Return on Investment in Higher Education – Evidence for Different Subjects, Degrees and Gender in Germany

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Abstract:

Applying an investment perspective to higher education, the paper presents detailed empirical evidence on the rate of return to higher education and its determinants. Employing a sample of 17,180 higher education graduates derived from the German Labor Force Survey 2004, we show considerable variation in the rates of return to higher education across the different subjects, with some subjects on average not representing attractive private investments from an economic point of view. We find that the decision what to study is worth several hundred thousand Euros. Applying regression analysis, we find gender- and degree-specific return advantages only in certain subjects. Comparing the return of an investment in higher education and the production cost of higher education, we show that more expensive subjects (apart from Medicine) yield a lower return. When considering the cost of study, the overall order of attractiveness of the different forms of education remains stable, but the investment in further subjects is no longer clearly attractive.

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JEL-Classification: I21, I28, J31.

1 Introduction

According to Human Capital Theory higher education represents an investment decision. Compared to other investment alternatives, education must yield a higher rate of return in order to be pursued from an economic point of view. Knowledge about the return on investment might help individuals to make better informed schooling decisions by adding an economic perspective to it. Taking the return on investment as a private decision criterion is gaining in importance, as we currently observe an increasing private contribution to higher education cost in many countries due to tight government budgets. Moreover, even if higher education is mainly publicly financed, knowing the private return to different education alternatives allows to generate important insights helping to prioritize the allocation of public funds to certain areas of education or to explain the demand for the different forms of education. Assessing the rate of return is of particular interest for the German higher education market, which is the focus of our analysis. Germany is the largest higher education market in Europe, which is still characterized by a dominant share of public financing in higher education.[1] Several federal states have, however, recently announced the introduction of tuition fees.[2]

In this paper, we follow a pure investment perspective and analyze the private monetary returns to higher education first without considering the production cost of higher education (traditional public financing system) and second including the cost of study, which corresponds to a return on investment under a full private financing system where the production cost of higher education are covered by the students, thus representing an extreme scenario catching up the trend to increased private contribution. In line with existing

[1] According to OECD (2006), Table B3.2b, p. 220, the public financing share in tertiary education reaches almost 90 %.

[2] Universities in several federal states introduce flat tuition fees of 500 Euro per semester in 2007.

literature, we do not consider any non-monetary benefits to the individual or externalities that might benefit the society as a whole (e.g., the consumption value of studies or better health and lower crime).

We base our analysis on a large dataset of 17,180 higher education graduates and 1,416 high school graduates without further post-secondary education derived from the German Labor Force Survey 2004. This allows us to assess the monetary benefits of higher education and its (opportunity) cost through foregone earnings. The dataset is ideally suited for our research as it contains detailed information on both subject and degree of graduates.

A large set of empirical research shows that, overall, higher education represents an attractive private investment (see, amongst others, Psacharopoulos, 1994 and Blöndal et al., 2002 for international comparisons, as well as Lauer and Steiner, 2000 and Ammermüller and Weber, 2005 for recent studies with German data). Each year of higher education yields a private return of between 7 and 19 %[3] on an international scale and 7 and 10 % in Germany depending on the data used and methodology applied. However, the existing studies do not simultaneously differentiate between three factors that have been identified by prior research to significantly influence the income prospects of graduates: gender, degree and subject. In addition to the income prospects, the cost of study in terms of production cost largely differs between the different subjects and degrees. It is therefore necessary to obtain a more detailed picture of the returns to education, which we perform in this paper.

Most previous studies approximate the private rate of return through the coefficient for years of schooling or degree-dummy variables in a "Mincer-Earnings-Equation". In this paper, we will apply an expanded "Mincer-Earnings-Equation" following Murphy and Welch (1990) to empirically estimate experience-income profiles of higher education graduates and high

[3] See Blöndal et al. (2002).

school graduates without further post-secondary education as the relevant control group for the assessment of foregone earnings. We use the generated wage profiles to calculate the return on investment for the different forms of higher education through the internal rate of return (IRR) and the net present value (NPV) as the relevant criteria for an investment decision (see Becker, 1993; Blöndal et al., 2002 and Psacharopoulos, 1995). We further use the calculated return on investment-figures for the different forms of higher education as input parameters in a regression analysis to test for factors determining the return on investment and apply an approach on the basis of individual data to test the robustness of our results.

The aim of this paper is threefold. First, we want to analyze which forms of higher education are attractive investments and how the private return on investment in higher education differs between the different gender-degree-subject-subgroups. We test the hypothesis that the returns strongly differ between the subgroups with some subjects having returns far below the average returns found in previous studies due to low earnings prospects. Second, we investigate how the picture changes if we consider the production cost of study[4] and what, if any, the "unobserved" return would be to make certain types of higher education a worthwhile monetary investment. Third, we aim to analyze which factors determine the return on investment in higher education.

Our main findings are the following. We show considerable variation in the rates of return to higher education across the different subjects and degrees, with some forms of higher education on average not being attractive from a monetary point of view. We further show that the decision what to study might be worth several hundred thousand Euros. Concerning the different subjects, we confirm the overall order of subjects found by prior research with

[4] Which corresponds to the return on investment under a full private financing system.

Medicine and Law, Economics and Social Studies yielding the highest private returns and studies in the subjects Art and Agriculture as well as to a certain extent Languages and Cultural Studies yielding average returns below those of alternative investments.

When looking at gender- and degree-specific returns to investment, we find a differentiated picture and can only partly confirm the generalist finding of prior research that women have a higher return than men and that studies at a University of Applied Sciences yield a higher return compared to University studies. We show that each gender reaches a return advantage in subjects where it shows a strong relative presence. Moreover, graduates from a University of Applied Sciences reach a higher relative return only in some subjects that are strongly represented at this type of institution.

When taking the cost of study into account, the relative order of the different subgroups remains stable, but the investment in some subjects is no longer clearly attractive (e.g., Engineering studies). Comparing the IRR of an investment in higher education and the cost of study, we find that apart from the subject Medicine the most expensive subjects also yield the lowest IRR, which might give an indication for a potential misallocation of public funds under the current financing system unless there are high social returns.

Regression analysis with aggregated return on investment figures for the different forms of higher education and based on individual data largely supports the findings.

This paper adds to the existing literature in the following ways. Our large micro-dataset allows us to analyze the returns to education in greater detail through simultaneous differentiation by gender, degree, and subject, as well as inclusion of the cost of study, while prior research only takes selected dimensions into account. Moreover, the paper is, to the best of our knowledge, the first study that estimates the return on investment in higher education for the different gender-degree-subject-subgroups by applying a classical investment approach and relying on regression techniques to estimate the income prospects

of both higher education graduates and high school graduates without further post-secondary education as the relevant control group. In addition, we use our calculations as input parameters for a regression analysis to test for factors influencing the return on investment and further test our results through a regression analysis with individual data. Our analysis therefore combines the advantages of the two approaches used to estimate returns to education in the previous literature. The direct calculation through the internal rate of return of an investment project allows for a better treatment of the cost occurred and the regression-based analysis of the income prospects and the return on investment allows to consider various influencing factors.

The paper is outlined as follows. The next section gives an overview of relevant previous research and describes the methodology applied. The third section describes the dataset and estimates experience-earnings profiles both for higher education graduates and high school leavers without further education using OLS regression. In the fourth section we calculate the returns on investment in different forms of higher education. In section 5, we test our findings with regression analysis based on aggregated and individual data. Section 6 concludes.

2 Background and Methodology

2.1 Human Capital and Signaling Theory

The investigation of the returns to higher education is both relevant following Human Capital Theory (see Schultz, 1961; Becker, 1993 and Mincer, 1974 for pioneering work) and Signaling Theory (see Spence, 1973). According to Human Capital Theory education can be considered as an investment project. It requires resources that have a cost in terms of opportunity cost through foregone earnings as well as direct cost, and increases the productivity of the individuals taught. Assuming that individuals get paid based on their

productivity, graduates with a higher education degree should yield a higher income compared to individuals that did not pursue higher education. Education should continue as long as there is a positive difference between the marginal benefit and the marginal cost of education.

Some economists dispute the productivity enhancing effect of higher education that is the fundamental assumption beyond Human Capital Theory. According to the signaling hypothesis education serves as a signal for higher quality, but it is the inherent ability that determines the productivity of individuals. Potential employers take higher education as a positive signal for the productivity and motivation of individuals. While at least a certain productivity enhancing effect of higher education appears undeniable (for medicine and engineering graduates, e.g., the skills obtained at university represent a prerequisite to do their work), we do not intend to contribute to solving the puzzle. We are interested in the question what the yield to higher education as an investment is and do not distinguish whether this yield is paid due to enhanced productivity or a positive signal associated with education.

2.2 Relevant Empirical Literature

In the following, we want to give an overview of previous empirical studies assessing the return on investment in higher education and differentiating by degree, subject or gender both for Germany and on an international scale.[5] Overall, the studies highlight that higher education is an attractive private investment. Each year of (higher) education yields a private

[5] We selected the studies based on their relevance for our research question. In addition to the studies described in this section, further studies presenting return to education-estimates exist.

return of between 7 and 19 %[6] on an international scale and 7 and 10 % in Germany depending on the data and methodology applied.

Concerning the methodology applied, the studies can be divided into two groups. Most studies approximate the private rate of return through the coefficient for years of schooling or for a degree/subject-dummy variable estimated in a "Mincer-type-Earnings-Equation". A second group of literature estimates the internal rate of return with empirical averages.

As for Germany, we outline two recent "Mincer-based" studies in the following.[7] Lauer and Steiner (2000) differentiate by level of education and higher education degree (University of Applied Sciences and University) as well as gender using data from the Socio-Economic-Panel (SOEP). They find an overall return to year of education of 10 % for women and 8 % for men. Robustness checks show that the rates of return are slightly decreasing over time and robust with regard to extended specifications to account for a possible endogeneity bias. When estimating a duration of study-adjusted annual return from higher education they find an excess return for graduates from a University of Applied Sciences compared to University graduates, the difference being higher for men than for women in the period 1984-1997.[8] Their analysis suggests that the rate of return decreases with the duration of education. Ammermüller and Weber (2005) also consider higher education subject when estimating the rate of return through a "Mincer-Earnings Equation", but do not differentiate between the two higher education degrees. Overall, they also find a return per year of education between 8 and 10 % for West-Germany with 2002 data from the SOEP, with women in general showing higher returns.[9] When differentiating by level of education they find that obtaining

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[6] See Blöndal et al. (2002).

[7] For a review of studies conducted before 2000 we refer the reader to Asplund and Pereira (1999).

[8] Bellmann et al. (1994) also find an excess return using 1987 data.

[9] Estimations with Labor Force Survey data yield similar results.

a higher education degree yields an annual return of 9.7 % for men and 10.4 % for women. Concerning the impact of the subject chosen, they show with data derived from the Labor Force Survey 2000 that returns are highest for higher education graduates in the subjects Medicine, Economics/Law and lowest for Agriculture-, Art- and Music-majors. The annual rates of return range from 3.5 % for female Agriculture graduates to 12 % for male Law graduates.[10] Moreover, their results indicate that each gender reaches high relative returns compared to the other gender in subjects where it has a strong presence (engineering for men and studies to become a teacher for women). Both Lauer and Steiner and Ammermüller and Weber do, however, only take opportunity cost into account. Moreover, as the income variable in the SOEP reflects gross income, their results mix private and social returns and they consider a broad control group (individuals with no degree, lower or upper secondary education), which might lead to upward biased returns to higher education.

Apart from the various "Mincer-based" studies, there is hardly any prior research for Germany that calculates the internal rate of return as the discount rate that equates an income stream from higher education to a stream of cost associated with it. Ederer and Schuller (1999) calculate the rate of return for different subjects, but do only analyze University graduates and do not differentiate by gender. They find that the private rates of return reflecting opportunity cost, labor force participation and course dropouts range from 8.5 % for Medicine to -1.6 % for Languages and Cultural Studies. Their results, however, rely on earnings profiles derived from empirical data points and not on econometric estimates.

In addition to above presented studies with German data, several international studies provide insights on the returns to education for the different gender and degrees both for

[10] Research for other countries (see, amongst others, Blackaby et al., 1999; Blundell et al., 2000 and O'Leary and Sloane, 2005 for UK; Rumberger and Thomas, 1993 and Black et al., 2003 for US) also finds a large variation in the returns by subject with a similar relative order of the different subjects.

Germany and other countries. Psacharopoulos (1994) and Psacharopoulos and Patrinos (2004) present return to education figures for a large set of countries. They show that over all countries considered, women have a higher rate of return per year of education than men. Concerning the different subjects, Engineering, Medicine, and Law and Economics have overall the highest private rates of return.

Blöndal et al. (2002) compare internal rates of return to higher education for various OECD-countries differentiating by gender. Their calculations are based on average empirical earnings and a broad definition of the private rate of return that takes labor force participation, cost of study (tuition) and subsidies to students in addition to opportunity cost and income differentials into account. They find a rate of return to higher education of 9.1 % for German men with SOEP data[11], which is below the international average of 11.6 %. In contrast to other studies, they find higher rates of return to higher education for Germany men than for women (8.4 %), which can, however, be explained by the inclusion of labor force participation rates and a benefit from higher relative labor force participation for men.[12]

Having in mind that the results of the above mentioned studies are difficult to compare due to differences in methodology, variable specification, data and observation period, the studies indicate that the rate of return to higher education differs between the different subjects and degrees of higher education as well as between the two genders.

[11] 2.7 % of which is attributable to public student support.

[12] Without considering labor force participation through unemployment risk, the difference between men and women narrows to 0.2 percentage points.

2.3 Methodology

Considering (higher) education as an investment, we follow in this study classical investment theory suggesting that the Net Present Value (NPV) or the Internal Rate of Return (IRR) of the income streams associated with higher education represent the relevant criteria in order to establish investment priorities.[13] The NPV is the present value of the difference between the benefits of higher education and its cost. The IRR represents the discount rate that equates the present value of additional income compared to those who had the opportunity to, but did not pursue higher education (control group) to the present value of cost (opportunity cost through foregone earnings and, if any, direct cost of study). If this rate of return is higher than an adequate market interest rate at which the individual can borrow, education represents a worthwhile investment for the individual. If the IRR is below the relevant interest rate, we can quantify an "unobserved" return component that would be necessary to make education a worthwhile monetary investment.

Figure 1 highlights the stylized costs and benefits from an investment in higher education following Psacharopoulos (1995).

[Figure 1]

We confine our analysis to the private monetary return to different forms of higher education and analyze two scenarios: First, a scenario without consideration of the production cost of higher education and second, one including the cost of study[14]. In line with existing literature, we do not consider any non-monetary benefits to the individual or externalities that might benefit the society as a whole in the calculations.

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[13] See also Psacharopoulos (1995) for a discussion of different methodological approaches.

[14] See Appendix B for a description of the methodology applied to calculate the production cost for the different subjects and degrees.

We calculate the private monetary return on investment through the IRR and NPV applying the following DCF-formula that consists of two major components, the excess income of higher education graduates over their working period and the (opportunity) cost pursuing higher education:

$$NPV_{j,k,s} = \sum_{t=1}^{T} \frac{w_{j,k,s}^{HE} - w_s^{CG}}{(1+r)^{t+D}} - \sum_{d=1}^{D} \frac{w_s^{CG} + C_{j,k}^{HE}}{(1+r)^{d}} \quad (1)$$

Where:

r = Internal Rate of Return (discount rate),
$w_{j,k,s}^{HE}$ = Net Income of higher education graduates for subject j, degree k, gender s,
w_s^{CG} = Net Income for the control group with gender s (foregone earnings),
$C_{j,k}^{HE}$ = Cost of Study for subject j and degree k
T = Working Life of Higher Education Graduates,
D = Duration of higher education studies.

Previous research often estimates the returns to education through a "Mincer-Earnings Equation" with the natural logarithm of net income as dependent variable and years of schooling and experience as independent variables. The coefficient for years of schooling approximates the rate of return to one additional year of schooling under stringent conditions (see, amongst others, Heckman et al., 2005 for a critical discussion of this approach). It assumes, e.g., a linear return to all years of schooling and separability of experience and schooling, measures the return to education only through income differentials of different forms of education and does not allow to analyze the impact of a consideration of the cost of study on the return to schooling. Heckman et al. (2005) show employing US data that the conditions under which the derived schooling coefficient equals the marginal internal rate of return have not been fulfilled in recent years. An estimation of rates of return through "Mincer-type" Earnings Equations might also be subject to both an endogeneity bias due to, e.g., omitted ability and a selectivity bias due to neglecting the decision whether a person

works or not (see, e.g., Card, 1999 and Heckman et al., 2003 for a review of studies analyzing these issues). Many contributions, e.g. Lauer and Steiner (2000) for Germany, that take potential limitations into account, however, do not find evidence for significant estimation biases.

In our study we use an expanded "Mincer-Earnings-Equation" following Murphy and Welch (1990) to estimate earnings profiles of higher education graduates working full-time and our control group as input parameters for the IRR-calculation instead of taking empirical averages, but do not directly derive return figures from a "Mincer-Earnings-Equation". Our approach might also be subject to an ability bias if the sample of higher education graduates has a higher ability or motivation than the control group. Since our dataset does not allow us to control for a potential bias, our results might be upward biased. The bias is, however, believed to be less than in estimations through "Mincer-Earnings-Regressions" as individuals in our sample have at least obtained an A-level degree. Moreover, it is important to have in mind that the results for the different forms of higher education do not imply direct causality if, e.g., individuals of different ability are sorted into different forms of higher education.

In addition to the RoI-calculations, we further apply regression analysis in order to determine factors that influence the return on investment in higher education. First, we perform a regression with the aggregated average NPV- and IRR-values for the different forms of higher education calculated in equation (1). Since the number of observations in this analysis is restricted to number of subgroups, we, second, also apply an alternative approach. We estimate the present value of income of each individual and perform a regression analysis with the individual estimates.[15]

[15] For a detailed application of the two approaches see section 5.

3 Earnings Capacity Estimates

3.1 Data and Descriptive Statistics

We use the German Labor Force Survey 2004 ("Mikrozensus"), the official representative statistics of the population and the labor market in Germany, for our analysis of the earnings capacity of both higher education graduates and the control group of high school graduates without further (post-secondary) education. The Labor Force Survey involves every year 1% of all households (continuous household sample survey) who have the same probability of selection (random sample). It is ideally suited for our research as it contains a large number of graduates and information on their subject and degree to derive detailed experience-earnings profiles.[16] The income variable in the Labor Force Survey comprises monthly net income, which is the relevant income figure to assess the private benefits of higher education as it abstracts from taxation. We analyze cross-sectional data as representative longitudinal data is not available for Germany.

We base our calculations on a scientific-use file of the Labor Force Survey 2004. It is a factually anonymized 70 %-sample of the original Labor Force Survey, which was drawn as a systematically random selection from the original data by the Federal Statistical Office. The scientific use-file consists of information on 499,849 individuals. For the purpose of our analysis, we derive two subsamples from the scientific-use file: one for full-time working higher education graduates (Panel A) and one for our control group of high school graduates without further (post-secondary) education (Panel B).

In order to derive Panel A we exclude all individuals who do not have a higher education degree (graduation from University or University of Applied Sciences) (-459,871). This

[16] The other potential source with information on higher education degree and subject of graduates, the Socio Economic Panel (SOEP), has a small sample size of higher education graduates with subject information (only approximately 2000 graduates).

leaves us with 39,978 higher education graduates. In addition, we exclude individuals younger than 25 years or older than 55 years from the dataset to avoid a selection bias due to early and partial retirement.[17] We also do not take into account individuals who did not indicate their income or subject. Furthermore, we drop graduates who have not been interviewed at their main residence to avoid double counting. After controlling for labor force participation, Panel A consists of 17,180 higher education graduates working full-time, on whom we will base our income estimation.

To get the control group subsample (Panel B), we exclude all individuals who have no high school degree and those who have a post-secondary degree (incl. vocational education), leaving us with individuals that only have a high school degree. In analogy to Panel A, we do not consider people older than 55, who did not indicate their income or have not been interviewed at their main residence. Furthermore, we exclude individuals who are currently attending an education institution and do not take into account those who perform their military or alternative national service as there is a high possibility that they attend college afterwards. After correcting for individuals whose major income source is not income from work, this leaves us with 1,828 high school graduates who are eligible for post-secondary education but do not obtain a further degree, 1,416 of them work full-time (Panel B).

Table 1 presents the descriptive statistics for our selected subsamples.

[Table 1]

For the full-time-working higher education graduates (Panel A), the average monthly net income is 2,656 Euro.[18] 34 % of the full-time working higher education graduates are

[17] We follow Fitzenberger and Reize (2002), who also apply this selection.

[18] As the income variable consists of income classes, we use the mid-point of class for our analysis. We approximate the highest, right-censored class that represents less than 0.3% of the higher education graduates with a value of 22,000 Euro assuming the same distance than in the previous class.

female. Concerning study information, Table 1 also shows the subject[19] and degree frequencies. Most graduates hold a university degree (60 %) and 40 % have a degree from a University of Applied Sciences. Engineering is the most represented subject (almost 30 %), followed by Law, Economics and Social Studies, and Languages and Cultural studies, subjects in which almost one quarter graduated in. When turning to the subsample of high school graduates without any further (post-secondary) education (Panel B), we see a significantly lower average net monthly income (1,753 Euro) and a slightly higher level of potential work experience, which reflects the fact that the control group starts working at a lower age. The share of females is slightly lower (32 %).

As we are interested in the earnings capacity of both higher education graduates and the control group, table 2 provides a more detailed picture of the income variable differentiating by subject, degree and gender.

[Table 2]

For Panel A, the table shows that the average net income differs significantly between the different subjects. Graduates in Medicine earn on average the highest income, followed by Law, Economics and Social Studies, both yielding on average more than 3000 Euro per month. Art majors have the lowest average net monthly income of less than 2000 Euro. Graduates from a University earn on average a significant premium of 143 Euro compared to graduates from a University of Applied Sciences and males have a significant average monthly net income premium of around 900 Euro, even when abstracting from labor force participation by considering full-time workers only. In our control group (Panel B), males have a significant average income premium of around 600 Euro. The analysis of the income variable gives an indication that the overall average income difference between Panel A and

[19] We follow the official subject classification of the Statistisches Bundesamt. The subject Sport, however, is part of Other studies due to a low number of observations.

Panel B of 900 Euro decreases significantly when looking at subgroups. Art majors have only an average income premium of less than 250 Euro compared to the control group.

3.2 Estimation of Experience-Income Profiles

Instead of taking the empirical averages, we estimate "Mincer-type" earnings equations for our subsamples of higher education graduates and the control group with the natural logarithm of net monthly income as the dependent variable following common practice among economists to predict the mean monthly net income per year of potential work experience. Based on the estimated coefficients, we are able to derive detailed experience-earnings profiles. Following the literature, we estimate profiles for full-time workers only and perform an ordinary least squares (OLS)-regression[20] (see Mincer, 1974 and Becker, 1993 for fundamental research). While the original specification by Jacob Mincer uses a quadratic function of work experience in the earnings function, Murphy and Welch (1990) showed that a quadratic specification leads to significantly biased estimates of the earnings profile, overestimating earnings at low levels of experience and underestimating earnings at high levels of experience. According to their analysis, a cubic or even quartic specification fits the "real" earnings data, measured by the estimated means per experience cohort, much better. Since our data supports their finding, we also apply higher order polynomials in experience in our analysis.[21]

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[20] As the dependent variable in our dataset is censored and indicated in classes, we also perform tobit and interval regression. Our results are, however, insensitive to the estimation method.

[21] In order to determine the optimal functional form in terms of degree of work experience, we estimated a regression with dummy variables for every year of experience. When comparing the results of this regression with regressions with different degrees of experience, we found that a cubic specification fits the empirical data much better compared to the quadratic form. In the fourth order, we found improvements for the control group, but only marginal improvements for the higher education subsample.

3.2.1 Higher Education Graduates

The descriptive statistics in section 3.1 have shown that the average net monthly income of higher education graduates differs by subject, degree and gender. Further motivated by prior literature, we therefore differentiate by subject, degree and gender when estimating the earnings capacity of higher education graduates using regression analysis. We take the average income for each gender-degree-subject-experience cell following Murphy and Welch (1990) weighted by the number of observations in each cell as dependent variable in the regression analysis[22] and introduce dummy variables for each subgroup (gender, degree and subject) as independent variables. To test the hypothesis that the slope of the experience-earnings profiles differs for the different subgroups, we also introduce interaction terms for experience and degree, and experience and gender into the regression.

Our regression function to estimate the mean net monthly income for full-time workers dependent on work experience, gender, degree and subject therefore takes the following form:

$$\ln \hat{w}^{HE} = const. + \hat{\alpha} * Female + \hat{\beta} * University + \sum_{j} \hat{\gamma}_j * dum_j + \sum_{x=1}^{3} \hat{\delta}_x * e^x + IT_{F,U} + \hat{u}$$

With:

$\ln \hat{w}^{HE}$ = Natural logarithm of mean net income of higher education graduates,
$const.$ = Regression constant,
dum_j = Independent dummy variable for subject j,
e^x = Independent variables for x - th order of work experience,
$IT_{F,U}$ = Interaction terms for different polynomials of exp. and Uni, and exp. and Female,
$\hat{\alpha}, \hat{\beta}, \hat{\gamma}, \hat{\delta}$ = Coefficients for the independent variables,
$\hat{u}$ = error term.

[22] We decide to use average income instead of individual values, as estimates with log of individual data tend to underestimate the empirical mean profiles.

[Table 3]

Table 3 gives an overview of the results from the above specified regression. All standard-errors are heteroscedasticity-robust. In addition to many independent variables the introduced interaction terms for both Experience and University, and Experience and Female are highly significant.[23] This indicates that the experience-income profiles for the different degrees and gender differ by their slope and justifies a closer investigation of the gender-degree subgroups. The coefficients for the subject dummy variables indicate that Medicine graduates earn on average the highest income followed by Law, Economics and Social Studies graduates. Graduates with a subject Art or Agriculture earn the lowest income, which reflects the findings from the empirical mean analysis and is in line with prior research by, e.g., Ammermüller and Weber (2005). The regression analysis also shows that University graduates earn c.p. a premium compared to graduates from a University of Applied Sciences after some years of experience. This result is in line with the Human Capital Theory that postulates that longer education should yield a higher outcome as each additional year of schooling yields a positive return and supports the finding of Lauer and Steiner (2000). Moreover, males earn more than females and the coefficients of the interaction terms indicate that the income gap between males and females increases with experience. This reflects the finding of Lauer and Steiner (2000) and Fitzenberger and Reize (2002).

Since the highly significant interaction terms indicate different slopes for the experience-earnings profiles by degree and gender, we also estimate regressions for four degree-gender-subgroups with a dummy variable for each subject. Table 3 also shows the results for the

[23] We also tested interaction terms for Subjects and Experience. However, we did not consider them in the final regression as the coefficients have to a large part not been significant, indicating that for the different subjects only a level effect can be observed in the data.

four subgroup regressions. Overall, the results are in line with the full regression analysis, but yield a more detailed picture. In all subgroup regressions, most subject variables become highly significant.[24]

Figure 2 shows the experience-income profiles for the different subgroups of higher education graduates derived from the subgroup regression analysis.

[Figure 2]

The profiles are concave until a work experience of around 25 years, indicating that earnings increase over time, but at a decreasing rate, which is consistent with the existing literature (Becker, 1993; Mincer, 1974; Murphy and Welch, 1990). Our estimated profiles also show, however, that our data supports an increase of net income after 25 years of experience until an experience of 30 years, which could be explained by major promotions at this level of experience. In line with prior research for Germany, the estimated profiles are much steeper for men than for women, as well as for University graduates compared to graduates from a University of Applied Sciences.

3.2.2 High School Graduates Without Further Post-secondary Education

Our regression function to predict the average net monthly income of the control group takes the following form[25]:

$$\ln \hat{w}^{CG} = const. + \hat{\alpha} * Female + \sum_{x=1}^{4} \hat{\beta}_x * e^x + IT_F + \hat{u}$$

The right hand column of table 3 shows the results from the Control Group regression (Panel B). All standard-errors are heteroscedasticity-robust. The coefficients for the independent

[24] The results are robust with regard to the application of standard errors clustered at the cell level.

[25] In comparison to the regressions for the higher education subsample, we consider a forth order polynomial in experience-specification. We apply this specification adding additional explanatory power to the model as the control group has longer potential work experience.

variables and the interaction terms for the different polynomials of experience and Female are highly significant.[26] Figure 2.5 shows the derived experience-income profile both for men and for women. As for the subsample of higher education graduates, the profiles are concave until a work experience of around 25 years, increase again until an experience of 30 years, and decrease slightly afterwards, which is in line with the functional form of the profiles derived from the original "Mincer-Earnings-Equation"-specification for high years of experience. The estimated profiles are only slightly steeper for men than for women.

4 Private Return on Investment in Higher Education

We use the estimated earnings capacity to empirically calculate the IRR and NPV of an investment into different forms of higher education. For our calculations, we assume an annual (constant) wage growth, e.g., due to technological progress, since the estimated income per year of experience for the different groups is derived from cross-sectional data and wages do not remain constant over time. We therefore adjust the estimated average earnings per year of experience with a wage growth factor g of 2 %, which reflects the average annual long-term real growth rate of gross wages for German employees.[27] For a detailed description of all assumptions underlying our Return on Investment-calculations, we refer the reader to Appendix A.

Table 4 shows the results of the Internal Rate of Return- and Net Present Value-calculations including and without consideration of the cost of study.

[Table 4]

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[26] For the control group, regressions with gender-subgroups yield the same result and can be directly constructed from the full regression displayed in table 4.

[27] The figure is calculated from nominal gross monthly wage figures for employees in Germany for the period 1976-2005 available from the National Statistical Authority ("Statistisches Bundesamt"), adjusted for inflation. An overall adjustment seems justified since several empirical studies found that the German wage structure stayed fairly stable in the past. Fitzenberger and Kurz (2003) find that earnings grew quite uniformly in Germany and that between and within groups' ratios remained fairly constant in the 1990s. Abraham and Houseman (1995) also find great stability in wage dispersion in Germany in the 1980s.

Without Cost of Study (only Opportunity Cost considered)

When first looking at the traditional public financing scheme displayed at the left hand side (i.e. with opportunity cost through foregone earnings as the only cost considered), we find that both the IRR and the NPV differ strongly between the different forms of higher education. Our calculations show in a detailed picture that most, but by far not all forms of higher education, as implicitly suggested by undifferentiated prior research, are a worthwhile investment in an economic sense. On the one hand, Medicine and Law, Economics and Social Studies have the highest average private returns, being above 11 % for all degrees and gender, followed by Mathematics and Natural Sciences showing a return on investment of above 8 % for all subgroups. On the other hand, studies in the subjects Art and Agriculture as well as to a certain extent Languages and Cultural Studies even yield on average a rate of return below the interest rate on long-term government bonds, for some subgroups being even negative. The overall order of subjects is in line with the findings by Ammermüller and Weber (2005) and international research. We do, however, find a much wider range in the returns when considering the different subgroups, ranging from a high of 13.6 % for female Medicine students to negative returns for male Art students. When analyzing the NPV assuming a (risk-free) discount rate of 4 % as the lower limit for the discount rate, we find that for the subgroup of male University students the NPV differs between 243 thousand Euro for Law, Economics and Social Studies graduates to a negative 106 thousand Euro for Art students. Applying a more conservative discount rate of 6% that takes the uncertainty with regard to an investment in human capital into account[28], the range narrows to 137 to a negative 96 thousand Euro. Assuming you are an average male student who wants to study at a University, your choice of subject might therefore be, c.p., a question worth more than 200

[28] We refer the reader to Weldi (2006) for a more detailed discussion of an adequate discount rate for investments in human capital.

thousand Euro. For female University of Applied Sciences graduates, e.g., the variation is less, but the average NPV of the different higher education investments still differs by more than 75 thousand Euro.

When looking at gender-specific returns to investment, we find a differentiated picture after taking account for subject and degree. For some subjects we confirm the finding of prior studies for Germany that show a return premium for women compared to men (see Lauer and Steiner, 2000 and Ammermüller and Weber, 2005). The premium is largest for graduates in the subject Languages and Cultural Studies (more than 4 percentage points for University graduates and more than 10 percentage points for graduates from a University of Applied Sciences). On the other hand, however, we show that male graduates in the subject Engineering (both from a University and from a University of Applied Sciences) as well as Law, Economics and Social Studies graduates from a University yield a higher return compared to women. It appears that both gender have a return advantage in subjects where they reach a strong relative presence (men in Engineering and Law, Economics and Social Studies and women in Languages and Cultural Studies and Art) indicating that the two gender choose the subjects where they have a competitive advantage compared to the other gender, a point mentioned by Ammermüller and Weber (2005).

Concerning degree-specific returns to education, we cannot support the generalist finding of prior studies that the duration of studies has a major impact on the rate of return and that shorter studies, e.g. at a University of Applied Sciences, yield a higher return (see Lauer and Steiner, 2000). In our sample, this appears to be only entirely the case for studies in the subject Engineering. It appears that graduation from a University of Applied Sciences yields a higher relative return in subjects that can be considered as their major competence areas in terms of number of students enrolled.

Including Cost of Study (Opportunity Cost and Cost of Study)

When comparing the IRR or NPV of an investment in higher education and the cost of study[29], we cannot observe a positive relationship between input in terms of cost of study and output measured through the return on investment for different education alternatives. Figure 3 even gives an indication for a negative relationship and shows that when excluding Medicine expensive subjects also yield a low IRR/NPV.

[Figure 3]

As a consequence, under a public financing scheme the government invests high amounts of money per student in subjects that do not yield high private returns and thus also provide low tax revenues as a major component of monetary social returns. In order to still justify the governmental sponsorship from an investment perspective high other social returns are required or we find an indication for some public misallocation of funds.

Considering the cost of study reduces the internal rates of return for all subgroups, but neither the gender-/degree-specific findings, however, nor the overall order of the different subjects change. The investment case for further subjects that have yielded a decent private monetary return before taking cost of study into account becomes, however, less clear. When considering an IRR of around 6 % as a more conservative hurdle rate including a risk premium for investments in Human Capital, studies in Engineering as well as Mathematics and Natural Sciences (at a University) are no longer clearly attractive investment cases and Languages and Cultural Studies are only worthwhile monetary investments if studied by women at a University.

[29] For a detailed description of the cost of study for the different degrees and subjects see Appendix B.

The findings presented in this section are robust with regard to changes in major assumptions, i.e. the assumed annual wage growth rate and different specifications of the wage equation.

Since we have confined our analysis to the private monetary returns to an investment in higher education, studies that yield an IRR below that of alternative investments would require a high non-monetary or "unobserved" return in order to become attractive. For Art, Agriculture and to a certain extent Languages and Cultural Studies this would mean that the "unobserved" return component would have to close an average return gap of more than 5 percentage points. As such an "unobserved return"-component appears to be high, certain subjects can hardly be studied following a pure investment perspective. It is important to recall, however, that we, as the presented prior studies do, calculate the average return on investment for the different forms of education and that individual returns might differ from those averages.

5 Regression analysis

5.1 Regression Analysis with Subgroup-IRR/NPV

To test the findings derived from the NPV- and IRR-calculations presented in section 4, we perform a regression analysis with the NPV and IRR of the different forms of education (subgroups presented in table 4) as the respective dependent variables and gender, degree, subject and production cost of study as independent variables.

The regression function takes the following form (example for NPV as dependent variable):

$$NPV = const. + \hat{\alpha} * Female + \hat{\beta} * University + \sum_j \hat{\gamma}_j * dum_j + \hat{\delta} * Cost + IT + \hat{u}$$

[Table 5]

Table 5 gives an overview of the results from the above specified regression function both for NPV- and IRR-regressions. All standard-errors are heteroscedasticity-robust. When looking at the NPV-regressions on the left hand side of table 5, we can confirm most findings derived from the calculations in the previous section. Subject significantly influences the NPV. Neither gender nor degree, however, are significant predictors, which highlights that no gender or degree shows an overall return advantage (regression 1). When introducing interaction terms for gender and subject in regression (2; only significant interaction terms are included), we confirm an advantage for women in the subjects Languages and Cultural Studies and Art. The analysis, however, does not support the return premium for University of Applied Sciences graduates in some subjects discussed in the previous section since interaction terms for degree and subject are not statistically significant (not displayed). Regression (3) confirms our hypothesis that more expensive studies yield a lower return. We find a negative relationship between cost and NPV when excluding Medicine. When accounting for subject, degree and gender in regression (4), however, cost of study is no longer statistically significant. The results are robust with regard to the discount rate applied and a consideration of cost of study (NPV of private financing scheme) in the NPV-calculation.

The IRR-regressions on the right hand side support the results. The cost variable in regression (3) is, however, not significant, which can be explained by the existence of outliers in the form of large negative values for some types of education.[30] In addition to the results from the NPV-regression, regression (2) confirms a relative return advantage for males in the subjects Law, Economics and Social Studies and Engineering.

[30] Applying an adjusted IRR figure that does not allow for negative values or calculating the IRR including the cost of study confirms the negative relationship found in the NPV-regression.

Since the regression analysis with subgroup NPV and IRR is subject to a small sample size that is restricted to the number of subject-degree-gender subgroups, the results serve as a first indication of the determinants of the RoI.

5.2 Regression Analysis on the basis of individual data

To further test the results, we also apply an approach on the basis of individual data. We estimate a general "Mincer-type" Earnings Equation dependent on different polynomials of experience[31] for higher education graduates and a broader sample including high school graduates who had the right to, but did not pursue higher education. We apply the derived earnings function to the individual observations and calculate individual earnings profiles assuming a constant difference in ln wages that translates into a constant wage growth rate in all individual profiles. The generated profiles are used to empirically calculate the Present Value of Income (PVI) until the age of 55 for each individual in our sample.[32]

To determine the factors influencing the PVI of (higher education) graduates, we perform an OLS regression analysis with the natural logarithm of the PVI as the dependent variable and gender, higher education, degree, subject and cost as independent (dummy) variables.

The regression function takes the following form:

$$LnPVI = const. + \hat{\alpha} * Female + \hat{\beta} * HE + \hat{\gamma} * University + \sum_j \hat{\delta}_j * dum_j + \hat{\phi} * Cost + IT + \hat{u}$$

[Table 6]

[31] Following Murphy and Welch (1990), we expand the traditional Mincer-Earnings-Equation to account for a third order polynomial in experience.

[32] As described in section 4, we assume an annual (constant) wage growth, e.g., due to technological progress, since the estimated income per year of experience is derived from cross-sectional data and wages do not remain constant over time.

Table 6 shows the results of the regression analysis. All standard-errors are heteroscedasticity-robust. When first looking at the sample of higher education graduates in Table 6a, we find that gender and subject are significant predictors of the Present Value of Income, which confirms the results from the earnings capacity analysis that the earnings capacity significantly differs between the different gender and subjects. Degree, however, appears to be not significant when controlling for gender and subject in regression (1). When introducing interaction terms for gender and subject, and degree and subject in regression (2; only significant interaction terms are included), we confirm an income advantage for women in the subjects Languages and Cultural Studies as well as Art and a premium for men in Engineering. Moreover, the analysis shows a significant return premium for University of Applied Sciences graduates in Engineering and a premium for University graduates in Languages and Cultural Studies, and Agriculture. Regression (3) indicates that more expensive studies have a lower average Present Value of Income. The results are robust with regard to changes in the functional form of the estimation function for the calculation of the PVI and a consideration of the cost of study in the PVI-calculation displayed on the right hand side of Table 6a (PVI including cost of study).

The PVI-regressions in table 6b for a broader sample consisting of both higher education graduates and individuals who had the right to, but did not pursue higher education, confirm the above discussed results. In addition, we find a significant premium of a higher education studies, although the negative effect of some subjects might be greater than the positive effect of higher education studies, indicating again that many forms of higher education, but not all are attractive investments.

Overall, the analysis with individual data supports and largely confirms our prior findings.

6 Conclusion

In this paper we consider higher education as a private investment decision and present empirical evidence on the private monetary rate of return on this investment and its determinants both without and including the production cost of higher education.

While a large set of general studies showed that higher education yields a return above the return on alternative investments, we find with German data considerable variation in the rates of return to higher education across the different subjects and degrees, with some forms of higher education not being attractive private investments from economic point of view.

Concerning the different subjects, we confirm the overall order of subjects found by prior research for Germany with Medicine and Law, Economics and Social Studies yielding the highest private returns, followed by Mathematics and Natural Sciences and Engineering. Studies in the subjects Art and Agriculture as well as to a certain extent Languages and Cultural Studies, however, appear to be on average an unattractive investment yielding even a rate of return below long-term government bonds.

When looking at gender- and degree-specific returns to investment, we find that each gender reaches a relative return advantage in subjects where it shows a strong relative presence (e.g. men in Engineering and women in Languages and Cultural Studies or Art) indicating that the two gender choose subjects where they have a competitive advantage. Moreover, graduates from a University of Applied Sciences only yield a higher relative return in some subjects that are strongly represented at this type of institution (e.g., Engineering).

Comparing the IRR of an investment in higher education and the cost of study, we find that apart from the subject Medicine expensive subjects also yield low returns, which gives an indication of potential misallocation of public funds unless there are high other (social) returns. When taking the cost of study into account in the calculation of the RoI, the overall order of the different subgroups remains stable, but the investment case for further subjects

is no longer clearly attractive (e.g., for Engineering studies). Regression analysis with subgroup-NPV and -IRR as well as individual data largely confirms our findings.

The presented findings provide important insights in the attractiveness of different forms of higher education. Before deriving an action plan from the results, however, it is important to keep in mind that rates of return are not static and that changes in demand and supply for different forms of higher education are likely to trigger changes in the rates of return to different forms of education.

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Appendix

Appendix A: List of assumptions underlying the estimation of the RoI

- Internal rate of return and net present value calculated as the relevant decision criteria for the private investment in different forms of higher education
- Calculation of the private return on investment with and without consideration of production cost of study
- Only consideration of direct monetary effects:(foregone) income and cost of study
- High school graduates without further (post-secondary) education considered as the control group to calculate the opportunity cost of higher education
- Entry into higher education assumed to be at the age of 20 (begin of working life for control group)
- Begin of working life assumed to be at the age of 26 for University graduates and at the age of 25 for graduates from a University of Applied Sciences
- No working activity assumed while pursuing higher education and no consideration of probability of course dropouts (results conditional on finishing higher education)
- Working period considered until 55 years
- Annual expected average income for full-time workers per year of experience estimated with OLS-regression analysis for different subgroups of higher education graduates and high school graduates without further post-secondary education
    - Average net monthly income taken as dependent variable and experience as well as gender-, degree- and subject dummy variables as independent variables
    - Income classes approximated by mid-point of class
    - Slopes of income profiles invariant to subject, but differing by gender and degree

    - Labor supply decisions assumed to be exogenous in the determination of the wage
    - Results conditional on full-time work - no consideration of differences in labor force participation

- Constant annual wage growth rate g of 2% assumed to transform estimated cross-sectional experience-earnings profiles into individual wage profiles; robustness checks with different growth rates performed

- Lower limit required rate of return for investments in Human Capital assumed to be 4% (interest rate on long term government bonds); a more conservative hurdle rate including a risk premium that takes the uncertainty with regard to investments in human capital into account assumed to be 6% (discount rate in NPV calculations; see Weldi, 2006 for a more detailed discussion of an adequate discount rate for investments in human capital).

Appendix B: Cost of Study

To assess the annual cost of study per student, we use detailed cost data per subject and degree and information on the number of students in 2003 from the Higher Education Financial Statistics of the National Statistical Authority ("Hochschulfinanzstatistik des Statistischen Bundesamtes, FS 11, R 4.3.2").

Building on the methodology suggested by Luedeke and Beckmann (1998) to determine the production cost in the higher education sector, we take the net production cost for the provision of higher education from the National Statistical Authority that is calculated using the following components:

Net production cost ("Grundmittel") = wages for university personnel + upkeep of buildings + other current expenditure – assorted fees and receipts ("Verwaltungseinnahmen") – research grants ("Drittmittel").[33]

We adjust the published figures for the cost of central departments and the share of research. We follow Luedeke and Beckmann (1998) and allocate the expenses for the central departments among the different subjects proportional to the number of students in the respective subject. For the subject Medicine we exclude the cost for the central departments of university hospitals that render medical studies expensive and are not directly related to obtaining education. We further exclude research expenses that are included in the cost base, since (fundamental) research serves to a large extent public purposes and is not directly attributable to teaching, by applying the official research coefficients of the National Statistical Authority that rely on time allocation by university personnel ("Statistisches Bundesamt, FS 11, R 4.3.2"; see Hetmeier, 1998 for detailed information).

[33] In contrast to Luedeke and Beckmann we do not take into account imputed cost (e.g., depreciation).

To get the annual cost of study in 2003, we divide the total cost for the different subjects and degrees by the number of students enrolled in the winter semester.[34] We derive the following annual and total[35] cost of study per student indicated in thousands of Euro as of 2003.

Subgroups	Number of students	Annual Cost of study	Annual Cost of study per student	Total cost of study per student
*University**				
Languages/Cult. St.	435,002	1,678,325	3.9	23.1
Law/Econ./Social St.	386,502	1,148,470	3.0	17.8
Math./Natural Sciences	292,554	1,653,869	5.7	33.9
Medicine**	94 225	2,974,022	31.6	189.4
Without central dep. of hospitals	94,225	752,023	8.0	47.9
Agriculture	22,121	178,649	8.1	48.5
Engineering	134,228	793,231	5.9	35.5
Art	66,035	463,915	7.0	42.2
University of Applied Sciences				
Languages/Cult. St.	12,433	50,057	4.0	18.1
Law/Econ./Social St.	211,793	688,716	3.3	14.6
Math./Natural Sciences	64,494	242,332	3.8	16.9
Agriculture	17,031	80,888	4.7	21.4
Engineering	183,643	930,002	5.1	22.8
Art	17,933	91,999	5.1	23.1

* Including Art schools ("Kunsthochschule")
** Only human medicine including central departments of hospitals

[34] Doing so, we do not consider the cost of dropouts.

[35] Assuming an average duration of study of 6 years to obtain a University degree and 4.5 years to get a degree at a University of Applied Sciences.

Appendix C: Description of Variables

Variable	Description
Earnings Capacity Regression Analysis	
	Dependent variable
Ln mean income	Natural logarithm of the average monthly net income of full-time workers (in Euro as of March 2004)
	Independent variables
Experience	(Potential) Work experience in years
Squared Experience	Squared work experience (Exp * Exp) in years
3rd order Experience	3rd order polynomial of work experience (Exp * Exp * Exp) in years
Female	Dummy variable equal to 1 if gender is female
University	Dummy variable equal to 1 if highest degree is a University degree (Reference group: University of Applied Sciences)
Subject	
Languages/Cult. St.	Dummy variable equal to 1 if subject is Languages and Cultural Studies
Law/Econ./Social St.	Dummy variable equal to 1 if subject is Law, Econ. and Social Studies
Math./Natural Sciences	Dummy variable equal to 1 if subject is Mathematics and Natural Sciences
Medicine	Dummy variable equal to 1 if subject is Medicine
Agriculture	Dummy variable equal to 1 if subject is Agriculture
Engineering	Dummy variable equal to 1 if subject is Engineering
Art	Dummy variable equal to 1 if subject is Art
Other studies	Dummy variable equal to 1 if subject is Other studies
Interaction terms	
InterExpFemale	Interaction term for Experience and Female (Experience * Female)
InterExpsqFemale	Interaction term for Squared Experience and Female
InterExp3Female	Interaction term for 3rd order Experience and Female
InterExpUni	Interaction term for Experience and University (Experience * University)
InterExpsqUni	Interaction term Squared Experience and University
InterExp3Uni	Interaction term 3rd order Experience and University
Additional variables for RoI-/PVI-Regression Analysis	
	Dependent variables
NPV	Net Present Value of the investment in higher education (in tsd. Euro)
IRR	Internal Rate of Return of the investment in higher education (in percent)
Ln PVI	Natural logarithm of the present value of income until the age of 55 in Euro
	Independent variables
Cost	Cost of Study (in tsd. of Euro)
Interaction terms	
InterFemaleLCS	Interaction term for Female and subject Languages/Cult. St.
InterFemaleLES	Interaction term for Female and subject Law/Econ./Social St.
InterFemaleEng	Interaction term for Female and subject Engineering
InterFemaleArt	Interaction term for Female and subject Art
InterUniLCS	Interaction term for University and subject Languages/Cult. St.
InterUniAgr	Interaction term for University and subject Agriculture
InterUniEng	Interaction term for University and subject Engineering
InterUniArt	Interaction term for University and subject Art

Figures and Tables

Figure 1: Stylized Costs and Benefits from an Investment in Higher Education

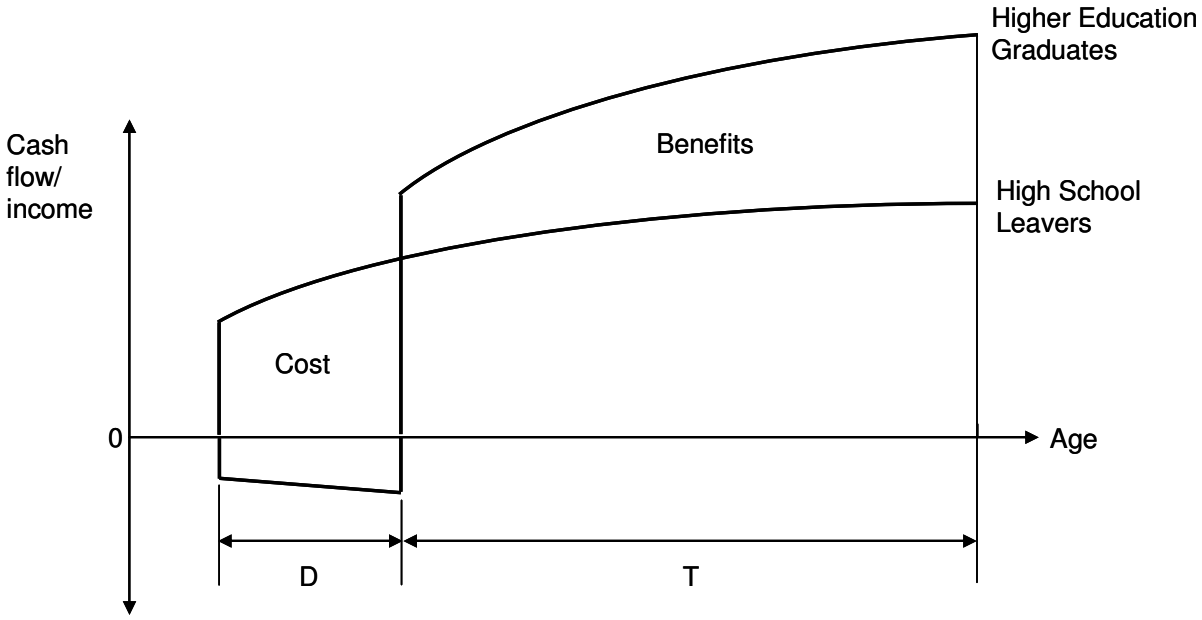
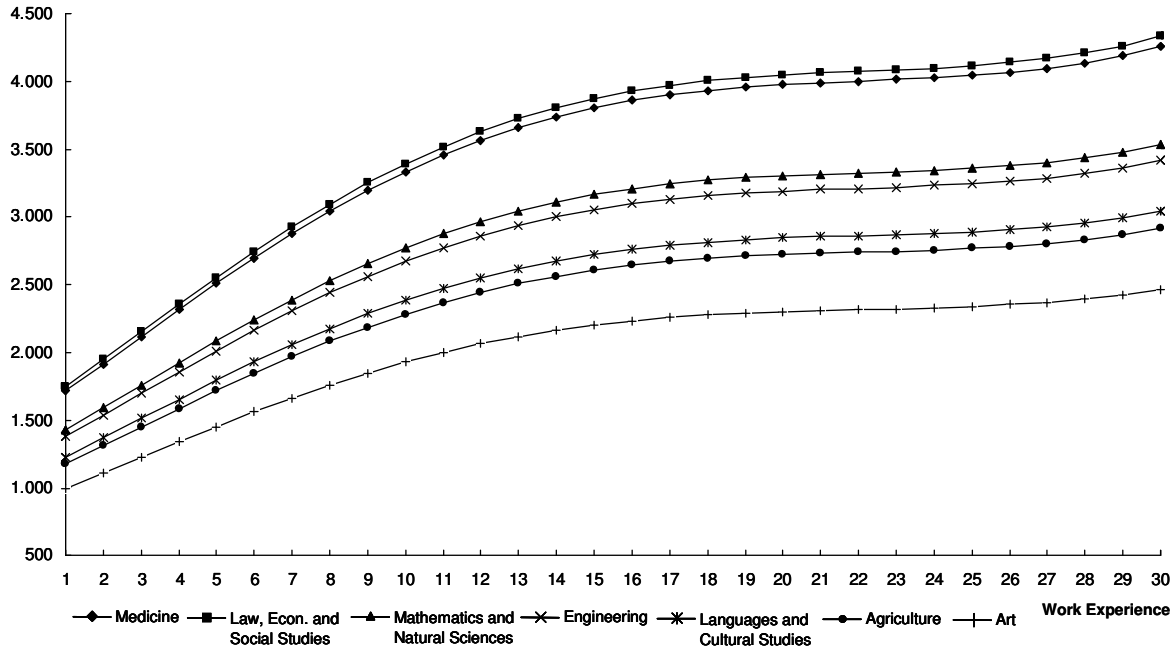
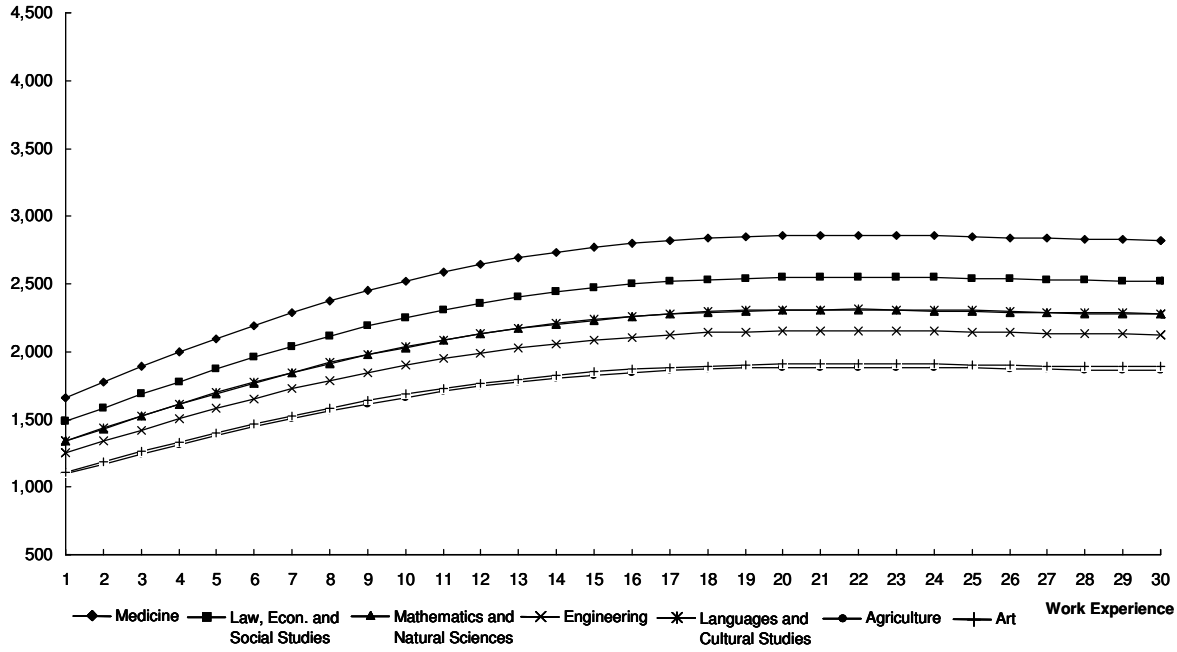


Figure 2: Experience-Income Profiles (net monthly income in Euro)

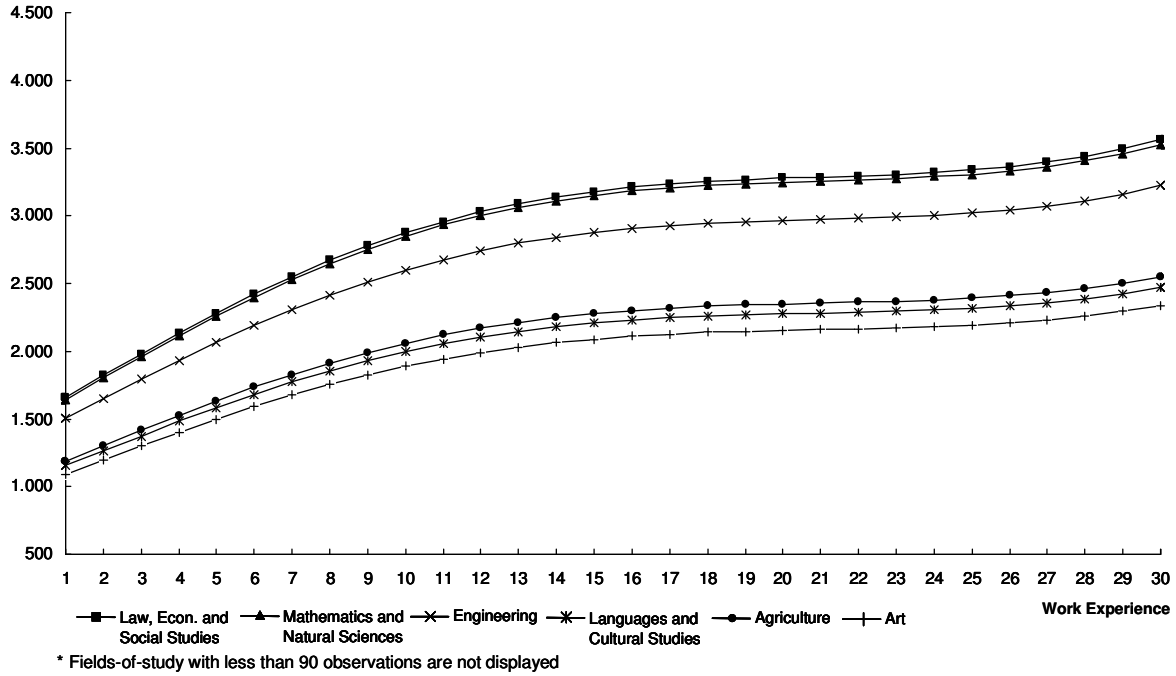
2.1 Higher Education Graduates – University, Male



2.2 Higher Education Graduates – University, Female

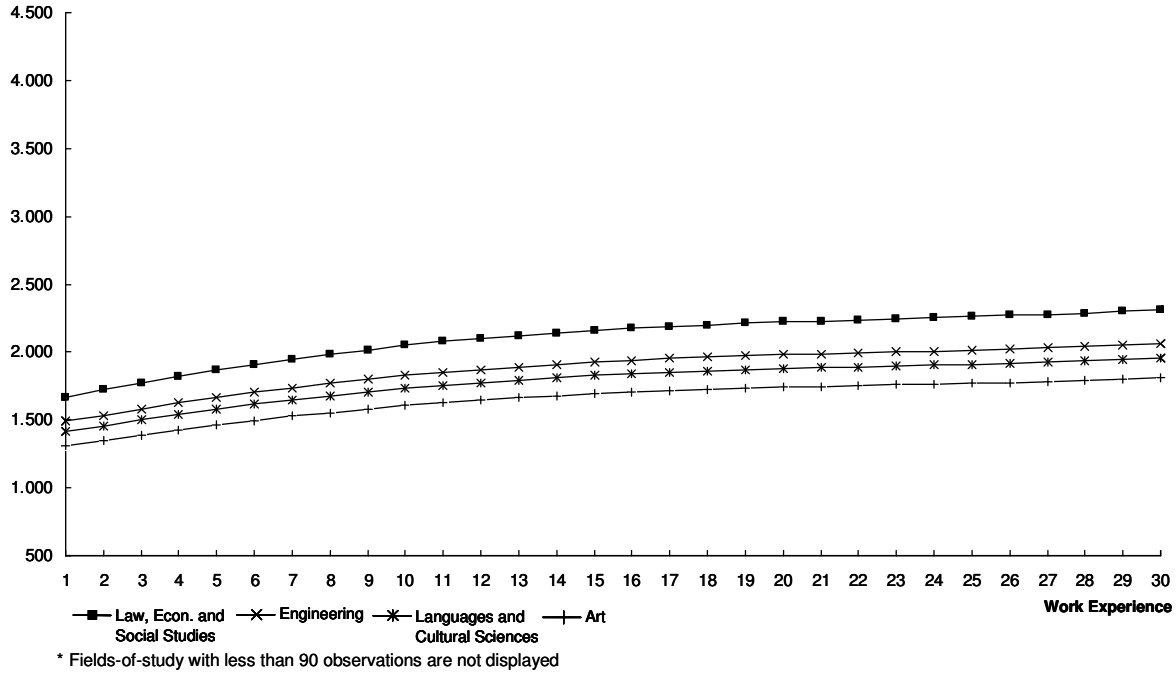


2.3 Higher Education Graduates – University of Applied Sciences, Male*



* Fields-of-study with less than 90 observations are not displayed

2.4 Higher Education Graduates – University of Applied Sciences, Female*



* Fields-of-study with less than 90 observations are not displayed

2.5 High School Graduates Without Further Post-sec. Education (Control Group)

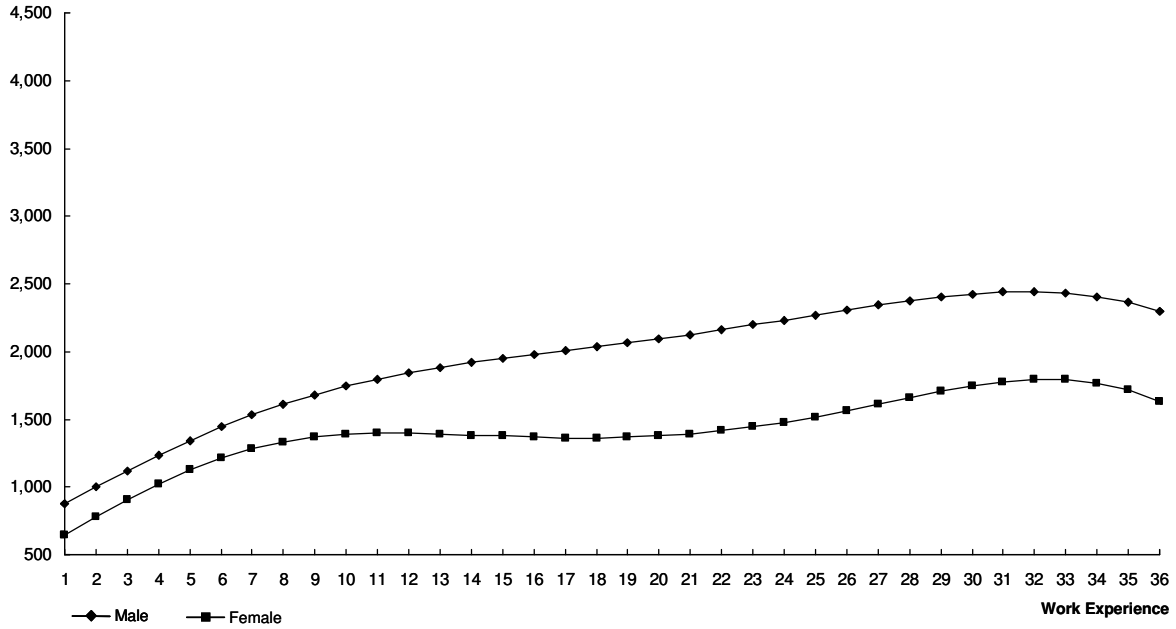
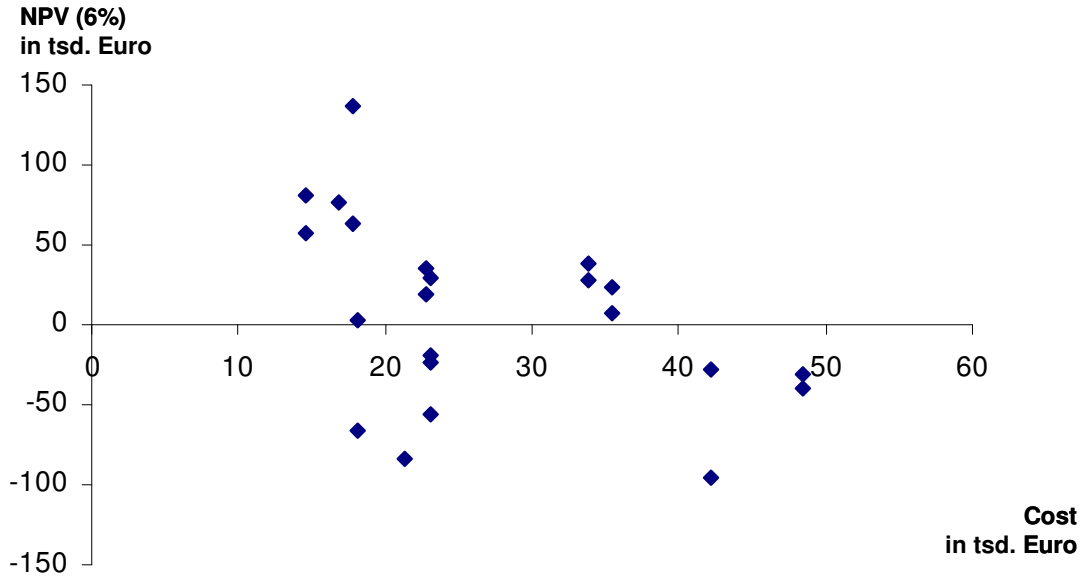
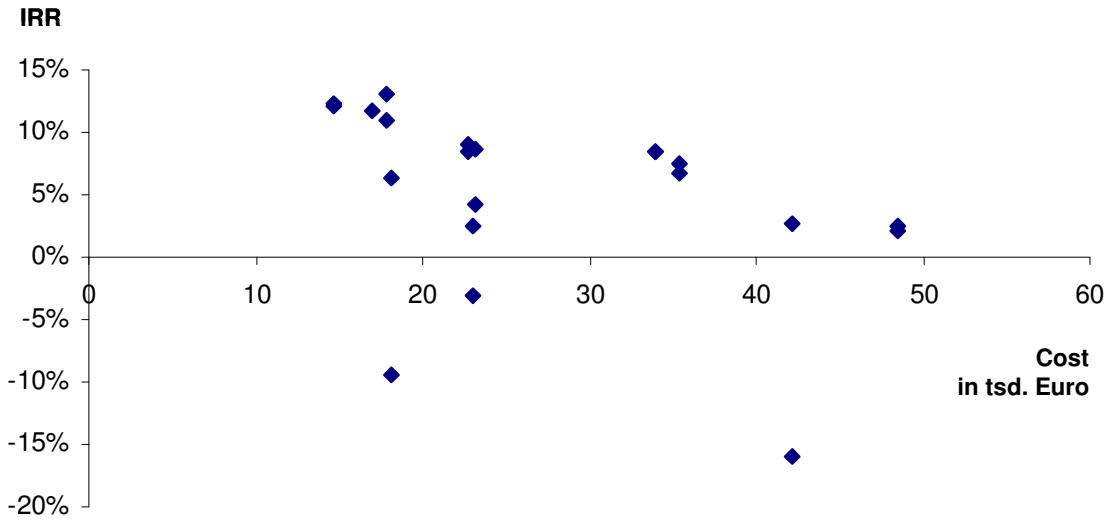


Figure 3: NPV/IRR from Investments in Higher Education compared to Cost of Study

3.1 NPV (6%) vs. Cost of Study*



3.2 IRR vs. Cost of Study*



* Without subject Medicine

Table 1
Descriptive Statistics

This table presents descriptive statistics (means and standard deviations) for the subsample of 17,180 higher education graduates working full-time (Panel A) and the control group of 1,416 high school graduates without further post-secondary education (Panel B) from the Labor Force Survey 2004.

	Panel A (N=17,180)		**Panel B (N=1,416)**		T-statistics for difference-in-mean test (A-B)
Variables	Mean	S.D.	Mean	S.D.	
Monthly Net Income	2,656	1,941	1,753	1,335	17.17***
Experience	16.31	8.16	16.67	9.38	-1.60
Female	0.34	0.47	0.32	0.47	1.33
University	0.60	0.49			
Subject					
Languages and Cult. St.	0.22	0.41			
Law/Econ./Social St.	0.25	0.43			
Math./Natural Sciences	0.09	0.28			
Medicine	0.04	0.20			
Agriculture	0.02	0.15			
Engineering	0.29	0.45			
Art	0.04	0.18			
Other studies	0.06	0.23			

Table 2
Descriptive Statistics for monthly Income of Full-time Workers

This table presents the means, standard deviations (S.D.) and number of observations of the income variable (net monthly income measured in Euro) for the relevant subsample of higher education graduates (Panel A) and the control group (Panel B) derived from the Labor Force Survey 2004. We distinguish by subject, degree and gender.

	Panel A (HE graduates)			**Panel B (Control group)**		
Subgroups	Mean	S.D.	N	Mean	S.D.	N
Total	2,656	1,941	17,180	1,753	1,335	1,416
Split by **Sex**						
Male	2,962	2,111	11,362	1,943	1,504	961
Female	2,059	1,374	5,818	1,353	729	455
Difference	*903****			*590****		
Split by **Degree**						
University	2,714	2,074	10,279			
University of Applied Sciences	2,571	1,721	6,901			
Difference	*143****					
Split by **Subject**						
Languages and Cult. St.	2,316***	1,068	3,713			
Law/Econ./Social St.	3,012***	2,555	4,335			
Math./Natural Sciences	2,761**	1,988	1,519			
Medicine	3,318***	2,590	708			
Agriculture	2,118***	1,481	410			
Engineering	2,724***	1,762	4,921			
Art	1,969***	1,435	607			
Other studies	2,034***	1,411	967			

*** Difference-in-mean-test indicates statistical difference at 0 to 1 % level

Table 3
Final Results from Income-Regression Analysis

This table reports coefficient estimates from OLS regressions relating the natural logarithm of average net monthly income (dependent variable) to subject, degree and gender variables (independent variables). It shows regressions on Panel A (Higher Education Graduates) and Panel B (High School Graduates without further post-secondary education as the Control Group). Standard errors (reported in parentheses) are heteroscedasticity-robust. For a detailed description of the variables see Appendix C.

	Dependent variable: Natural logarithm of monthly mean net income in Euro					
	Higher Education Graduates (Panel A)					
		Subgroup regressions				
Variables	**Full regression**	**University, Male**	**University, Female**	**Univ. of Appl. Science, Male**	**Univ. of Appl. Science, Female**	**Control Group (Panel B)**
Constant	7.129***	6.993***	7.132***	6.948***	7.218***	6.629***
	(0.012)	(0.014)	(0.014)	(0.018)	(0.019)	(0.016)
Experience	0.104***	0.125***	0.074***	0.107***	0.036***	0.161***
	(0.003)	(0.003)	(0.004)	(0.003)	(0.005)	(0.010)
Squared Experience	-0.005***	-0.006***	-0.003***	-0.005***	-0.001***	-0.011***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
3rd order Experience	0.000***	0.000***	0.000***	0.000***	0.000**	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
4th order Experience						0.000***
						(0.000)
Law/Econ./Social St.	0.226***	0.353***	0.099***	0.365***	0.168***	
	(0.003)	(0.003)	(0.005)	(0.015)	(0.008)	
Math./Natural Sciences	0.108***	0.150***	-0.003	0.355***	0.158***	
	(0.005)	(0.004)	(0.011)	(0.018)	(0.042)	
Medicine	0.270***	0.335***	0.213***	0.423***	0.166	
	(0.010)	(0.011)	(0.016)	(0.150)	(0.125)	
Agriculture	-0.181***	-0.044**	-0.203***	-0.055**	-0.298***	
	(0.014)	(0.022)	(0.034)	(0.022)	(0.043)	
Engineering	0.077***	0.115***	-0.070***	0.264***	0.053***	
	(0.004)	(0.004)	(0.013)	(0.014)	(0.012)	
Art	-0.177***	-0.212***	-0.190***	0.031	-0.076**	
	(0.012)	(0.016)	(0.021)	(0.030)	(0.033)	
Female	0.040***					-0.386***
	(0.015)					(0.023)
InterExpFemale	-0.060***					0.086***
	(0.004)					(0.014)
InterExpsqFemale	0.003***					-0.011***
	(0.000)					(0.002)
InterExp3Female	0.000***					0.000***
	(0.000)					(0.000)
University	-0.079***					
	(0.014)					
InterExpUni	0.024***					
	(0.003)					
InterExpsqUni	-0.001***					
	(0.000)					
InterExp3Uni	0.000*					
	(0.000)					
N cells	922	238	237	219	228	72
N weights	17,180	6,351	3,928	5,011	1,890	1,416
Prob > F	0	0	0	0	0	0
Adjusted R^2	75.7%	78.3%	55.5%	71.9%	33.8%	83.4%

*** Significant at 0 to 1 percent level, ** Significant at 1 to 5 percent level, * Significant at 5 to 10 percent level, others: Significant at above 10 percent level; Languages and Cult. St. is the omitted subject; coefficient for Other studies not displayed

Table 4
IRR and NPV from Investment in Higher Education

This table presents the Internal Rate of Return (IRR) and the Net Present Value (NPV) associated with private investments in different forms of higher education assuming full-time work. We differentiate by gender, degree and subject and present calculations without and including higher education production cost. For a detailed description of the underlying assumptions see Appendix A.

in thousand Euro, percent	Without Cost of Study (Only Opportunity Cost)			Including Cost of Study (Opportunity Cost and Cost of Study)		
Subgroups	NPV* (6%)	NPV* (4%)	IRR	NPV* (6%)	NPV* (4%)	IRR
University, Male						
Languages/Cult. St.	-23.1	2.7	4.2%	-44.0	-19.5	3.0%
Law/Econ./Social St.	137.2	242.8	13.2%	121.1	225.7	11.6%
Math./Natural Sciences	38.1	94.5	8.4%	7.6	61.8	6.4%
Medicine	127.7	228.6	12.8%	84.5	182.5	9.4%
Agriculture	-39.5	-21.7	2.6%	-83.1	-68.4	0.6%
Engineering	23.0	71.8	7.5%	-9.0	37.7	5.5%
Art	-95.6	-105.8	-16.0%	-133.6	-146.4	-16.3%
University, Female						
Languages/Cult. St.	28.8	68.7	8.6%	7.9	46.4	6.6%
Law/Econ./Social St.	62.6	118.8	11.0%	46.6	101.7	9.2%
Math./Natural Sciences	27.9	67.4	8.5%	-2.7	34.8	5.8%
Medicine	105.9	182.8	13.6%	62.8	136.7	9.2%
Agriculture	-31.0	-19.7	2.1%	-74.7	-66.3	-0.6%
Engineering	6.9	36.4	6.7%	-25.0	2.3	4.1%
Art	-27.4	-14.3	2.7%	-65.3	-54.9	0.2%
*University of Applied Sciences, Male***						
Languages/Cult. St.	-66.2	-70.3	-9.4%	-82.7	-87.8	-9.9%
Law/Econ./Social St.	81.6	147.3	12.1%	68.3	133.2	10.5%
Math./Natural Sciences	77.0	140.5	11.8%	61.6	124.3	10.0%
Agriculture	-84.3	-96.9	N/A	-103.8	-117.5	N/A
Engineering	35.4	79.3	9.0%	14.6	57.4	7.0%
Art	-55.5	-54.6	-3.0%	-76.6	-76.8	-4.1%
*University of Applied Sciences, Female***						
Languages/Cult. St.	2.5	21.1	6.4%	-14.0	3.7	4.3%
Law/Econ./Social St.	57.1	100.2	12.4%	43.7	86.1	10.1%
Engineering	18.7	44.6	8.5%	-2.1	22.7	5.8%
Art	-19.4	-10.6	2.5%	-40.4	-32.8	0.3%

* At the age of 20 (entry into higher education; begin of working life for control group)

** Subgroups with less than 90 observations are not displayed

Table 5

Results from NPV-/IRR-Regression Analysis

This table reports coefficient estimates from OLS regressions relating the NPV and IRR of the different forms of higher education presented in Table 4 as dependent variables to gender, subject, degree and cost variables (independent variables). Standard errors (reported in parentheses) are heteroscedasticity-robust. The NPV figures are calculated with a discount rate of 6%. Regressions including the cost variable do not consider the subject Medicine.

	Dependent variable: Net Present Value, in thousand Euro				***Dependent variable: Internal Rate of Return***			
	NPV-Regressions				**IRR-Regressions**			
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(1)**	**(2)**	**(3)**	**(4)**
Constant	79.13***	90.94***	72.03**	97.62***	0.099***	0.125***	0.107**	0.137**
	(21.49)	(17.13)	(31.24)	(31.49)	(0.022)	(0.013)	(0.044)	(0.046)
Female	5.63	-21.36		-19.90	0.040*	0.066*		0.077*
	(13.58)	(13.05)		(14.38)	(0.022)	(0.033)		(0.040)
University	5.36	8.73		18.33	0.006	0.002		0.016
	(15.35)	(11.88)		(23.02)	(0.026)	(0.025)		(0.043)
Languages/Cult. St.	-99.14***	-139.97***		-135.93***	-0.097**	-0.135***		-0.135***
	(28.68)	(24.73)		(21.81)	(0.039)	(0.044)		(0.043)
Math./Natural Sc.	-36.90	-41.96*		-34.28	-0.020	-0.053		-0.045
	(29.43)	(23.00)		(26.89)	(0.030)	(0.033)		(0.051)
Medicine	29.49	27.80			0.008	-0.028		
	(27.39)	(18.03)			(0.026)	(0.033)		
Agriculture	-136.17***	-141.23***		-125.14**	-0.134***	-0.166***		-0.146
	(26.59)	(27.61)		(56.00)	(0.040)	(0.045)		(0.099)
Engineering	-63.62**	-63.62***		-53.93*	-0.042*	-0.043***		-0.029
	(22.58)	(16.49)		(25.41)	(0.023)	(0.009)		(0.051)
Art	-134.09***	-170.87***		-157.82***	-0.156***	-0.194***		-0.180**
	(27.56)	(29.83)		(37.05)	(0.043)	(0.047)		(0.063)
InterFemaleLCS		81.67***		80.21***				
		(22.65)		(21.08)				
InterFemaleLES						-0.075**		-0.086*
						(0.034)		(0.042)
InterFemaleEng						-0.073*		-0.084*
						(0.035)		(0.042)
InterFemaleArt		73.56**		72.10**				
		(28.03)		(27.00)				
Cost			-2.39**	-0.75			-0.002	-0.001
			(0.88)	(1.94)			(0.001)	(0.004)
N	24	24	22	22	24	24	22	22
Prob > F	0	0	0.014	0	0.006	0	0.146	0
Adj. R^2	74.0%	85.1%	16.1%	79.3%	52.4%	53.9%	5.3%	48.4%

*** Significant at 0 to 1 percent level, ** Significant at 1 to 5 percent level, * Significant at 5 to 10 percent level, others: Significant at above 10 percent level; Law, Economics and Social Studies is the omitted subject and University of Applied Sciences the omitted degree variable.

Table 6a

Results from PVI-Regression Analysis with individual data for Higher Education Graduates

This table reports coefficient estimates from OLS regressions relating the natural logarithm of the Present Value of Income at the age of 25 for higher education graduates as dependent variable to gender, degree, subject and cost variables (independent variables). Standard errors (in parentheses) are heteroscedasticity-robust. The PVI figures are calculated applying a discount rate of 6%.

	Dependent variable: Ln Present Value of Income					
	PVI without Cost of Study			**PVI including Cost of Study**		
Variables	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Constant	13.193***	13.202***	13.234***	13.180***	13.175***	13.256***
	(0.010)	(0.011)	(0.020)	(0.010)	(0.012)	(0.022)
Female	-0.290***	-0.317***	-0.290***	-0.316***	-0.344***	-0.315***
	(0.009)	(0.013)	(0.009)	(0.010)	(0.015)	(0.010)
University	0.003	0.002	0.036**	-0.031***	-0.009	0.037**
	(0.009)	(0.013)	(0.017)	(0.010)	(0.015)	(0.018)
Languages/Cult. St.	-0.148***	-0.298***	-0.136***	-0.159***	-0.319***	-0.137***
	(0.012)	(0.024)	(0.012)	(0.013)	(0.026)	(0.014)
Math./Natural Sciences	-0.080***	-0.082***	-0.037*	-0.113***	-0.119***	-0.033
	(0.015)	(0.015)	(0.022)	(0.016)	(0.017)	(0.025)
Medicine	0.065***	0.068***	0.168***	0.009	0.002	0.201***
	(0.024)	(0.024)	(0.047)	(0.027)	(0.028)	(0.053)
Agriculture	-0.345***	-0.419***	-0.274***	-0.439***	-0.436***	-0.302***
	(0.027)	(0.039)	(0.040)	(0.032)	(0.032)	(0.045)
Engineering	-0.122***	-0.104***	-0.074***	-0.168***	-0.131***	-0.077***
	(0.011)	(0.014)	(0.022)	(0.012)	(0.015)	(0.024)
Art	-0.379***	-0.441***	-0.310***	-0.464***	-0.435***	-0.335***
	(0.026)	(0.033)	(0.037)	(0.029)	(0.054)	(0.042)
Cost			-0.000**			-0.000***
			(0.000)			(0.000)
Interaction Terms:						
InterFemaleLCS		0.120***			0.129***	
		(0.019)			(0.022)	
InterFemaleEng		-0.064**			-0.078**	
		(0.027)			(0.031)	
InterFemaleArt		0.148***			0.120**	
		(0.050)			(0.058)	
InterUniLCS		0.099***			0.098***	
		(0.025)			(0.027)	
InterUniAgr		0.146***				
		(0.053)				
InterUniEng		-0.039**			-0.073***	
		(0.020)			(0.023)	
InterabsArt					-0.122**	
					(0.060)	
N	17,180	17,180	16,181	16,175	16,175	16,175
Prob > F	0	0	0	0	0	0
Adjusted R^2	10.9%	11.4%	10.2%	10.3%	10.8%	10.4%

*** Significant at 0 to 1 percent level, ** Significant at 1 to 5 percent level, * Significant at 5 to 10 percent level, others: Significant at above 10 percent level; Law, Economics and Social St. is the omitted subject and University of Applied Sciences the omitted degree; coefficient for Other studies not displayed

Table 6b

Results from PVI-Regression Analysis with individual data for the Sample of High School and Higher Education Graduates

This table reports coefficient estimates from OLS regressions relating the natural logarithm of the Present Value of Income at the age of 20 for higher education graduates and the group of high school graduates who had the opportunity to but did not pursue higher education as dependent variable to gender, higher education studies, degree and subject variables (independent variables). Standard errors (reported in parentheses) are heteroscedasticity-robust. The PVI figures are calculated applying a discount rate of 6%.

	Dependent variable: Ln Present Value of Income			
	PVI without Cost of Study		**PVI including Cost of Study**	
Variables	**(1)**	**(2)**	**(1)**	**(2)**
Constant	12.770***	12.777***	12.780***	12.785***
	(0.015)	(0.016)	(0.015)	(0.016)
Female	-0.286***	-0.308***	-0.316***	-0.332***
	(0.009)	(0.012)	(0.010)	(0.014)
Higher Education	0.228***	0.228***	0.199***	0.194***
	(0.018)	(0.018)	(0.018)	(0.019)
University	0.004	0.003	-0.035***	-0.025*
	(0.009)	(0.013)	(0.010)	(0.015)
Languages/Cult. St.	-0.150***	-0.298***	-0.166***	-0.330***
	(0.012)	(0.024)	(0.013)	(0.027)
Math./Natural Sciences	-0.080***	-0.082***	-0.119***	-0.122***
	(0.015)	(0.015)	(0.017)	(0.017)
Medicine	0.063***	0.065***	-0.013	-0.016
	(0.024)	(0.024)	(0.028)	(0.029)
Agriculture	-0.350***	-0.423***	-0.472***	-0.470***
	(0.027)	(0.039)	(0.034)	(0.034)
Engineering	-0.124***	-0.104***	-0.177***	-0.143***
	(0.011)	(0.014)	(0.012)	(0.015)
Art	-0.380***	-0.441***	-0.495***	-0.539***
	(0.026)	(0.033)	(0.031)	(0.037)
Interaction Terms:				
InterFemaleLCS		0.113***		0.115***
		(0.019)		(0.022)
InterFemaleEng		-0.071***		-0.107***
		(0.026)		(0.032)
InterFemaleArt		0.142***		0.101*
		(0.050)		(0.061)
InterUniLCS		0.099***		0.111***
		(0.025)		(0.028)
InterUniAgr		0.143***		
		(0.053)		
InterUniEng		-0.040**		-0.058**
		(0.020)		(0.023)
N	18,596	18,596	17,586	17,586
Prob > F	0	0	0	0
Adjusted R^2	10.6%	11.0%	10.1%	10.5%

*** Significant at 0 to 1 percent level, ** Significant at 1 to 5 percent level, * Significant at 5 to 10 percent level, others: Significant at above 10 percent level; Law, Economics and Social Studies is the omitted subject and University of Applied Sciences the omitted degree; coefficient for Other studies not displayed