p(e_i)MP_h + [1 - p(e_i)]MP_l - C_i(e_i)\}$$

where e_i indicates the level of education chosen by individual i [34]. The first order condition implies that the applicant invests in education up to a point where the possible gain in terms of the expected wage difference is equal to the marginal cost of investment:

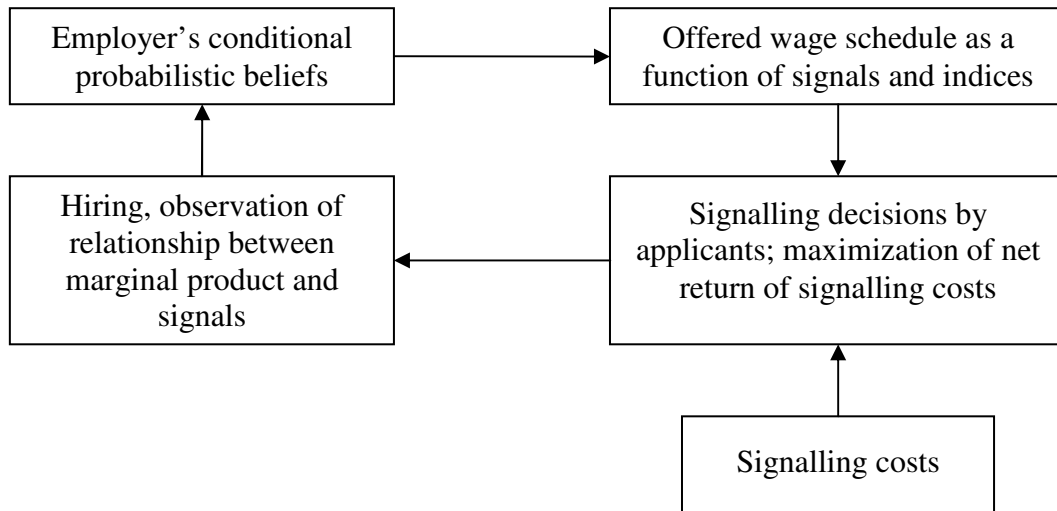$$\frac{\partial p}{\partial e_i}(MP_h - MP_l) = \frac{\partial C_i}{\partial e_i}.$$

The process of information feedback in the job market is presented through figure 2.

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[33] Weiss A., Human capital vs. signaling explanations of wages, Journal of Economic Perspectives, Volume 9, Number 4, Fall 1995, pp.145.

[34] Here all other signals except education are ignored.

Figure 2. Informational feedback in the job market

```
┌─────────────────────────┐              ┌─────────────────────────┐
│  Employer's conditional  │─────────────▶│  Offered wage schedule as a │
│  probabilistic beliefs   │              │ function of signals and indices │
└─────────────────────────┘              └─────────────────────────┘
            ▲                                         │
            │                                         ▼
┌─────────────────────────┐              ┌─────────────────────────┐
│   Hiring, observation of │              │   Signalling decisions by │
│   relationship between   │◀─────────────│ applicants; maximization of net │
│   marginal product and   │              │  return of signalling costs │
│        signals           │              └─────────────────────────┘
└─────────────────────────┘                         ▲
                                                     │
                                          ┌─────────────────────────┐
                                          │    Signalling costs      │
                                          └─────────────────────────┘
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In order to reveal the real productivity of the worker one more assumption is needed. The cost of education should be higher for the less able workers. In a more general sense, signalling costs should be negatively correlated with the productivity[35]. For simplification I will assume that the cost of education for a high ability worker is equal to $C_h(e) = a_h e$, and for the remaining group $C_l(e) = a_l e$, where, of course, $a_l > a_h$.

Spence in his original model uses a conditional probability function that is not differentiable. Based on his formulation, let us assume that the employer forms his beliefs in such a way: an employer believes that an applicant i belongs to the group with high productivity with the probability 1 if his level of education is larger or equal to e*, otherwise he is thought to be a low productivity applicant.

$$p_i = \begin{cases} 1 \ if \ e \geq e* \\ 0 \ if \ e \prec e* \end{cases}$$

This probability can be used to write the offered wage schedule presented earlier. The wage schedule presented through the figure 3 takes the form:

$$W_i = p_i MP_h + (1 - p_i) MP_l = \begin{cases} MP_h \ if \ e \geq e* \\ MP_l \ if \ e \prec e* \end{cases}$$

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[35] Spence Michael, Job Market Signaling, The Quarterly Journal of Economics, Vol. 87, No. 3, (Aug., 1973), pp. 358.

The employer, based on his initial beliefs, is willing to offer the wage equal to MP_h to all potential workers that invested at least e* in their education or MP_l otherwise.

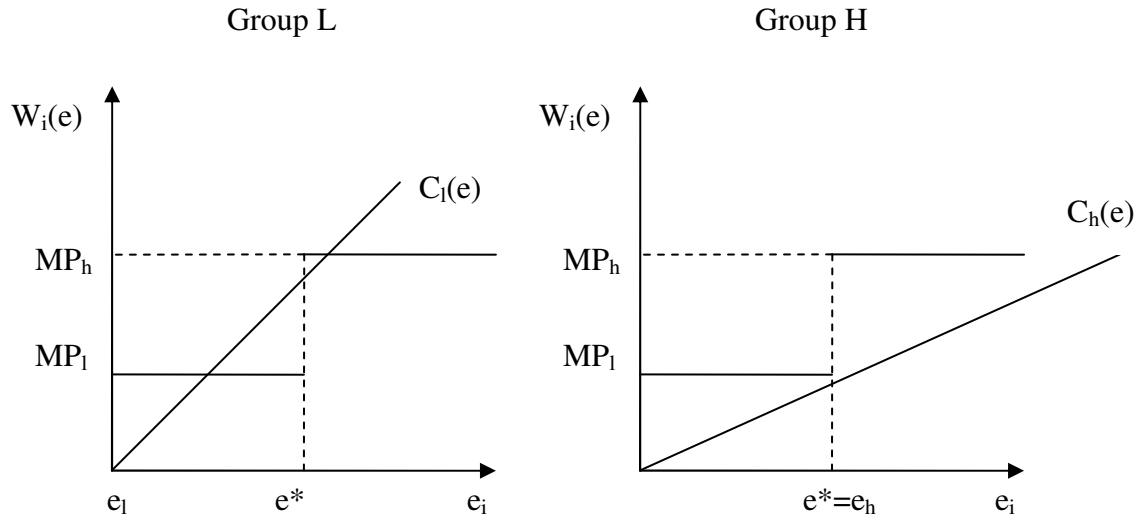Figure 3. Offered wage schedule as a function of education
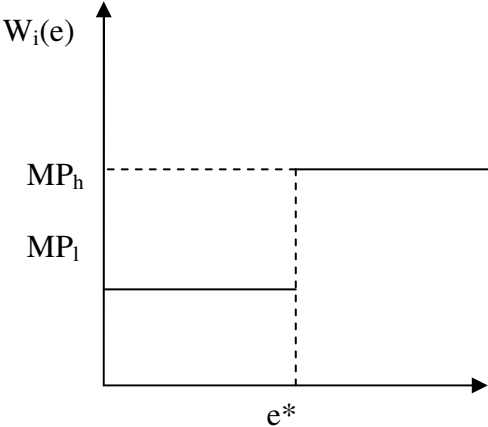
Source: Spence Michael, Job Market Signaling, The Quarterly Journal of Economics, Vol. 87, No. 3, (Aug., 1973), pp. 359.

The set of players in this game include employers and both types of workers, a set of strategies of the workers consist of choosing different amount of education. On the other hand, the employer can choose the offered wage. Moreover, it is a standard signalling game. The employer has private information concerning his productivity and he moves first choosing the education level. Then, a firm observes his action (but not his productivity) and decides how high the offered wage should be[36].

Now it is possible to graphically show the investment decision problem of the applicants from both groups and define the conditions under which separating equilibrium occurs. Each individual's objective is to maximize their net earnings, videlicet, the difference between the offered wage and the cost of education that is characteristic for the given group. It can be seen through the figure 4 that members of the L group maximize their net earnings for the level of investment equal to $e_l=0$, whereas H-type applicants would rather invest $e_h=e^*$. Any other investment above the optimal levels would deteriorate the applicant's financial situation. Unnecessary investment is called overinvestment and may occur when the applicant does not know the initial beliefs of the employer.

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[36] Employees are the leaders and employers are followers using game theory terminology.

Figure 4. Optimal investment in education and wage offered to both groups

However, it should be noticed that levels e_l and e_h will be chosen if and only if following conditions are met

$$MP_l \succ MP_h - a_l e^*$$

$$MP_h - a_h e^* \succ MP_l .$$

The wage offered to a low productivity worker (that can be earned without any investment) should be higher than the net wage of the low productivity worker that has been recognized as a high productivity worker after investing in signal. Similarly, net wage of a high ability person should be higher than the wage of person that was recognized as low productivity worker. This is equivalent to:

$$a_h e^* \prec MP_h - MP_l \prec a_l e^* ,$$

or more general to the fact that the cost of sending the signal by the low ability group in not compensated by possible gains connected with the wage difference. Nevertheless, if the high ability workers choose e* signalling costs must be fully compensated for them:

$$C_h(e^*) \prec MP_h - MP_l \prec C_l(e^*) .$$

Another important question is whether signalling is always a better solution comparing to wages based on unconstrained expected value of productivity. Low productivity workers are, of course offered lower wages, because they are recognized. What is also surprising for a high ability worker, is a possibly worse financial situation. In the absence of signalling an activity but when there is an imperfect information, the employer would offer W_a (defined as above). Being recognized as a high productivity worker is beneficial only when W_a is lower than the net wage that is possible to maintain oneself when the individual invests in signal. This is true for:

$$\underbrace{(1-p)MP_l + pMP_h}_{W_a} \prec \underbrace{MP_h - C_h(e^*)}_{net\ wage}$$

$$p \prec 1 - \frac{C_h(e^*)}{MP_h - MP_l} \quad .$$

The condition is that the share of the 'better' workers should be small enough. This is quite a reasonable assumption. Then, high ability workers are more unique and the benefit of being recognized is bigger.

So far, I have concentrated only on signals. At this point, it would be useful to describe the impact of indices. Spence (1973) claims that sometimes indices can have some informational role[37]. He gives an example of different opportunity sets of men and women. Let us assume that except for the education level, all the candidates can also be distinguished on the basis of their sex. The share of high ability men is equal to the share of high ability women. Education costs do not depend on the sex of an individual. The summary of the developed model is presented in the table 1.

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[37] Spence Michael, Job Market Signaling, The Quarterly Journal of Economics, Vol. 87, No. 3, (Aug., 1973), pp. 370-371.

Table 1. Data of the model with one index and one signal variable

| No.	Value of index	Productivity	Education cost	Proportion within group	Proportion in society
1.	W	MP_h	$C_h(e) = a_h e$	p	p(1-m)
2.	W	MP_l	$C_l(e) = a_l e$	1-p	(1-p)(1-m)
3.	M	MP_h	$C_h(e) = a_h e$	p	pm
4.	M	MP_l	$C_l(e) = a_l e$	1-p	(1-p)m

In the original article the author assumes that the employer makes his conditional expectations concerning productivity of the worker in the following way: if a given person is a male and his level of education is higher or equal to e_m*, then he is a high ability worker, if his level of education is smaller than e_m*, he is of low ability, and similarly if a given person is a woman and her level of education is higher or equal to e_w*, then she is a high ability worker. Otherwise, she is a low productivity worker[38]. The author gives little explanation why different boundary levels are expected from different sexes. For the sake of simplicity, let us assume that the employer's offered wage is given, or for example, based on experiences from the previous rounds of the game that had changed.

Figure 5 illustrates the choice made by some individuals. First of all, high productivity men will choose $e_m*=e_{hm}$, less productive men will not invest at all. High productivity women will choose $e_w*=e_{wh}$ level and the less productive will choose zero. It is worth noticing that the level of investment in education undertaken by women with high abilities is higher than in a corresponding male group. However, their net earnings are smaller. These signalling strategies will affect members of the same group in the next rounds of the game. In this way externalities of a single decision are formed.

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[38] Spence Michael, Job Market Signaling, The Quarterly Journal of Economics, Vol. 87, No. 3, (Aug., 1973), pp. 369.

Figure 5. Optimal investment with one signal and index
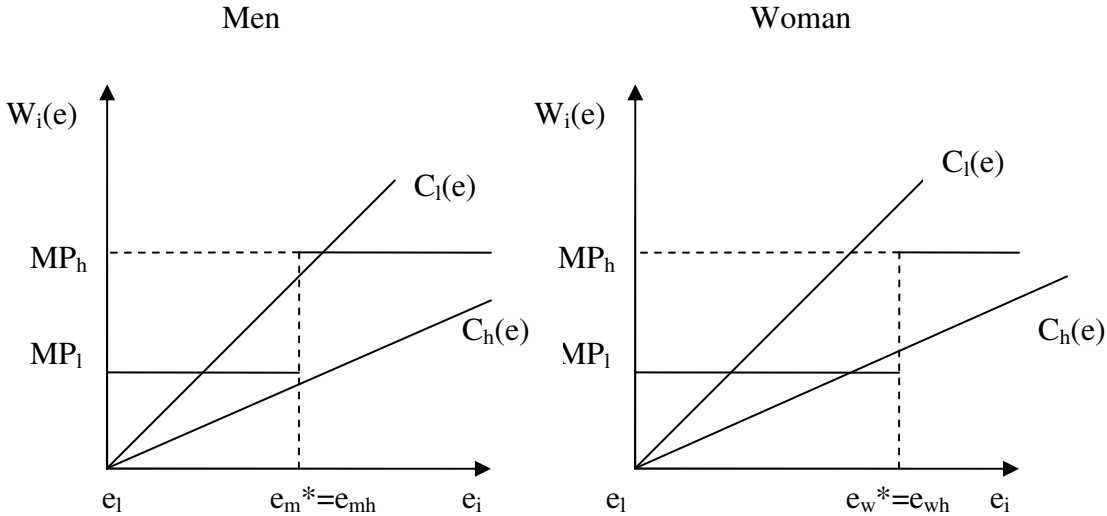
Men   Woman

So far, I have assumed that there are two types of individuals who want to signal their level of productivity to their potential employer. However, Weiss (1995) gives another interpretation to the signalling model. He claims that some individuals may have features that lower their non pecuniary cost of education. Various aspects of perseverance are given as an example. These traits are not directly observable but are also searched by future employers. Thus, Weiss believes that students do not signal their traits consciously by the level of education[39]. The employer associates high education with lower level of absenteeism and propensities to leave a job. That is why he is willing to pay more to the applicant with higher education. Sorting models are supported by some economic evidence (Weiss (1988), Klein et al. (1991)).

Sorting and screening hypotheses change the interpretation of the coefficient on earnings in a wage regression. I shall elaborate on the model comparison and describing implications for wage regressions in the next few paragraphs.

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[39] Weiss A., Human capital vs. signaling explanations of wages, Journal of Economic Perspectives, Volume 9, Number 4, Fall 1995, pp.142.

1. 4. Comparison of models and implications for wage regressions

I have shown the basis of two important models that are trying to explain the investment in education. Both assume that it is undertaken because of higher earnings in the future. However, the first one suggests that the investment is undertaken by individuals who value future earnings relatively more than the rest of the people[40], the job market signalling model on the other hand suggests that the investment is undertaken by individuals with higher abilities. The connection between the abilities and education is one of the main assumptions of the sorting models. In the human capital approach, higher ability individuals that are also more productive, have higher opportunity cost of each additional year of education, so the relationship between the abilities and education is ambiguous.

To check whether the signalling hypothesis has some explanatory power, Groot and Oosterbeek (1994) analyzed the effect of

-skipped years,

-extra years that do not directly lead to progression,

-repeated academic years as well as

-years spent at school without reaching a diploma.

They made several hypotheses about the influence of each one mentioned on wages under human capital and job market signalling approach.

Table 2. Hypothesis and results of Groot and Oosterbeek (1994)

No.	Analyzed factor	Effect on wages under human capital approach	Effect on wages under signaling approach	Evidence
1.	Skipped year	Non- positive	Positive	Negative
2.	Extra year	Non-negative	No effect	No effect
3.	Repeated year	Non-negative	Negative	No effect
4.	Drop out years	Positive	No effect	Positive

Source: Groot W., Oosterbeek H., Earnings effects of different components of schooling, human capital versus screening, Review of Economics and Statistics, 76, pp. 318-321.

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[40] It means that their discounting factor is not very high.

Under the human capital hypothesis, skipped years should have non-positive effect on the wage. Under the alternative model, skipping a year is the signal of higher abilities. This hypothesis in not supported by the evidence. Next, an extra year that does not lead to progression, should have a non-negative effect on wages under the human capital approach. This extra year is not a signal for the employer. Thus, it should have no effect. Here, the evidence supports signalling. Repeated year is a signal of lower ability so it should negatively influence a wage under the job market signalling approach. However, it should have non-negative effect in the human capital approach. The evidence supports the human capital approach in this case. When it comes to dropping out years, the human capital approach predicts positive influence on wages, whereas job market signalling predicts no effect. In this case, the date showed positive correlation providing strong support for human capital models[41].

Kroch and Sjoblom (1994) also tested which model: the human capital or the signalling model better reflect the labour market conditions. They assumed that the coefficient on the relative[42] measure of education level should be stronger than on absolute measure of education if education is a signal. However, the evidence was unambiguous, but it gave more support to the human capital models[43].

In addition, Angrist and Krueger (1991) made a very detailed analysis of the wages in order to find out which hypothesis, the signalling or the learning one is true. They used a sample of individuals from states with different compulsory years of education. The paper showed that group of people who have to attend school because of the law regulation have the same return in additional year of schooling as the second group that voluntarily continued[44]. This clearly suggests that human capital models are more adequate to analyze wages since compulsory education is not a signal for the employer. All the people in the given country have at least minimum required years of schooling so it does not signal anything.

Altonji (1995) analyzed the relationship between wages and courses chosen in high schools. According to the human capital model, the sum of the influence of each individual course should equal the influence of high school education. Nevertheless, he found out that

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[41] Groot W., Oosterbeek H., Earnings effects of different components of schooling, human capital versus screening, Reviev of Economics of Economics and Statistics, 76, pp. 317-321.

[42] relative to the cohort

[43] Kroch E. A., Sjoblom K., Schooling as Human Capital or a Signal: Some Evidence, The Journal of Human Resources, Vol. 29, No. 1, (Winter, 1994), pp. 175.

[44] Angrist J., Krueger A., Does compulsory school attendance affect schooling and earnings?, Quarterly Journal of Economics, November 1991, 106, pp. 979-1014.

the course work has no significant effect on wages[45]. Similar results were also presented by Kang and Bishop (1986)[46].

In another article, the author uses the sample of individuals with the same abilities, namely twins. Ashenfelter and Krueger (1994) estimated the economic return to schooling in this sample. Each twin was assumed to have the same or almost the same abilities and also according to the signalling models, the same level of productivity as his brother or sister. The authors assumed that the difference in earnings of the twins that have different education level should decline over time. It is consistent with the signalling approach. When twins start their job they are paid according to the signal, but after some time the employer realizes that their productivity is equal and adjust their salaries. In fact, the paper provides evidence that this difference declines over time[47]. The analysis made by Ashenfelter, Krueger (1994) was repeated on larger sample by Ashenfelter and Rouse (1998)[48].

As it was shown on some examples mentioned above, the signalling hypothesis cannot be ignored. Weiss (1995) believes that sorting is

> "extension of human capital models by allowing for some productivity differences that firms do not observe to be correlated with the cost or benefits of schooling"[49].

Another issue would be to answer the question how the coefficient of education should be interpreted in this situation. It is usually a percentage change in earning associated with an additional year of education. If we admit that there are some attributes that are not observed by the employer and are correlated with schooling, the standard human capital explanation must be slightly changed. Thus, the coefficient of the years of education in the wage regression is the sum of two effects: the additional year of schooling that according to human capital models leads to the increase of productivity, and the fact that a given person was recognized as a higher productivity worker. It also means that the private gain from education is higher than the social gain. Consequently, it is almost impossible to find the social gain

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[45] Altonji J., The effect of high school curriculum on education and labor market outcomes, Journal of human resources, Vol. 30, No. 3, Summer 1995, pp. 409-438.

[46] Kang S., Bishop J., Effects of curriculum on labor market success immediately after high school, Journal of Industrial Teacher Education, 1986, pp. 14-29.

[47] Ashenfelter O., Krueger, Estimate of the economic return to schooling from a new sample of twins, The American Economic Review, Vol. 84, No. 5, (Dec., 1994), pp. 1157-1173.

[48] Ashenfelter O., Rouse C., Income, Schooling, and Ability: Evidence from a New Sample of Identical Twins, The Quarterly Journal of Economics, Vol. 113, No. 1, (Feb., 1998), pp. 253-284.

[49] Weiss A., Human capital vs. signaling explanations of wages, Journal of Economic Perspectives, Volume 9, Number 4, Fall 1995, pp.134.

since there is always an effect of unobserved characteristics on estimations of returns to education. Even if the independent variables include ability measure as IQ, usually its coefficient is very small or not significant. This is because firms simply do not have such direct information. Thus, the wages are proposed according to the signal that is according to education.

Moreover, signalling models seem to be Pareto inefficient, because social gains are smaller than private gains since signalling and screening do not upgrade the human capital and consequently, the productivity of an individual. Nevertheless, there are some gains connected with signalling equilibrium. Stigliz (1975) claimed that it can help to match between workers and jobs. He believes that in the absence of information, a large training cost may be wasted when the person with low abilities is employed to the job that requires high ability and vice versa[50].

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[50] Stiglitz J. E., The Theory of "Screening," Education, and the Distribution of Income, The American Economic Review, Vol. 65, No. 3, (Jun., 1975), pp. 288.

Chapter II. Data description and methodology

This chapter describes briefly the data set that I have used in my research. Detailed definitions of the variables are extremely important since their choice often has some influence on results. Education, for example, can be defined both by the number of years of education or attained educational level and the interpretation of coefficient in both cases would be slightly different. Moreover, I shall present the process of sample selection and how the original data set was truncated.

2.1. Data source and definitions

To estimate the return on education in Poland I used the data gathered by the Institute for Social Studies of the University of Warsaw. The formal name of the data set is Polish General Social Survey (PGSS). The PGSS data set was created on the basis of individual surveys that were conducted by professional pollsters on a representative sample of adults. The main point of interest of PGSS is the respondents' situation on the labour market including sectors, the size of the companies, ownership structure, job activity and wages. Another important group of variables is connected with the respondents' education, including their degree, years of education and the perception of the importance of schooling. A big part of the study is devoted to questions connected with the respondents' voting patterns, religion, political preferences, satisfaction as well as health[51].

I use the samples from the year 1999 and 2005. The first survey was done in November and December and includes 2282 individuals. The second was conducted in January and includes 1277. I chose these two years because I assumed that the return on education might change slightly after joining the European Union. I suspected that the return on education would be higher in 2005 than in 1999.

Bedi and Cieślik (2002) conducted a detailed research to examine the relationship between the wages in a given industry and the presence of FDI in this industry. They showed that there is a positive and significant link between the wages and a foreign direct investment (FDI)[52]. Thus, I assume that liberalization of trade connected with joining the European Union caused the wage growth. However, it cannot be said that the positive effect was the same for

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[51] Cichomski B., Jerzyński T., i Zieliński M., Polskie Generalne Sondaże Społeczne: struktura skumulowanych wyników badań 1992-2005. Instytut Studiów Społecznych, Uniwersytet Warszawski, Warszawa 2006, pp. iv-v.

[52] Bedi A. S., Cieślik A., Wages and wage growth in Poland. The role of foreign direct investment. Economics of Transition, Volume 10 (1) 2002, 2002, pp. 24.

people with different schooling levels since the structure of the demand of labour force could change.

All calculations were made using statistical package STATA ver. 9.1.

The first stage of data preparation was connected with the sample selection. In PGSS database there are responses of people with different job activities. To deal only with people who are professionally active, I truncated the original data only to people that work full time. I did this by using answers to the question about the respondents' situation on the labour market (variable q18st). Observations of the unemployed, pensioners, students, housewives or househusbands, and people that due to a break are professionally inactive or work part time, were dropped. After this data manipulation I have 996 observations in 1999 and 479 in 2005. It means that after the described data manipulation 43,7% of total observations is left in 1999, and 37,5% in 2005.

The explained variable wage is based on the answers to question q32. Respondents were asked to give their monthly average earnings taking into consideration the last 12 months. The responses were given in Polish currency (PLN)[53]. The basic statistics connected with the variable wage are presented in table 3.

Table 3. Summary statistics of variable 'wage'

No.	Statistic	1999	2005
1.	Number of observations	838	433
2.	Mean	1039.14 PLN	1319.06 PLN
3.	Standard deviation	711.67 PLN	927.53 PLN
4.	Minimum	0.00 PLN	50.00 PLN
5.	Maximum	7000.00 PLN	8000.00 PLN

Source: own calculations.

Through the figure 6 and 7, where histograms of the dependent variable are presented, it can be seen that the density of the variable is skewed to the left. It can be also noticed that the minimum of the variable 'wage' in both years is in 1999 equal to 0, and in 2005 it is equal to 50 PLN. This is possible because I decided not to exclude farmers who do not have fixed

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[53] Yearly average rates according to National Bank of Poland: 1USD=3,9675PLN in 1999, 1USD=3,2348PLN in 2005.

wages. I assume that the result of the farmers' work also depends on their qualifications and other characteristics. The same applies to entrepreneurs who are also present in the sample.

Figure 6. Wages in 1999
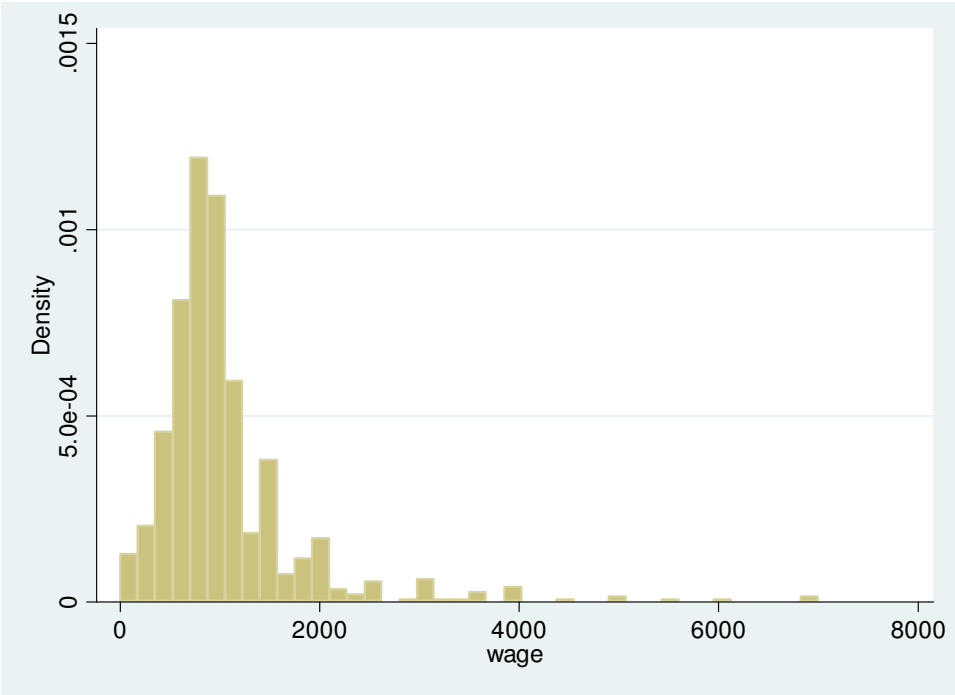
Source: own calculations.

Figure 7. Wages in 2005
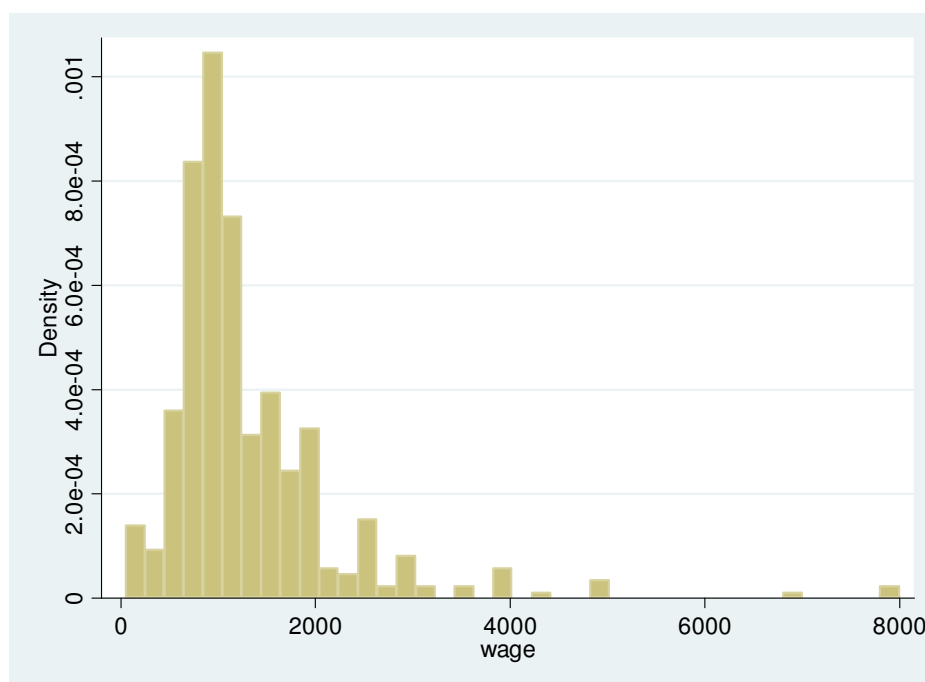
According to the approach presented by Mincer, the dependent variable in wage equation should be a logarithm value of wage. Thus, I took logs of wages and created variable 'ln_wage'. Moreover, the shape of wage density implies that taking logs would mimic Normal density. The logs of wage are my dependent variable in regressions. The summary of the logarithm value of wage is presented in table 4.

Table 4. Summary statistics of variable 'ln_wage'

No.	Statistic	1999	2005
1.	Number of observations	831	433
2.	Mean	6.78	6.99
3.	Standard deviation	0.59	0.66
4.	Minimum	4.09	3.91
5.	Maximum	8.85	8.99

I employed 16 independent variables to the first regression. Some of these variables proved to be insignificant on the 5% significance level. However, I think it is worth mentioning that all of them seemed to be correlated both with the respondents' education and their wage. Thus, in order to avoid the omitted variable problem, I started constructing my models with all variables described below. Then, I eliminated the insignificant ones.

The key explanatory variable is the one that is the indicator of the respondents' education. It is based on question q131edr. Respondents were asked to give the total number of years of education they have in any type of school they ever attended excluding trainings taken after completing formal education. The variable was labelled 'educat'. In 1999 the mean number of years of education was equal to 12,4 and it rose to obtain 13,25 in 2005. In 1999 the minimum value of variable was equal to zero which means no formal education, and the maximum was 23. In 2005 the respondent with the lowest education completed only primary school, and with the highest had been learning for 23 years. The statistics concerning this variable are presented though table 5.

Table 5. Summary statistics of variable 'educat'

No.	Statistic	1999	2005
1.	Number of observations	892	469
2.	Mean	12.40	13.25
3.	Standard deviation	2.99	3.09
4.	Minimum	0	8
5.	Maximum	23	23

Source: own calculations.

The first dummy variable that is included in the model is named 'woman'. The dummy has the value 1 if the respondent is a woman and the value 0 if he is a man. The proof that the women's earnings are on average lower than men's earnings can be found in most of the papers concerning wage inequality as well as return on education. Summary statistics concerning the 'woman' dummy for both years are presented in table 6. It can be observed that in 1999 the share of a woman in the sample is 49%, whereas in 2005 it is 42%.

Table 6. Statistics summary of the variable 'woman'

No.	Statistic	1999	2005
1.	Number of observations	894	433
2.	Mean	0.49	0.42
3.	Standard deviation	0.5	0.5
4.	Minimum	0	0
5.	Maximum	1	1

Source: own calculations.

Another employed explanatory variable is the respondents' age. The influence of the age on earnings reflects the life cycle of earnings. This variable can be treated as an approximation of the respondents' ability to work. Moreover, it can be an indicator of their experience.

However, human capital also depreciates with the growing age. From observations of the labour market as well from empirical proofs presented before, it may be assumed that the wage grows with the age, then obtains its maximum for middle-aged people, then declines when an individual becomes older. Thus, I also decided to include in the model a variable equal to age squared. It was labelled as 'age_2'. In 1999 the mean respondents age was equal to about 39, whereas in 2005 it was closer to 40 years old. The standard deviation of age in 2005 is also slightly higher.

Table 7. Summary statistics of variable 'age'

No.	Statistic	1999	2005
1.	Number of observations	894	469
2.	Mean	39.20	39.67
3.	Standard deviation	10.3	10.37
4.	Minimum	18	19
5.	Maximum	79	66

Source: own calculations.

Experience denoted as 'exp' is the variable created on the basis of question q24c from PGSS. Respondents were asked how many years they had been working since they were 14. Experience is an indicator of learning by the doing process.

Table 8. Summary statistics of variable 'experience'

No.	Statistic	1999	2005
1.	Number of observations	882	468
2.	Mean	18.82	19.00
3.	Standard deviation	10.76	10.99
4.	Minimum	1	1
5.	Maximum	65	46

Source: own calculations.

I also decided to check if there is a statistical dependence between wages and working in a public sector. Thus, on the basis on question q22e12 I have created a dummy called 'public'. The dummy takes value one if the respondent worked for a public or communal owned company or for a budget entity. The share of the respondents who worked in such firms was 37% in 1999 and 33% in 2005.

Table 9. Summary statistics of the variable 'public'

No.	Statistic	1999	2005
1.	Number of observations	894	469
2.	Mean	0.37	0.33
3.	Standard deviation	0.48	0.47
4.	Minimum	0	0
5.	Maximum	1	1

Source: own calculations.

Next, I created 8 dummies for regions. I did not use the formal administrative division into counties. Instead, I used 8 huge regions. Thus, the following regions are distinguished: central, Wielkopolska, Silesian, the west, Pomeranian, the north-east and Malopolska. The mean of dummies is presented in table 10. Some differences between the year 1999 and 2005 are observed when it comes to the share of particular regions in the sample. The minimum and maximum of each variable is, of course 0 and 1 since all these variables are binary.

Table 10. The shares of region in the sample in 1999 and 2005

No	Region	1999	2005
		Mean	Mean
1.	Central	0.18	0.21
2.	Wielkopolska	0.14	0.12
3.	Silesian	0.18	0.20
4.	West	0.08	0.10
5.	Pomeranian	0.13	0.07
6.	North-East	0.09	0.08
7.	East	0.05	0.07
8.	Malopolska	0.15	0.15

Source: own calculations.

Moreover, it would be important to put an additional dummy for respondents that live in big cities. Dummy takes the value 1 if the respondent lives in a city with more than 500 000 inhabitants. The proportion of such respondents in my sample was equal to 9% in 1999 and 15% in 2005.

Table 11. Summary statistics of variable 'city'

No.	Statistic	1999	2005
1.	Number of observations	894	469
2.	Mean	0.09	0.15
3.	Standard deviation	0.28	0.36
4.	Minimum	0	0
5.	Maximum	1	1

Source: own calculations.

Human capital depends not only on education, but also on health. Thus, to find out if a positive correlation between the respondent's health and their wage exists, I have added a variable that is an indicator of health. This variable takes value 1 if the respondent was a patient in a hospital during the last 12 months and 0, otherwise. The stay in hospital due to pregnancy or having a baby is not considered here. However, it is surprising that in 1999

only 4% of the respondents had some health problems, whereas in 2005 this number rose to 12%.

Table 12. Summary statistics of variable 'health'

No.	Statistic	1999	2005
1.	Number of observations	894	469
2.	Mean	0.04	0.12
3.	Standard deviation	0.20	0.32
4.	Minimum	0	0
5.	Maximum	1	1

Source: own calculations.

In order to take into consideration a family background, I used the respondents' mothers' education. The variable 'motheredu' has been created. It is equal to the number of years of the respondents' mothers' education. Moreover, I included a dummy variable 'married' for respondents who are married or live with their partners.

To sum up, the data description part in the table 13 I presents all variables used and their brief description.

Table 13. Variables used in regressions with short description

No.	Variable	Description
1.	ln_wage	log of respondent's wage
2.	educat	number years of education
3.	woman	dummy for woman
4.	age	respondent's age
5.	age_2	respondent's age squared
6.	exp	work experience
7.	public	dummy for respondents who work in public sector
8.	central	dummy for inhabitants of central poland
9.	wielkopolska	dummy for inhabitants of wielkopolska
10.	silesian	dummy for inhabitants of silesia

11.	west	dummy for inhabitants of west poland
12.	pomeranian	dummy for inhabitants of inhabitants of pomeranian region
13.	northeast	dummy for inhabitants of north-east of poland
14.	east	dummy for inhabitants of eastern poland
15.	malopolska	dummy for inhabitants of małopolska
16.	city	dummy for inhabitants of biggest cities
17.	health	dummy for respondent's that had health problems
18.	motheredu	indicator of mother education
19.	married	dummy for married respondents

Source: own calculations.

Additionally, I wanted to check if my results would change if I will add also dummies for sectors in which given respondent works. On the basis of variable Q22kgn25 from PGSS I created 25 dummies for sectors. The definitions of these variables are presented though table 14. Table 14 presents also the shares of respondents working in particular sector in years 1999 and 2005.

Table 14. Sectors' dummies

No.	Dummy	Definition	Mean	
			1999	2000
1.	sector_1	fuel and power industry	0.0425056	0.0362473
2.	sector_2	metallurgical industry	0.0067114	0.0021322
3.	sector_3	electrical machinery industry	0.0592841	0.0575693
4.	sector_4	chemicals and chemical products	0.0223714	0.0063966
5.	sector_5	mineral industry	0.0134228	0.0127932
6.	sector_6	manufacture of pulp, paper and paper products	0.0234899	0.021322
7.	sector_7	light industry	0.0436242	0.0405117
8.	sector_8	manufacture of food products and beverages	0.0425056	0.0405117
9.	sector_9	other industries	0.0055928	0.0298507
10.	sector_10	building industry	0.0872483	0.0660981
11.	sector_11	agriculture	0.1387025	0.08742

12.	sector_12	forestry	0.0145414	0.0021322
13.	sector_13	transport	0.0346756	0.0405117
14.	sector_14	telecommunications	0.0212528	0.0191898
15.	sector_15	trade	0.139821	0.1215352
16.	sector_16	municipal services	0.0223714	0.0021322
17.	sector_17	real estate	0.0089485	0.00
18.	sector_18	science	0.0044743	0.00
19.	sector_19	educational sector	0.0671141	0.0554371
20.	sector_20	culture and art	0.0055928	0.0042644
21.	sector_21	health services	0.0592841	0.0383795
22.	sector_22	tourism, sport services	0.033557	0.0682303
23.	sector_23	public administration, justice administration	0.0536913	0.0234542
24.	sector_24	finance and insurance	0.0302013	0.0298507
25.	sector_25	organizations (social, political etc.)	0.0033557	0.0042644

Source: own calculations.

2.2. Methodology

To examine the dependence between wages and education, and consequently to approximate the return on education before and after joining the European Union, I used a form of the model based on the Mincerian approach. However, I also controlled for personal characteristics that may serve as signals for a potential employer. Moreover, as the equivalent of the experience in the original Mincer's framework I used the respondents' age. I also applied a variable which value was equal to the respondents' tenure. However, I discovered that for my samples it was not significant at the 5% significance level. Thus, I decided to use the following form of wage regression:

$$wage_i = \exp\left(\alpha + \alpha_1 educat_i + \alpha_2 age + \alpha_4 age^2 + \sum_j \alpha_j X_j + \varepsilon_i \right).$$

where X denotes a vector of other explanatory variables mentioned in the previous subchapter, videlicet: woman, exp, public, central, wielkopolska, silesian, the west, pomeranian, the northeast, the east, malopolska, city, health, motheredu and married.

After taking logs it gives following form of the model where dependent variable is in logarithm and independent variables are not in logarithms:

$$\ln wage_i = \alpha + \alpha_1 educat_i + \alpha_2 age + \alpha_4 age^2 + \sum_j \alpha_j X_j + \varepsilon_i.$$

The coefficients in such constructed model are semielasticities. Semielasticity measures the percentage change in wage as an effect of unit changes in the value of given independent variable.

$$E(wage_i) = \exp\left(\alpha + \alpha_1 educat_i + \alpha_2 age + \alpha_4 age^2 + \sum_j \alpha_j X_j\right)\exp\left(\frac{1}{2}\sigma^2\right)$$

$$\ln E(wage_i) = \alpha + \alpha_1 educat_i + \alpha_2 age + \alpha_4 age^2 + \sum_j \alpha_j X_j + \frac{1}{2}\sigma^2 \quad .$$

$$\frac{\partial \ln E(wage_i)}{\partial educat_i} = \alpha_i.$$

I assume the α_1 and α_2 to be positive. α_3 is assumed to be negative due to human capital depreciation. Such a constructed model was significant at the 5% significance level. Nevertheless, not all variables were individually significant, some of them were significant just in regression for one year. I shall briefly explain the process of the variable elimination that I have employed.

To eliminate insignificant variables I employed the general to specific method. This method consists of gradual simplifying the model using more and more complex nested hypothesis. Currently, it is assumed to be the most correct method of data mining. The choice between alternative models was done using a standard F statistic. It could be also done by the so called information criteria. A standard F test is usually used for testing joint hypothesis, and has the following form

$$F = \frac{\dfrac{S_r - S}{g}}{\dfrac{S}{N - K}} \sim F(g, N - K),$$

where g is the number of restrictions, N the number of observations and K the number of estimated parameters, S_r is the sum of squared residuals from a restricted model, S is equal to the sum of squares from an unrestricted model. The statistic F has Snedecor's F distribution. I eliminated sequentially the insignificant variables using null hypothesis that the coefficients on these variables are equal to zero.

Testing the correctness of the functional form of the model should be also mentioned. To verify if the choice of explanatory variables and their functional form was correct I

employed Regression Specification Error Test (RESET). The null hypothesis is that specification is correct and the alternative that is incorrect. In the case of my estimations for both years there were no reasons to reject the null hypothesis.

Another important methodological problem was the one with the choice of proper estimation method. I employed robust ordinary least squares. In the next paragraphs I will explain why I have chosen this particular method.

According to Gauss-Markov theorem, ordinary least squares estimator in linear models is efficient and unbiased (BLUE-best linear, unbiased estimator). However, the assumptions that the expected value of errors is equal to 0, there is no autocorrelation and heteroskedasticity must be fulfilled. The important step after estimating regression should be to check if the above assumptions are met.

The problem of heteroskedasticity occurs when the variance of error term is different for different observations, so when

$$Var\varepsilon_i = E\left(\varepsilon_i^2\right) \neq const \ for \ i = 1,..., N \ .$$

When we consider cross section samples the main problem is that the variance of the error term depends on the values of explanatory variables. A heteroskedasticity problem is often met in wage regressions. I shall explain why this is the case, using wage equation proposed by Mincer. However, now we allow for different individuals' return on education and on the job training. So, we assume that the logarithm of the wage of individual i is equal to some constant characteristic for person i plus the return on schooling times number of years of schooling plus the influence of experience and experience squared plus the error term:

$$\ln wage_i = \alpha_i + \beta_i s_i + \delta_i \exp_i + \gamma_i \exp_i^2 + \varepsilon_i,$$

where s is equal to the number of years of schooling.

While the cross section analysis is used, then expected values of parameters are estimated for the total sample. For example, the return on education of the whole sample is estimated not for a given individual. Then the expression takes the form:

$$\ln wage_i = \overline{\alpha} + \overline{\beta}s_i + \overline{\delta}\exp_i + \overline{\gamma}\exp_i^2 + \underbrace{\left[(\alpha_i - \overline{\alpha}) + (\beta_i - \overline{\beta})s_i + (\delta_i - \overline{\delta})\exp_i + (\gamma_i - \overline{\gamma})\exp_i^2\right]}_{\xi}$$

where ξ denotes the error term. Now, it can be easily remarked that the error term depends on the values of independent variables. Heteroskedasticity is then not rare in wage regressions.

To test if this problem occurred in my regressions for the years 1999 and 2005 I used the Breusch-Pagan test. This test estimates the regression with an additional explanatory variable that is equal to normalized errors squared. The null hypothesis of this test is that the error term is homoskedastic, an alternative hypothesis is that it is heteroskedastic.

Testing statistic has χ^2 distribution with m-1 degrees of freedom, where m is equal to the number of explanatory variables in the estimated model. The outcomes of the Breusch-Pagan test for both regressions showed that heteroskedasticity has occurred. Therefore, estimators that are received by using simple ordinary least squares were not effective.

In such cases it is advised to use the variance-matrix that is valid even when heteroskedasticity occurs. The most popular robust estimator of the variance-matrix is called the White's estimator. Thus, I have employed this method using robust ordinary least squares.

Chapter III. Estimation results

In this charter I will describe the results of my regressions for both years 1999 and 2005. I will also compare the rate of return on education estimated by my model with rates proposed by other authors. I am also going to place results attained for Poland with those for other European countries.

3. 1. Robust OLS estimates' results

Robust OLS regression for the year 1999 was build out of 829 observations. The value of the F statistic (37.29) suggests that the null hypothesis, in which regression is insignificant can be rejected (Prob>F=0.000). R squared is equal to 23.74 %. It means that 23.74% of total variation of dependent variable is explained by the model.

There were 7 independent variables significant in the regression. The constant was also significant. Among the variables that have influence on the logarithm of wages there are years of education, age, age squared dummies for women, huge cities and 2 regions- Silesian and Pomeranian. All the variables, apart from the ones mentioned above, were not significant at the 5 or 10% significance levels and were rejected using general to specific method.

According to the model variable that illustrates a respondent's education is significant at 5% significance level. Education is positively correlated with a logarithm wage. The estimated coefficient suggests that each additional year of education increases the earnings by 7.96%. This means that, for example, graduating from secondary school increases a worker's earnings by 31%, as compared to people who graduated only from a primary school. Obtaining university diploma causes almost 40% increase in wages as compared to secondary school's graduates.

The expected change in wage associated with a unit change of the variable woman is equal to -23.86%. It means that in the year 1999 women's salaries were lower by 23.86%.

The influence of age on wages is not linear, which can be observed through figure 8. The presented function is upward sloping for age smaller than 42 years. Then, it becomes downward sloping.

Figure 8. Influence of age on logarithm wage (1999)

dummies silesian, pomeranian and city were assumed to be equal to 0

Source: own calculations.

It means that each additional year increases the wage when a respondent is younger than 42 years old. When the respondent is older, each additional year reduces their wage. The mean age in the sample for 1999 is equal to 39 years. Thus, one additional year above the mean age increases the salary by 0.29%. The partial effects that depend on the respondent's age are presented through figure 9.

Figure 9. Partial effect of age on logarithm of wages estimates (1999)
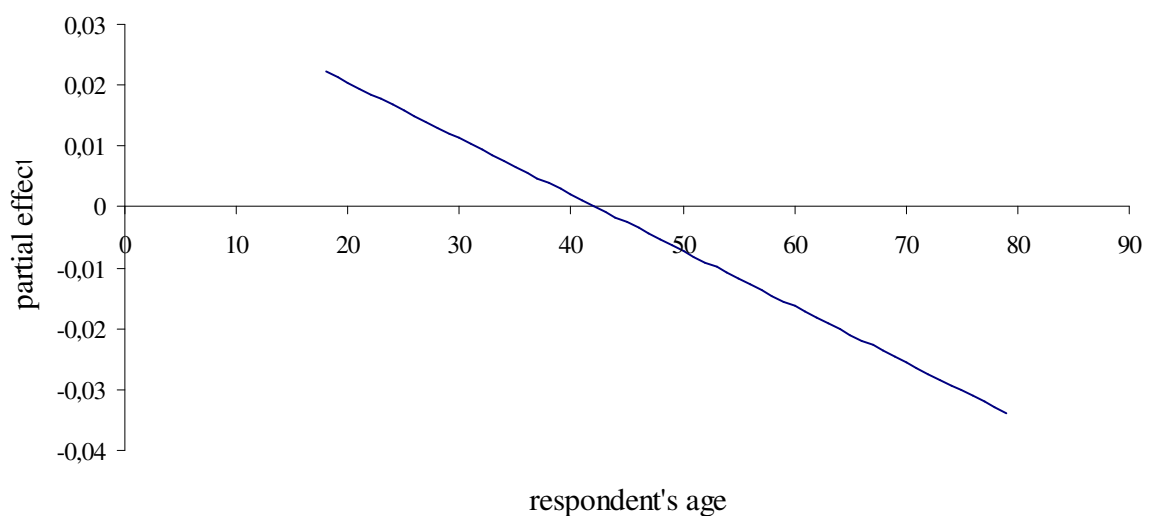
Source: own calculations.

In the case of regression that apply the data for 1999, two dummies for regions proved to be significant. These are the variables that take the value 1 for inhabitants of the Pomeranian and Silesian regions. Probably, the reason is that the situation on labour market was somehow different than in other regions, and, consequently workers could demand higher wages.

The dummy for inhabitants of huge cities is also significant at 5% significance level. The conditions on the labour markets are much more favourable for workers there. The headquarters of many companies or banks are usually placed in the biggest Polish cities. This boosts the demand for workers there and consequently, the wages are on average higher than in smaller towns or villages.

All the described above results obtained by robust OLS regression for 1999 are presented in table 15.

Table 15. Robust OLS estimates (1999)

No.	Variable	Coefficient	Robust standard error	t	P>|t|	95% Conf. Interval	
1.	woman	-0.23865	0.03757	-6.35	0.000	-0.312317	-0.164802
2.	age	0.03882	0.01265	3.07	0.002	0.014008	0.063662
3.	age_2	-0.00046	0.00017	-2.76	0.006	-0.000796	-0.000135
4.	silesian	0.16681	0.04260	3.92	0.000	0.083187	0.250437
5.	pomeranian	0.14471	0.06230	2.32	0.020	0.022440	0.266999
6.	city	0.27973	0.06505	4.30	0.000	0.152060	0.407414
7.	educat	0.07963	0.00662	12.04	0.000	0.066650	0.092622
8.	_cons	5.07796	0.24203	20.98	0.000	4.602894	5.553041

Source: own calculations.

Robust OLS regression for 2005 applied 433 observations. The value of F statistic (20,86) suggests that the null hypothesis of joint insignificance of all dependent variables can be rejected at 5 % significance level (Prob>F=0.0000). The variation of the independent variables explains 55% of the variation of the logarithm wage.

In the case of regression for the year 2005, there were 9 significant variables plus the constant. I decided not to exclude some of the variables that were not significant at the 5% significance level since it deteriorated the fit of the model. Thus, the variables age squared, wielkopolska as well as the northeast are significant only on 10% significance level. All but

the mentioned variables, videlicet, woman, age, the east, małopolska, the city and education are significant at 5% level.

The return on education in the year 2005 was a bit higher than in 1999 and amounted to 9,35%. Each additional year of schooling increased the wage by 9,35%. Completing, for example secondary school amounts to 37% increase in earnings as compared to respondents with only primary education. The analogical number for university's graduate is equal to 46,75%.

The partial effect connected with a dummy for women is equal to 0.335. This means the women's wages were on average 33,5% lower than those earned by men.

Again the effect connected with a respondent's age depends on the age. The sketch of the dependence between the age and the logarithm wage is presented through figure 10. The function is upward sloping for respondents that are younger than 49 years. For older, the function becomes downward sloping. It reaches maximum for respondents that are 49.

Figure 10. Influence of age on logarithm wage (2005)
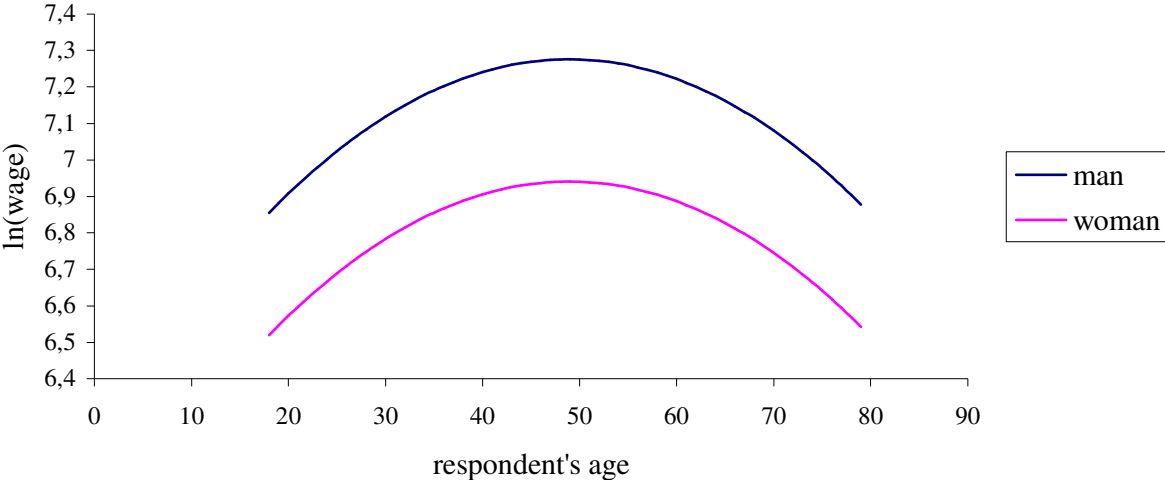
dummies silesian, pomeranian, northeast, east, małopolska, wielkopolska and city were assumed to be equal to 0

Source: own calculations.

Consequently, the partial effect that is equal to the first derivative of expected earnings with respect to age, is positive for respondents younger than 49, then it becomes negative. Of course it is equal to zero for respondents that are 49. The partial effect connected with age is presented through figure 11.

Figure 11. Partial effect of age on logarithm of wages estimates (2005)
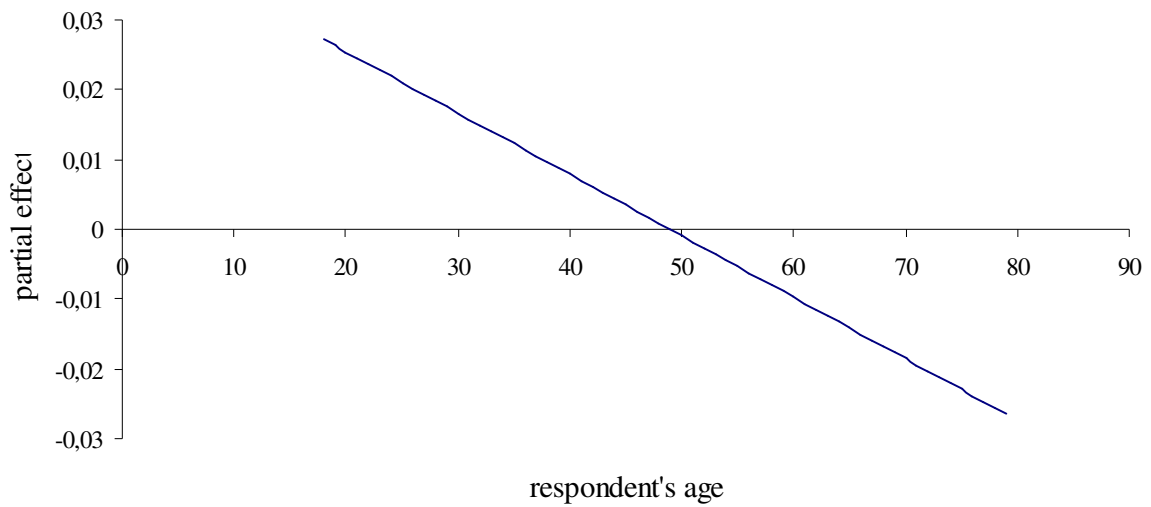
Source: own calculations.

Four dummies for regions are significant at 10% significance level. Moreover, the dummy for inhabitants of huge cities has also significant influence on wages. Respondents who live in cities that have more than 500 000 inhabitants have on average wages higher by 28.3%.

Results of robust OLS estimates are presented in table 16.

Table 16. Robust OLS estimates for 2005

No.	Variable	Coefficient	Robust standard error	t	P>|t|	95% Conf. Interval	
1.	woman	-0.33513	0.05471	-6.13	0.000	-0.44266	-0.22760
2.	age	0.04305	0.01985	2.17	0.031	0.00402	0.08208
3.	age_2	-0.00044	0.00026	-1.68	0.093	-0.00095	0.00007
4.	wielkopolska	-0.17257	0.09059	-1.91	0.057	-0.35063	0.00549
5.	northeast	-0.22206	0.12944	-1.72	0.087	-0.47648	0.03236
6.	east	-0.36628	0.14323	-2.56	0.011	-0.64781	-0.08475
7.	malopolska	-0.23314	0.07747	-3.01	0.003	-0.38542	-0.08087
8.	city	0.28299	0.06444	4.39	0.000	0.15633	0.40966
9.	educat	0.09353	0.00889	10.52	0.000	0.07606	0.11101
10.	_cons	4.98366	0.39049	12.76	0.000	4.21611	5.75121

Source: own calculations.

It is also worth mentioning the variables that turned out to be insignificant in regressions for both years. The first example of such a variable is the respondent's experience. Possibly, the variable is collinear with the respondent's age. Thus, the respondent's age can be treated as a proxy of experience.

Secondly, the variable that indicates respondents who work in public sector does not influence the logarithm wage. Employees are simply finding job irrespectively of the ownership structure of a company. This suggests the presence of some workers' mobility. They can choose the employer who offers a higher salary substituting for public and private owned companies.

The third variable - 'health' was thought to be an approximation of the respondent's human capital connected with health in this particular aspect since human capital is not only education but also physical possibility to work. However, it proved to be insignificant. Probably, a serious health problem influences more the decision connected with labour force participation rather than the respondents' wage.

The variable 'motheredu' does not seem to be a good indicator of family backgrounds or family backgrounds are not important for this particular Polish data set. The dummy for married does not also influence the earnings. The result of the marital status result are

surprising since there is a large amount of empirical evidence suggesting that it should be significant.

The result of my regressions suggests that the return on education in 1999 was equal to 7.96 %, whereas in 2005 it amounted to 9.35%. I expected this result as a consequence of joining the European Union, which is connected with trade liberalization. More and more foreign investment projects took place in Poland during this period. Thus, the demand for labour increased. Moreover, it can be noticed that the experience is valued more in 2005. The maximum of earning was reached in 2005 for 49 years old respondents. The corresponding age was 42 in 1999.

However, what is also surprising is that a gender gap in earnings increased during between 1999 and 2005. The coefficient on the variable 'woman' is lower in 2005. It varied between 23.86- 33.5%. OECD publication entitled 'Education at glance' suggests that such a gap is not an exception[54] in OECD counties.

Now, I should switch to results of the estimations that used the sector dummies. More precisely I should check if introducing the sector dummies will change the return on education calculated before. In the case of estimation for year 1999 general to specific method left the model with dummies for sixth, seventh, eleventh, fifteenth, ninetieth, twentieth, twenty first and twenty fifth industry. Regression is significant at 5% significance level.

Basically, controlling for industry lowered the estimated return on education. In the broader model it amount to 6.43% annually. Moreover, the negative coefficient on dummy for women is also lower. The coefficient on age and age squared remained almost the same. Table 17 presents details of regression for 1999 with industry dummies.

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[54] Education at a Glance 2007, OECD 2007, pp. 141.

Table 17. Robust OLS estimates with industry dummies for 1999

No.	Variable	Coefficient	Robust standard error	t	P>|t|	95% Conf. Interval	
1.	woman	-0.1772	0.03927	-4.51	0.000	-0.2543	-0.1002
2.	age	0.0354	0.0113	3.13	0.002	0.0132	0.0577
3.	age_2	-0.0004	0.0001	-2.50	0.013	-0.0007	-0.0001
4.	silesian	0.0739	0.0387	1.91	0.056	-0.0021	0.1501
5.	pomeranian	0.1046	0.0569	1.83	0.067	-0.0073	0.2164
6.	city	0.1847	0.0641	2.88	0.004	0.0589	0.3106
7.	educat	0.0643	0.0065	9.92	0.000	0.0515	0.0769
8.	sector_6	-0.2427	0.0882	-2.75	0.006	-0.4159	-0.0696
9.	sector_7	-0.1552	0.0604	-2.57	0.010	-0.2737	-0.0366
10.	sector_11	-0.7409	0.0872	-8.49	0.000	-0.9122	-0.5696
11.	sector_15	-0.0937	0.0548	-1.71	0.088	-0.2013	0.0138
12.	sector_19	-0.2491	0.0592	-4.21	0.000	-0.3653	-0.1329
13.	sector_20	-0.3792	0.1534	-2.47	0.014	-0.6803	-0.0781
14.	sector_21	-0.2278	0.0696	-3.27	0.001	-0.3644	-0.0912
15.	sector_25	-0.5388	0.1802	-2.99	0.003	-0.8924	-0.1851
16.	_cons	5.3969	0.2207	24.46	0.000	4.9648	5.8300

Source: own calculations.

Regression for year 2005 includes additional 6 significant sector dummies. Dummies for second, eight, twelfth, thirteenth, sixteenth as well as twenty third sector were significant. As compared to regression without sectors dummies return on education fell. However, the change is almost imperceptible. According to estimates each year of schooling can be associated with 9,17% increase in earnings. Moreover, the coefficients on dummy for woman, age and age squared remained almost the same. Table 18 present details of regression for 2005 with industry dummies.

Table 18. Robust OLS estimates with industry dummies for 2005

No.	Variable	Coefficient	Robust standard error	t	P>|t|	95% Conf. Interval	
1.	woman	-0.3317	0.0545	-6.09	0.000	-0.4388	-0.2246
2.	age	0.0449	0.0195	2.31	0.022	0.0066	0.0832
3.	age_2	-0.0005	0.0003	-1.88	0.061	-0.0009	0.0001
4.	wielkopolska	-0.2181	0.0895	-2.44	0.015	-0.3939	-0.0422
5.	northeast	-0.2119	0.1302	-1.63	0.104	-0.4678	0.0439
6.	east	-0.3823	0.1415	-2.70	0.007	-0.6605	-0.1042
7.	malopolska	-0.2239	0.0773	-2.90	0.004	-0.3760	-0.0719
8.	city	0.3128	0.0636	4.92	0.000	0.1877	0.4379
9.	educat	0.0916	0.0088	10.41	0.000	0.0743	0.1089
10.	sector_2	-0.2124	0.0629	-3.38	0.001	-0.3361	-0.0889
11.	sector_8	0.2594	0.0919	2.82	0.005	0.0787	0.4400
12.	sector_12	0.4669	0.0635	7.35	0.000	0.3420	0.5917
13.	sector_13	0.3866	0.1352	2.86	0.004	0.1208	0.6525
14.	sector_16	1.2161	0.1042	11.67	0.000	1.0110	1.4210
15.	sector_23	0.2094	0.0905	2.31	0.021	0.0315	0.3873
16.	_cons	4.9571	0.3922	12.64	0.000	4.1861	5.7281

Source: own calculations.

Introducing sectors' dummies changed estimated return on education for 1999. However, in case of 2005 estimates remained almost the same. One of possible explanation is that labour force becomes more and more mobile and can substitute between sectors. This causes the return on education to be independent of sector.

3.2. Comparison of other empirical evidences

The next few paragraphs are devoted to comparison of my results and those obtained by other authors both in the case of Poland and other countries. I shall start with Psacharopoulos and Patrinos (2002) who claim that a return on education is adversely related to per capita

income of the country[55]. Their opinion is supported by the data presented in tables 19 and 20. The first table presents the coefficient on years of schooling in countries of different income level. The second table shows regional averages of return.

Table 19. The coefficient on years of schooling: mean rate of return

No.	Per capita income group	Mean per capita (US$)	Years of schooling	Coefficient
1.	High income ($9 266 or more)	23 463	9.4	7.4
2.	Low income ($755 an less)	375	7.6	10.9
3.	Middle income (to $9 265)	3 025	8.2	10.7
4.	World	9 160	8.3	9.7

Source: Psacharopoulos G., Patrinos H. A., Returns to Investment in Education. A Further Update, Policy Research Working Paper 2881, The World Bank, 2002, pp. 14.

Table 20. The coefficient on years of schooling, regional averages

No.	Region	Mean per capita (US$)	Years of schooling	Coefficient
1.	Asia	5182	8.4	9.9
2.	Europe, Middle East, North Africa	6299	8.8	7.1
3.	Latin America, Caribbean	3125	8.2	12.0
4.	OECD	24582	9.0	7.5
5.	Sub-Saharan Africa	974	7.3	11.7
6.	World	9160	8.3	9.7

Source: Psacharopoulos G., Patrinos H. A., Returns to Investment in Education. A Further Update, Policy Research Working Paper 2881, The World Bank, 2002, pp. 14.

According to the data presented, Poland as an European middle income country should have a return between 7.1-10.7%. This seems to be consistent with my estimates that varied between 7.96 and 9.35%. The return on investment in education estimated in regressions presented in previous chapter is smaller than the world average presented by Psacharopoulos and Patrinos (2002), but it is slightly above the European average.

Other important estimates of the rate of return include, for example, a research made by Harmon, Oosterbeek and Walker (2002). Their result for 15 European Union countries was

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[55] Psacharopoulos G., Patrinos H. A., Returns to Investment in Education. A Further Update, Policy Research Working Paper 2881, The World Bank, 2002, pp. 5.

6.5%. However, it is worth noticing that the sample includes the old EU countries that are high income countries.

The Italian example was subject to a detailed analysis made by Brunello, Coni and Lucifora (2000). They estimated that one additional year of schooling increases the earnings by 6.2% in the case of males. The rate is higher for females. It amounted to 7.5%. In a more recent paper, Mendolichcio (2005) showed that the rate of return in Italy is equal to 7-12% for men and 6.5-11% women.

The example of a new European Union member[56] was given by Vacernik (1995), who analyzed the Czech Republic in the year 1992 case. In this year the return for males was 5.3% annually. The analogical number for woman was 6.7%. A recent survey made by Filer, Jurajda and Planovsky (1999) that concerned the year 1997 found much higher coefficient on education that was equal to 9%.

Some Polish data were also examined. The analysis presented by Nesterova and Sabirianova (1998) estimated the rate on education in Poland as 7%. The authors analyzed the period between the years 1995-1996. The same years were examined by Rutkowski (1997) that found that each additional year of education is connected with 7-7.8% increase in earnings. Stawiński (2007) estimated the rate of return on university education as 6-9% annually, depending on a used specification of the wage equation.

The rate of return in university education is also a field of a detailed analysis. Caponi and Plesca (2007) think that obtaining university diploma raises the income by 30-40%. Blundell (2001) estimated that it is approximately 25%, whereas Card (1999) suggest 6-11% annually depending on a field of study.

More detailed comparison between countries can be made on the basis of one research that using the same method estimate return for several countries. This kind of research was provided by Trostel, Walker and Woolley (2002). They estimated the rates of return on education for 28 countries including Poland. They used the microdata from 1985 to 1995. Basing on their sample, the authors were able to say that there is no significant trend in the rate of return. However, the worldwide rate slightly declined during the analyzed period[57].

The rates of returns computed by Trostel, Walker and Woolley (2002) are presented in table 21. The maximal rate for men was observed in Northern Ireland (17.4%) and the minimal for Norway (2.3%). In the case of females, the maximal was in the Philippines

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[56] This research analyzed the period before accession to EU.
[57] Trostel P., Walker I., Woolley P., Estimates of the economic return to schooling for 28 countries, Labour Economics 9 (2002), pp.2.

(19.2%), in the Netherlands (1.8%). It can be observed that in the case of Poland rate of return is equal to 7.3% of men and 10% for woman.

According to these findings, the rate of return for both genders in Poland is almost the same as in the USA. Moreover, this rate for the United States are confirmed by an earlier study by Acemoglu and Angrist (1999). When it comes to the Polish rate of return for woman, a similar one can be found in Slovenia.

Table 21. OLS estimates of return on investment in some countries (1985-1995), Trostel, Walker and Woolley (2002)

No.	Country	Males	Females
1.	USA	0.074 (0.004)	0.096 (0.005)
2.	Great Britain	0.127 (0.006)	0.130 (0.006)
3.	West Germany	0.036 (0.002)	0.043 (0.004)
4.	Russia	0.044 (0.004)	0.053 (0.004)
5.	Norway	0.023 (0.002)	0.025 (0.003)
6.	Australia	0.051 (0.004)	0.052 (0.006)
7.	Netherlands	0.031 (0.002)	0.019 (0.004)
8.	Austria	0.038 (0.004)	0.064 (0.006)
9.	Poland	0.073 (0.005)	0.100 (0.005)
10.	East Germany	0.026 (0.003)	0.045 (0.004)
11.	New Zealand	0.033 (0.004)	0.029 (0.005)
12.	Italy	0.037 (0.003)	0.053 (0.005)
13.	Ireland	0.085 (0.006)	0.090 (0.008)
14.	Japan	0.075 (0.007)	0.094 (0.014)
15.	Hungary	0.075 (0.007)	0.077 (0.006)
16.	Northern Ireland	0.174 (0.011)	0.146 (0.011)
17.	Sweden	0.024 (0.004)	0.033 (0.005)
18.	Slovenia	0.080 (0.007)	0.101 (0.007)
19.	Israel	0.053 (0.007)	0.061 (0.008)
20.	Czech Republik	0.035 (0.007)	0.043 (0.007)
21.	Bulgaria	0.040 (0.009)	0.057 (0.010)
22.	Slovak Republic	0.052 (0.012)	0.064 (0.009)

23.	Canada	0.038 (0.008)	0.045 (0.008)
24.	Czechoslovakia	0.031 (0.010)	0.036 (0.007)
25.	Spain	0.046 (0.005)	0.038 (0.010)
26.	Switzerland	0.045 (0.007)	0.048 (0.012)
27.	Latvia	0.067 (0.020)	0.078 (0.014)
28.	Philippines	0.113 (0.015)	0.192 (0.030)
29.	Pooled	0.048 (0.001)	0.057 (0.001)

Robust standard errors are in parenthesis.

Source: Trostel P., Walker I., Woolley P., Estimates of the economic return to schooling for 28 countries, Labour Economics 9 (2002), pp. 5.

There is also a methodological discussion on whether the measured schooling is an exogenous variable. If it is not, then the coefficient on schooling is biased. Some authors argue that the omitted variable is an ability that determines both the education level and earnings. One way of dealing with this problem is to use the instrumental variable method. Trostel, Walker and Woolley (2002) tried several instruments for education, for example, the spouse's education, father's education or mother's education. I shall present their results of IV estimated concerning the Polish rate of return in table 22. Both returns- in the case of men and females are higher in comparison with OLS results.

In lieu of a summary I can conclude that the estimates of return in education in the case of Poland are in the 6-10% intercept. My results that are equal to 7.96 for 1999 and 9.35% for 2005 are consistent with other works.

Table 22. IV Estimates using father's education to instrument for education, Trostel, Walker and Woolley (2002)

No.	Instrument used for education	Return on education	
		Males	Females
1.	spouse's education	0.073 (0.009)	0.102 (0.014)
2.	father's education	0.078 (0.013)	0.143 (0.018)
3.	mother's education	0.074 (0.020)	0.161 (0.024)
4.	OLS results	0.073 (0.005)	0.100 (0.005)

Robust standard errors are in parenthesis.

Source: Trostel P., Walker I., Woolley P., Estimates of the economic return to schooling for 28 countries, Labour Economics 9 (2002), pp. 11-13.

In lieu of a summary I can conclude that the estimates of return in education in the case of Poland mange from 6-10% intercept. My point estimates are equal to 7.96 for 1999 and 9.35% for 2005 and they are consistent with other works.

Conclusions

In this master's thesis I analyzed the relationship between education and earnings. My main assumption was that individuals invest in education to have a possibility to earn more in the future. The amount of investment in schooling can influence receipts in two ways. Firstly, it upgrades the human capital of an individual. Potential workers have more information and skills which can be used at work. Therefore, the productivity is higher. Assuming the existence of perfect information on the labour market, a potential employer offers the worker a wage equal to his marginal productivity. Also, the worker knows the stream of earnings that can be reached for a given level of education. Consequently, he invests up to a point where marginal revenues are equal to the marginal costs.

However, we cannot assume the perfect information on the labour market. The employer does not know the real abilities of the potential worker the moment the worker is being employed. Thus, the employer can make a mistake while offering the wage. In this situation the worker needs education as a signal of his abilities. He is willing to bear some cost connected with schooling to make sure that he will not be recognized as a worse quality worker. Therefore, education serves as a kind of insurance for him. Some amount of money must be paid to reduce the risk of low earnings.

I suggest that the impact of imperfect information in this case does not change the fact that investment in education is undertaken to upgrade the individual's human capital level. For sure, this is the one of the reasons. However, the intention to signal the abilities both that are characteristic for a given person and gained during the schooling period is also very important. Due to imperfect information, another function of education is introduced. Therefore, both explanations suggest positive correlation between earnings and the individual's education.

In this thesis I made an estimated wage equation using years of education as an explanatory variable and controlling for work experience and other individual's characteristics. I examined this relationship using some Polish data. The coefficient on years of education- the rate of return on education in the year 1999 was found to be equal to 7.96% or to 6,43% when sector dummies are included. The corresponding number for the year 2005 was 9.35%. I confirmed my hypothesis about positive influence of education on wages. Also, my hypothesis about the height of return was confirmed.

The results of the thesis that are presented in the first subchapter of the third chapter are consistent with the results estimated by other researches' authors[58]. In order to prove this I provided a detailed comparison in the second subchapter. The comparison includes the estimates for Poland, but also for some other countries.

Moreover, the return in investment in education seems to be quite high even in comparison with other types of investment. It has more advantages over some other investment types. It is the most approachable opportunity to invest the money . Secondly, it is partially financed by the state. Another more intuitive argument is that the risk connected with the investment in education is much smaller.

However, it must be admitted that my results are limited to some extent. I concentrated only on monetary benefits of investment in education. Non pecuniary benefits were neglected in my analysis. It seems that calculating the value of non pecuniary benefits is a more difficult task since it is hard to express it in monetary terms. Nevertheless, non financial incentives were also studied by economists. Vila (2000) presents 3 dimensions, in which non monetary benefits can be studied.

According to Vila (2000), the first way systematizing non monetary benefits is whether they are the private (internal) or social (external) ones. The private ones include all the benefits that are received by the person who undertakes education. A good example is the influence on family life or prestige. The social ones are those that accrue to other members of society. The second dimension is the moment when the effects of education are visible. There are non monetary benefits that can be observed before the process of education is finished, like satisfaction with studying.

Other benefits occur after completing school and some last even for the lifetime. There are also such benefits that can be even felt by children. These are the benefits connected with having educated parents. The last criterion mentioned by Vila (2000) is the perception of the effect. She gives an example of the positive influence of education on health[59] or on the consumer choices' efficiency[60]. Although the benefits that are mentioned improve the quality of the individual's life, people may not associate them with previous educational choices[61].

To sum up, I can conclude that education can be to some extent treated as every other kind of investment. Thus, a return on such investment can be estimated. However, it should be

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[58] For example Trostel P., Walker I., Woolley P. (2002) or Nesterova and Sabirianova (1998).

[59] Health consequences were studied for example by Hartog and Oosterbeck (1998), Sander (1999).

[60] Example of analysis of this problem can be found for example in Arrow (1997).

[61] Vila L. E., The non-monetary benefits of education, European Journal of Education, Vol. 35, No. 1, 2000, pp. 22-23.

remembered that the result of such estimates should be interpreted taking into consideration the fact that signaling also takes place. What is more, the results can be even larger when we consider additional benefits that are difficult or even impossible to measure.

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<h1 style="text-align: center;">CURRICULUM VITAE</h1>

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Abstract

Die Magisterarbeit handelt von Mikrodeterminanten der Investitionen in die Bildung. Sie stützt auf die Grundvoraussetzung, dass die Investitionen vorgenommen werden, um den künftigen Ertragsfluss zu maximieren. Dabei werden zwei alternative Konzeptionen dargestellt. Der einen zufolge steigert die Bildung die Produktivität der Personen durch die Erhöhung des Humancapitals. Die andere dagegen besagt, dass die Produktivität gegeben ist und die Bildung für den potentiellen Arbeitgeber als ihr Signal dient. Der Meinung der Autorin dieser Arbeit schließen sich die beiden Konzeptionen nicht aus. Signaling auf dem Arbeitsmarkt ist nämlich als eine Ergänzung zur auf dem Humancapital. basierenden Konzeption zu betrachten. Im Untersuchungsteil versucht die Autorin aufgrund von Daten aus den Jahren 1999 und 2005 die Rückvergütung der Investitionen in die Bildung in Polen zu errechnen. Die Untersuchung besteht in der Durchführung der Lohnregression auf Variablen, die die Anzahl der Bildungsjahren eines Befragten und andere soziodemographische Faktoren betreffen.

Schlüsselwörter

Menschenkapital, Erträge der Investitionen in die Bildung, Signale auf dem Arbeitsmarkt, Lohnunterschiete, Polen

Abstract

This master thesis analyses the micro determinants of investment in education. The main assumption is that any investment is undertaken to maximize the stream of future receipts. Two alternative approaches are presented. The first one is that education increases the productivity of an individual, and the second one is that it serves as a signal of some characteristic of a potential worker. I would like to argue further that these two approaches do not exclude one another. Job market signalling can be a useful extension of human capital theories. Then, using the example of Poland in 1999 and 2005, I shall attempt to find the return on education. I will examine the influence of education, controlling also the influence of socio-demographic factors on the wages. This dependency can be checked by taking advantage of the least squares method and taking data from PGSS.

Keywords

human capital, return on education, job market signalling, wages, Poland