Gender Gap Developments in Tertiary Education

- A cross-country time-series analysis on European level

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“*An investment in knowledge pays the best interest.*”

Benjamin Franklin

Abstract

During recent decades, a reversal of the gender gap in tertiary enrollment and a subsequent growing gap in favor of women could be observed in most industrialized countries. This dissertation shows developments of the female-male gender gap in tertiary educational enrollment and analyzes factors behind the widening female-male gap with time-series data on European level. The analysis is based on a model of educational investment, which suggests that gender differences in benefits and costs of tertiary education help to explain gender gaps in tertiary educational investment. Using a first difference model to ensure stationarity, we find that only gender differences in cognitive and non-cognitive skills, as measured by PISA scores in levels and standard deviations, significantly correlate with the gender gap in tertiary educational enrollment. We further find significant differences across time and country subgroup. Whether levels or the dispersion of cognitive and non-cognitive skills have explanatory power varies with country subregions and with the type of the PISA score used (Math or Reading).

Resumo

Recentemente, na maioria dos países industrializados, verifica-se uma inversão da diferença de genéro nas matrículas no ensino superior e, subsequentemente, um crescimento da diferença em favor das mulheres. Esta tese expõe tendências recentes das diferenças de género mulher-homem no acesso ao ensino superior. Analisa ainda os factores que levam ao aumento das diferenças de género com dados de séries temporais de países europeus. A análise é baseada no modelo básico de investimento educativo que sugere que diferenças de género em benefícios e custos do ensino superior podem ajudar a explicar a evolução no investimento feito no ensino superior. Para garantir estacionaridade, usamos um modelo em primeiras diferenças e concluímos que apenas as diferenças em competências cognitivas e não-cognitivas, medidas pelas classificações de leitura do PISA (níveis ou dispersão), se correlacionam significativamente com as diferenças de género no número de matrículas no ensino superior. Este resultado varia com o tempo e subgrupo de países. O poder explanatório dos níveis ou da dispersão de competências cognitivas e não-cognitivas varia consoante as sub-regiões dos países e a classificação das disciplinas do teste PISA.

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1 Introduction

During recent decades, higher educational attainment grew rapidly in developed countries. Becker, Hubbard, and Murphy (2010) argue that a large part of this growth is caused by an increase in higher educational attainment of women. While more men than women used to be enrolled in and graduate from tertiary education decades ago, a stronger increase in educational attainment of women during recent decades led to convergence of female and male attainment patterns in most industrialized countries (Heath and Jayachandran, 2016). Data, disaggregated by gender, shows that educational attainment in industrialized countries did not only converge to relatively equal levels across genders, but female attainment continued to increase faster than male attainment. This allowed women to overtake men with respect to tertiary educational attainment and led to a positive and increasing female-male gender gap in higher educational attainment.

Authors such as Vincent-Lancrin (2008) argue that changing gender norms and tear-downs of societal restrictions for women can help to explain why women caught up with men in tertiary educational attainment. These factors, however, unlikely explain why women nowadays invest more in tertiary education than men do (Vincent-Lancrin, 2008).

The identification of factors behind the widening of the gap in favor of women, however, is of great interest as changing educational gender patterns are expected to bring along important consequences for labor markets and societies: A positive and increasing female-male gender gap in tertiary educational attainment is expected to alter the skill composition in labor markets, which ultimately leads to a higher female share among advantaged high skilled workers and a higher male share among disadvantaged low skilled workers (Pekkarinen, 2012). The author argues that these developments are of particular interest in current times, in which the importance of educational investments for labor market outcomes increases significantly.

Since most industrialized countries experience similar developments in female-male gender gaps in tertiary education, it is interesting to analyze these developments on a cross-country level. So far, there is little literature available which assesses the factors behind current developments in higher education qualitatively and quantitatively on a cross-country time-series level. Most existing literature follows either a descriptive approach or focuses its empirical analysis only on specific countries, such as Canada or the United States. Therefore, the aim of this dissertation is first, to shed light on developments of the female-male gender gap in tertiary educational attainment in industrialized countries. Second, to outline empirically correlations of the gender gap with other socioeconomic developments.

Since individual investment decisions in education can be explained theoretically by a standard model of investment in tertiary education, in which individuals make investment decisions based on a cost-benefit analysis of tertiary education, we use this model as a starting point for the analysis of gender gaps in educational attainment patterns in tertiary education. Thus, this dissertation will be based on an approach of Becker, Hubbard and Murphy (2010) who use the model of educational investment to analyze gender differences in tertiary educational attainment for the United States. Even though their model is a model of individual decision making, it will be adapted to aggregated country-level data.

The dissertation seeks to answer the following questions:

- Are gender differences in costs and benefits of tertiary education correlated with gender differences in tertiary educational attainment in industrialized countries on aggregated level?
- Are there differences in correlations between country subgroups and over time sub-periods?

The study is based on a sample of the period 2003-2014 and 18 European countries consisting of the Nordic countries: Norway, Sweden, Denmark and Finland; the Western European countries: The Netherlands, Belgium, France, Ireland and Great Britain; the Southern European countries: Portugal, Spain, Greece and Italy and the Eastern European countries: Poland, Czech Republic, Hungary, Slovenia and Slovakia. All countries show a relatively high level of homogeneity and face similar gender gap developments over time. The empirical analysis uses a model in first differences including time, year and GDP per capita as a country-year effect.

We do not intend to identify causalities, but rather correlations to make first indications about factors that accompany gender gap developments in tertiary education across countries. Hence, our findings can be used as first insights and a teaser for future research, but should not be used for policy recommendations. To better understand what lies behind each country's behavior, specific country and richer data is desirable, which allows for a richer exploitation of correlations and causalities with respect to the model of individual investment in tertiary education.

The reminder of this dissertation is structured as follows: The next chapter gives a brief literature review. Chapter 3 shows educational attainment patterns over time for selected European countries. In chapter 4, the basic model of educational investment as developed by Becker, Hubbard, and Murphy (2010) is being presented on which the empirical analysis is based on. Chapter 5 describes the data sources and variables used for the empirical analysis. Chapter 6 outlines the econometric model and shows the results obtained from regressions. In chapter 7, potential shortcomings are discussed, suggestions for future research made and conclusions drawn.

2 Literature Review

Most existing literature on gender developments in tertiary education focuses either on single countries, such as the United States or Canada, or outlines potential factors behind developments of gender patterns over time only qualitatively, but does not analyze them empirically. Thereby, authors often state that the catching up of women with men and their overtaking of men are not necessarily driven by the same factors (Vincent-Lancrin, 2008). Vincent-Lancrin (2008) looks at gender inequalities in higher education for OECD countries. The author concludes that the reversal of gender differences in tertiary educational participation and graduation rates is already well established across OECD countries. Only on doctoral level and in the science field does male participation still exceed female participation. According to the author, factors which could help to explain growing gaps in favor of women are potentially higher returns to tertiary education, higher professional aspiration of women, better non-cognitive skills of women as well as the feminization of the teaching profession and an increase in "female" courses during the educational expansion process.

A cross-country study which focuses more on the increasing gender gap in favor of women was conducted by Pekkarinen (2012). The author puts emphasis on a comparison between Nordic countries and the United States and uses a standard economic model of educational investment, in which investment decisions depend on the costs and benefits of tertiary education, as a starting point for his analysis. The author concludes that increasing female-male gender gaps in education result from decreasing career restrictions for women in combination with higher returns to education for both genders and lower effort costs for women. The latter ones are caused by higher non-cognitive skills of women. Hence, following the author, there is a higher increase in net benefits of education for women than for men.

Becker, Hubbard, and Murphy (2010) present a model where the distribution of costs and benefits of higher education across individuals determines the supply of college graduates in the market. The authors apply their analysis to US data only and, contrary to Pekkarinen (2012), do not find significant gender differences in the benefits of education. They show, in contrast, that gender differences in the distribution of non-cognitive skills lead to a higher elasticity of supply to college for women. This, in turn, allows female attainment to surpass male attainment even if changes in higher educational benefits are similar across the genders.

Another study for the Unites States by Jacob (2002), which is based on longitudinal data, focuses on gender differences in average levels of financial returns to schooling and non-cognitive skills. The author shows that male students have lower grades and more advanced behavioral problems than female students. Jacob (2002) hence concludes that gender differences in non-cognitive skills, together with gender differences in returns to higher education, explain close to 90 percent of the female-male gender gap in higher educational attainment.

Goldin, Katz, and Kuziemko (2006) confirm for the United States, that changing social norms, increased gender equality and changing expectations about the role of work, marriage and family planning allowed women to make better use of increasing educational and labor market benefits and hence incentivized them to increase their educational investment. Since these developments, as the authors argue, were accompanied by pronounced behavioral problems and slower social development of young men, women overtook men with respect to college attainment.

Again, for the United States, Buchmann and DiPrete (2006) examine whether the growing female-male gender gap with respect to college completion can be explained by either a gender-egalitarian hypothesis or by a gender-role hypothesis. The former assumes that higher average educational levels of parents are significantly correlated with educational gender gaps in favor of women whereas the latter one states that changes in education or employment of mothers could have a greater impact on daughters than on sons and hence lead to trends in educational attainment in the detriment of men. Nevertheless, the authors do not find evidence for any of the two hypotheses, but conclude instead that the recently growing female-male gender gap was caused by a decrease in attainment of young men whose fathers were absent or low-educated. In addition, the authors confirm that better female behavior and performance allowed women to overtake men regardless of family backgrounds.

Buchmann, DiPrete, and McDaniel (2008) also present gender gaps for the United States and divide potential factors behind the differences in individual-level factors, such as family resources, academic achievements and returns to college and institutional factors, such as gender role attitudes, labor market factors, educational institutions and military service. Nevertheless, the authors do not analyze these factors empirically.

Christofides, Hoy, and Yang (2010) estimate gender differences in university participation rates for Canada by a linear probability and a logit model. The authors confirm the existence of a rising female-male enrollment gender gap in higher educational attainment. Using decomposition methods, they identify that gender gaps can be explained entirely by differences in variables, of which the university premium accounts for approximately 80%. Furthermore, the authors conclude that higher levels of college participation of both sexes are significantly correlated with changes in social norms, the university premium, tuition fees, real income and parent's education.

Another single country analysis was conducted by Riphahn and Schwientek (2015) for Germany. The authors use a binary outcome model to estimate whether individual, labor market, institutional or demographic characteristics as well as changing norms can help to explain gender gaps in graduation from upper secondary school, entry to tertiary and completion of tertiary education. For gender gaps in tertiary education, the authors conclude that neither labor market factors nor family backgrounds help to explain developments over time.

In contrast, decreasing class sizes as well as changes in social norms are said to positively influence female-male gender gaps in tertiary education.

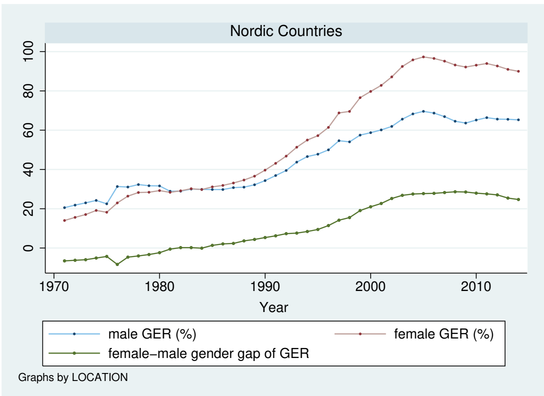
3 Developments in Tertiary Educational Attainment

In this dissertation, educational attainment will be measured by the gross enrollment ratio (GER) for which data is available dis-aggregated by gender for a sufficiently long period and a cross section of countries. The was taken from the UNESCO Institute for Statistics where it is described as a measure of "total enrollment in tertiary education (ISCED 5 to 8), regardless of age, expressed as a percentage of the total population of the five-year age group following on from secondary school leaving". In other words, the GER is used to measure enrollment of students in school or university in comparison to the number of students who qualify for the particular grade level. It hence allows to show how enrollment increased over time, but also the difference in enrollment patterns between the sexes. The gross enrollment ratio includes over-age and under-age students and therefore often takes on relatively high values which can exceed 100%. This makes it a somewhat noisy measure of educational attainment. Nevertheless, as this dissertation focuses on gender differences rather than on absolute values of educational attainment, the GER is considered an adequate measure of educational attainment in the framework of this dissertation.

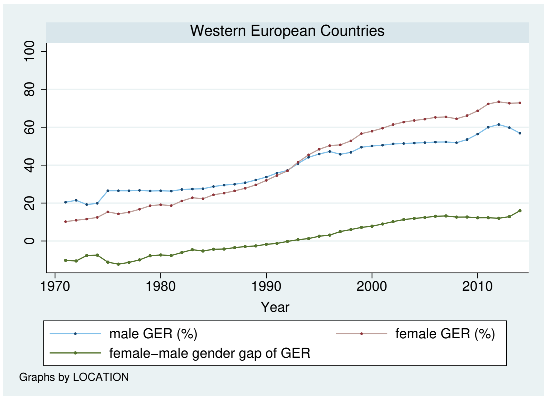
Figure 3.1 shows developments of female and male gross enrollment ratios for regional country groups (for a table with enrollment numbers by gender and their change from decade to decade see table A.1 in the appendix). It becomes apparent that different country groups started off with different gross enrollment ratios in 1975 for both genders, with Nordic countries showing the highest ratios and Eastern European the lowest. Over time, enrollment of both sexes increased significantly, but female enrollment increased more rapidly than male enrollment:

Whereas in 1975, average gross enrollment was still significantly higher among men than among women, already 20 years later, in 1995, the reverse was the case in all country groups under observation. Over time, the female GER continued to grow faster which led to an increase in the female-male gender difference of gross enrollment ratios.

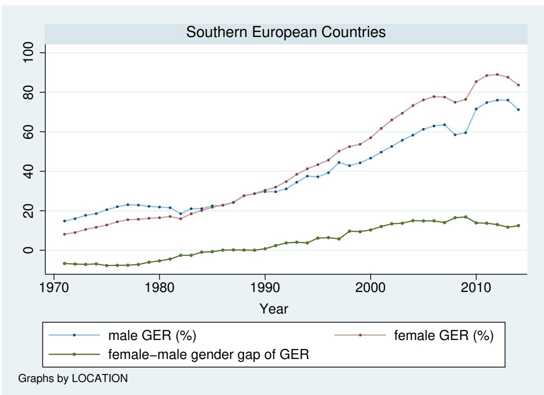
Nevertheless, during the most recent decade, a change in patterns can be observed: First, the average female and male increase in enrollment ratios slowed down in all country groups and turned even negative in Nordic ones. This indicates that the countries under observation have already seen their strongest increase in tertiary educational expansion - at least for now. Second, in some country groups, this slowed down increase was more advanced for women than for men. This translates into a decreasing trend of the female-male gender gap in most recent years.



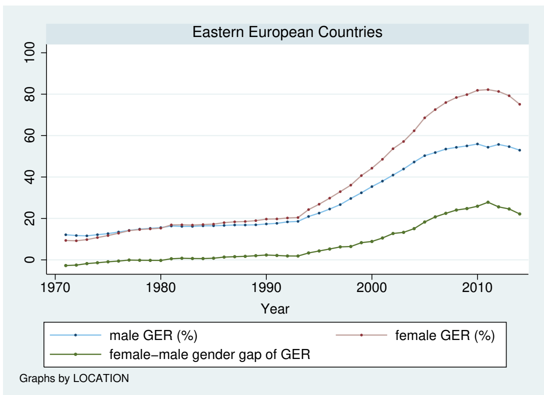
(a) Nordic Countries



(b) Western European Countries



(c) Southern European Countries



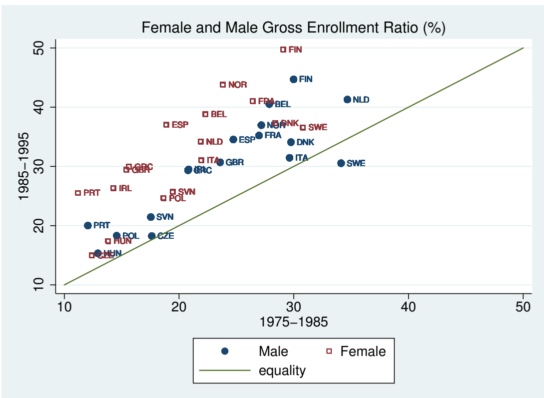
(d) Eastern European Countries

Figure 3.1: Gross Enrollment in Tertiary Education Over Time

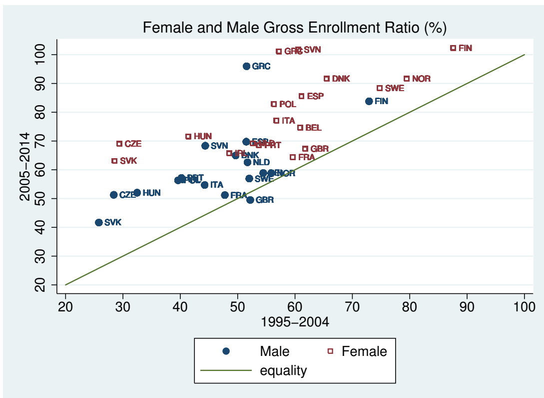
From figure 3.1 we hence can summarize the following:

1. Enrollment of men and women increased over time
2. female enrollment increased faster than male enrollment, leading to a reversal of the enrollment gender gap
3. the increase in enrollment of men and women as well as of the female-male gender gap slowed down in most recent years

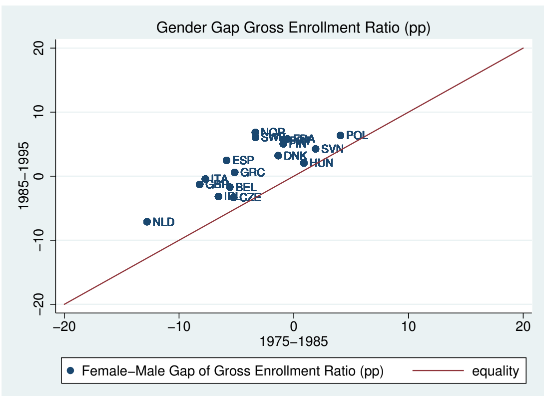
Let's now take a closer look at developments by country. To do so, decade averages are plotted against each other for the decades 1975-1985 vs. 1985-1995 and 1995-2004 vs. 2005-2014 respectively (figure 3.2). This allows to determine increases or decreases of enrollment ratios and the development of the female-male gender gap over time on a more country specific level.



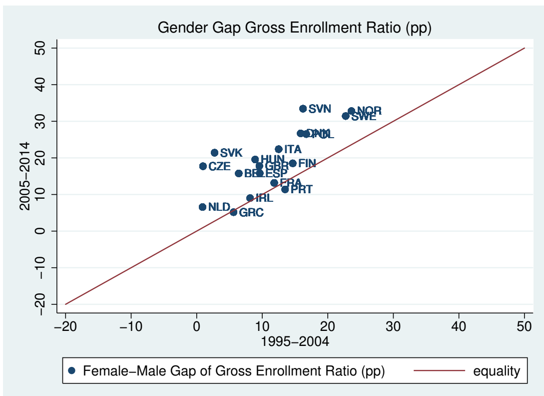
(a) male and female 1975-1995 vs. 1985-1995



(b) male and female 1995-2004 vs. 2005-2014



(c) gender gap 1975-1995 vs 1985-1995



(d) gender gap 1995-2004 vs 2005-2014

Figure 3.2: Gross Enrollment in Tertiary Education Decade to Decade

Figure 3.2 (a) shows that average female as well as average male enrollment ratios were lower in the 1975-1985 than in the 1985-1995 period in all countries. One exception is Sweden in which average male enrollment decreased between the two decades while average female enrollment increased. A similar statement can be made for more recent decades (figure 3.2 (b)): Average enrollment of men and women, respectively, increased between the two decades, with the exception being Great Britain for which average male enrollment decreased. The graphs further show that female and male enrollment was more equally distributed in earlier decades (a) than in more recent ones (b) and show that female enrollment increased faster than male enrollment in all countries.

Figure 3.2 (c) and (d), which show the gender gap of enrollment ratios, confirm these findings: While the decade averages of the female-male gender gap during the 1975-1985 period are still negative for most countries, and hence, male enrollment ratios exceeded female ones, they are positive during the 1985-1995 period for more than half of the countries. Hence, for most countries, a gender gap reversal had taken place between the two decades. Overall, the gender gap developed in favor of women in all countries under observation: Figure 3.2 (d) shows that the previously observed negative female-male gap had turned into a positive one in all countries. Again, in almost all countries the average of the female-male gender gap in the 1995-2004 period was lower than in the 2005-2014 period which indicates an increase in the female-male gender gap. The exceptions are Greece and Portugal where the average decade gap started to develop backwards again between 1995-2004 and 2005-2014.

A faster increase for women than for men and an increasing female-male gender gap can also be found for the share with tertiary degree among the 25-29 year old population as another measure of tertiary educational attainment (see figure A.1 in the appendix). The labor force participation rate of the 25-64-year-old population, however, shows that women did not yet fully catch up or overtake men with respect to labor market factors (see figure A.2 in the appendix).

4 Theoretical Considerations

After having shown that the female-male gender gap of tertiary educational enrollment increased significantly over time, we present the model of educational investment in tertiary education by Becker, Hubbard and Murphy (2010) on which the empirical analysis will be based on. The equations presented in the following were one-to-one taken from the author's paper.

4.1 Individual Decision Framework by Becker at al. (2010)

In the standard model of investment in education, rational individuals make their investment decisions in education based on a cost benefit analysis. Individuals with secondary degree only pursue further education, if benefits exceed costs or in other words if the net benefits are positive. Based on this model, Becker, Hubbard, and Murphy (2010) argue that gender differences in the marginal costs and benefits of tertiary education could help to explain why women caught up and surpassed men with respect to tertiary educational attainment.

The authors develop a model of investment in tertiary education in which they define the production of optimal investment as follows:

$$S_i = F(h, H, A_c, A_n) \tag{4.1}$$

where H_i = initial human capital level; h = time spent in tertiary education; A_{ci} = cognitive skills; A_{ni} = non-cognitive skills. The first derivatives of F(.) with respect to any of the input factors are positive, allowing for S to increase in all the inputs. At the optimal level of h, $F_{hh} < 0$: The higher forgone earnings the higher the cost of h. $F_{hH}, F_{hA_c}, F_{hA_n} > 0$ holds: high skilled students (greater A_c and/or A_n) need less time to produce the same S than low skilled students. The same holds for students with higher initial stock of human capital (higher H).

Individuals invest in period 1 and reap educational benefits in period 2. Hence, optimal investment in tertiary education is chosen by maximizing discounted expected utility:

$$V = U_1(x_1, l; H) + p(S; H)\beta U_2(x_2, l_2, S; H) \tag{4.2}$$

subject to a budget constraint such that expected discounted consumption equals expected discounted income:

$$W = x_1 + \frac{px_2}{1+r} + w_1 l_1 + \frac{p(S,H)w_2 l_2}{1+r} + T(h) + w_1 h = w_1 + \frac{p(S,H)w_2}{1+r} + \frac{p(S,H)M(S)}{1+r} \tag{4.3}$$

Borrowing and lending takes place at rate r. β = discount rate; p(S;H) = probability of surviving until period 2; x = consumption of goods; l = household time; W = full wealth (expected); w = earnings per hour; T = tuition and other fees; $w_1 h$ = foregone earnings and p(S)M(S) = gain from marriage (expected). p depends positively on H and S, reflecting the positive impact of education on health and specifically on chances of survival. U(.) is increasing in x,l,S and the total time in each period equals 1. The first derivatives of w_2 as well as M with respect to S are both greater than 0, reflecting the positive impact higher levels of education have on post-educational earnings and the higher gain from marriage for individuals with higher levels of education, respectively. Taking derivatives with respect to x_1, x_2, l_1 and l_2 and h ultimately leads to:

$$\underbrace{\frac{p_S U_2}{U_{2x}(1+r)}}_{\substack{\text{expected effect}\\ \text{of higher}\\ \text{survival prospects}}} + \underbrace{\frac{p\beta U_{2S}}{U_{1x}}}_{\substack{\text{expected effect}\\ \text{from future}\\ \text{consumption}}} + \underbrace{\frac{p_S M + pM_S}{1+r}}_{\substack{\text{expected effect of}\\ \text{marriage benefits}}}$$

$$+ \underbrace{\frac{p_S(w_2e_2 - x_2)}{1+r}}_{\substack{\text{expected effect}\\ \text{of higher}\\ \text{survival probab. if}\\ \text{if future earnings >}\\ \text{future consumption}}} + \underbrace{\frac{pw_{2S}e_2}{1+r}}_{\substack{\text{expected effect}\\ \text{of financial}\\ \text{returns to}\\ \text{tertiary education}}} = \underbrace{\frac{w_1 + T_h}{F_h}}_{\substack{\text{marginal cost}\\ \text{of additional unit}\\ \text{of tertiary education}}} \tag{4.4}$$

(The derivations with respect to x_1, x_2, l_1, l_2 can be found in the appendix).

Since this dissertation seeks to identify similarities across industrialized countries, data aggregated on country level is used. The model, however, is a model of individual decision making and is therefore more adequate for individual level data. To analyze correlations between gender gaps in tertiary enrollment and gender gaps in costs and benefits with aggregated data, we adjust the model and depart from it whenever necessary.

Equation 4.4 shows that optimal investment in schooling depends on benefits and costs of additional education, which can be grouped as follows:

Table 4.1: Costs and Benefits of Tertiary Education as in Becker, Hubbard, and Murphy (2010)

Benefits	**Costs**
LABOR MARKET BENEFITS: financial returns	DIRECT COSTS: tuition fees
MARRIAGE MARKET BENEFITS: propensity to marry and stay married	
HEALTH BENEFITS: higher survival prospects	INDIRECT COSTS: foregone earnings and time spent at university (cognitive and non-cognitive skills)[1]
HOUSEHOLD PRODUCTION BENEFITS: effect of parent's education on children's education	

We base the selection of explanatory variables on these five categories. We will not include tuition fees in our empirical analysis due to lack of data availability and based on the argumentation that tuition fees do not vary by gender and hence are unlikely to explain part of the gender gap's variation in tertiary education (Becker, Hubbard, and Murphy, 2010). Furthermore, in most countries of our sample, tuition fees are non-existent or negligible and did not change significantly during most recent decades.

4.1.1 Other Considerations

Table 4.1 shows the costs and benefits of tertiary education as considered by Becker, Hubbard and Murphy (2010). Besides, we consider two other factors important for our analysis which could help to explain gender gap developments in tertiary educational attainment: labor market expectations and expectations about family planning.

Becker, Hubbard, and Murphy (2010) do not include labor market expectations in their analysis due to potential endogeneity problems. However, other authors, such as Goldin, Katz, and Kuziemko (2006),Vincent-Lancrin (2008) or Pekkarinen (2012) consider labor market expectations an important factor for investment decisions in tertiary education and gender gap developments. Better labor market prospects increase the value of educational benefits, especially in times of increased demand for high-skilled workers and increased financial returns to educational investment (Pekkarinen, 2012). Goldin, Katz, and Kuziemko (2006) find for the US, that higher expectations of employment in the future worked as an incentive for women to invest in college education. Hence, similar developments on cross-country level could help to explain gender gap developments in tertiary education

In addition to labor market expectations, a vast amount of literature considers changes in family norms and gender restrictions as potential explanations for the catching up of women. A decrease in discrimination of women, the possibility to postpone family planning and better possibilities to combine family with professional life allow for higher female investments in tertiary education (Pekkarinen, 2012, Vincent-Lancrin, 2008). Even though such developments are more likely to be correlated with catching up of women, switching importance from family planning to career planning could help to explain why women nowadays invest more in education: if women expect to spend less time raising kids and more for work, they can better reap the benefits of education.

5 Data Sampling and Variable Definition

5.1 Outcome Variable

We measure educational attainment as outcome variable by the Gross Enrollment Ratio in Tertiary Education (GER) which had already been presented in chapter 3. The GER is dis-aggregated by gender and data is available across countries and years which allows for the construction of a cross-section time-series dataset on aggregated level. Gender differences in educational attainment are calculated by subtracting male from female GERs by country and year respectively.

5.2 Explanatory Variables

We include the following variables as explanatory variables.

1. **Labor Markets:**

   Gender Gap in Labor Force Participation Rate: We measure labor market expectations by the labor force participation rate of the population aged 25-64. Ideally, we would use the gender gap of a variable which measures the difference in labor force participation rates of the population with tertiary degree vs. secondary degree. However, due to lack of data, the labor force participation rate is used independently from educational degree.

   Gender Gap in Earnings Premium (in logs): The financial return to tertiary education is measured by the difference in the median equivalized income of the population aged 18-64 with tertiary degree versus the median equivalized income of the population aged 18-64 with secondary degree, for men and women respectively.

2. **Health/Longevity:**

   Gender Gap in Life Expectancy at Birth: We measure survival prospects by the life expectancy at birth dis-aggregated by gender. It would be ideal to use life expectancy dis-aggregated also by educational level to measure the "health premium" of tertiary education. However, due to data restrictions, we rely on life expectancy at birth dis-aggregated by gender only.

3. **Marriage Markets:**

   Crude Divorce Rate: Following the model by Becker, Hubbard and Murphy (2010) we would like to have data on marriage or divorce rates dis-aggregated by gender and educational level of individuals to perfectly capture gender differences in the "marriage market premium" of tertiary education. However, due to the aggregated structure of our data, we cannot capture marriage market benefits as in the model. We thus depart from the model and measure marriage market factors by the overall crude divorce rate based on Pekkarinen (2012), who argues that increasing divorce rates act as an incentive for women to be financially independent and hence to invest more in tertiary education.

4. **"Household Production" Factors:**

   Population Share With Tertiary Education of Parent's Age Cohort: To measure the effect of parent's education on their son's or daughter's education on aggregate level, we proxy parent's education by the total share of the population aged 45 to 59 with tertiary degree.

   Fertility Rates (in logs): We use fertility rates to reflect changes in the importance of family planning and women's possibility to devote time to education and labor markets instead of family.

5. <u>**Costs of Education:**</u>

   Gender Gap in Foregone Earnings (in logs): We measure foregone earnings by average annual income of the population with secondary education.

   Gender Gap in Cognitive and Non-Cognitive Skills: We use average PISA reading scores as well as their dispersion (standard deviation) to measure cognitive and non-cognitive skills. Instead, math scores or an average of math and reading scores could be used. However, gender differences are most advanced in reading scores and gender gaps in math and reading scores are highly positively correlated across countries and years as Pekkarinen (2012) argues[1] and figure A.3 in the appendix shows[2].

5.3 Summary Statistics

Table 5.1 shows the summary statistics for the baseline sample (2003-2014, 18 countries). Variables are lagged due to potential endogeneity issues and to make them capture the year in which now-enrolled students made their educational investment decisions (see chapter 6 for a more detailed explanation). Summary statistics for regional country subgroups can be found in table A.3 in the appendix.

The average gender gap of the gross enrollment ratio with 18.6 percentage points is positive and hence in favor of women. A positive average gender gap can also be found for life expectancy at birth and PISA scores: Women, on average, live almost seven years longer than men and score 39.5 points higher in PISA reading exams. The average gender gap of labor force participation, foregone earnings and the "earnings premium" of tertiary education, on the contrary, are still negative and to the detriment of women. Table A.3 in the appendix

[1]Pekkarinen (2012) finds that in countries where the gender gap in reading was high in favor of women, the gender gap in mathematics was close to zero or very low in favor of men.

[2]Nevertheless, in a robustness check we will run a regression also with PISA math scores and the average of math and reading PISA scores to identify differences and similarities with respect to PISA reading scores.

Table 5.1: Summary Statistics in Levels

Variable	Mean	Std. Dev.	Min.	Max.	N
Gender Gap of GER_t	18.658	8.954	-1.304	44.24	216
Gender Gap of Log Enrollment Numbers, age 20-24 (in thousands)$_t$	0.223	0.099	0.021	0.471	216
Gender Gap of Labor Force Participation (age 25-64)$_{t-3}$	-15.402	7.114	-33.075	-3.91	216
Gender Gap of Life Expectancy at Birth_{t-22}	6.989	1.004	5	9.26	216
Crude Divorce Rate_{t-3}	2.022	0.709	0.6	3.8	216
Log Fertility Rate_{t-3}	0.444	0.171	0.131	0.728	216
Population Share With Tertiary Education (Parent's Generation: age 45-59)$_t$	22.202	7.890	7.549	41.291	216
Gender Gap in PISA Reading Score_t	39.466	9.354	21	66.17	216
Gender Gap in Std.Dev. of PISA Reading Score_t	-9.431	3.802	-24.057	-0.483	216
Gender Gap in PISA Math Score_t	-9.82	5.585	-22	6.657	216
Gender Gap in Std.Dev. of PISA Math Score_t	-5.796	3.171	-13.91	1.57	216
Gender Gap in PISA Score_t	14.823	6.890	0.655	36.413	216
Gender Gap in Std.Dev. of PISA Score_t	-15.227	6.566	-37.967	0.733	216
Gender Gap of Log Foregone Earnings_{t-3}	-0.053	0.038	-0.237	0.02	126
Gender Gap of Log Rate of Return_{t-3}	-0.003	0.048	-0.112	0.139	126
Log Male Population Numbers, age 20-24 (in thousands)$_t$	6.01	0.995	4.051	7.692	216
Log Female Population Numbers, age 20-24 (in thousands)$_t$	5.975	1.001	3.994	7.666	216
Female-Male Ratio of Log Population Numbers age 20-24 (in thousands)$_t$	0.994	0.004	0.976	1.009	216
Log GDP per capita_{t-3}	10.408	0.294	9.627	11.026	216

The gender gap always refers to female-male values. PISA scores refer to the average of math and reading scores when not explicitly called math or reading scores.

shows differences between country subgroups: the average GER gender gap, for example, is highest in Nordic countries and lowest in Western European ones. Similarly, the mean gender gap in PISA reading scores is highest among Nordic and lowest among Western European countries.

Data was collected from different online databases. A table with the source by variable can be found in A.2 in the appendix. Countries were selected based on two criteria: by limiting the country sample to European OECD countries, only relatively homogeneous countries were selected to make sure that all countries experienced a faster increase in female than in male enrollment and a widening of the gender gap in favor of women. Second, some countries had to be dropped from the sample due to lack of data availability. Data availability also determined the time dimension of the sample. The baseline sample therefore covers 18 countries and the period 2003-2014[3]. Another concern with respect to data were missing values. To avoid a high loss of information due to list-wise deletion, we used linear interpolation to deal with missing values. Nevertheless, countries for

[3]Countries included: The Nordic countries Denmark, Finland, Sweden and Norway; the Western European countries Belgium, France, the Netherlands, Ireland and Great Britain; the Southern European countries Spain, Greece, Italy and Portugal as well as the Eastern European Countries Czech Republic, Poland, Hungary, Slovenia and Slovakia.

which too many values were missing consecutively or for which data was not available for earlier years could not be added to the sample.

Scatter plots which show correlations between the dependent and the explanatory variables can be found in figures A.4 - A.12 in the appendix for pooled as well as a country and time demeaned data.

6 Empirical Analysis

6.1 Methodology

We want to estimate the effect of gender differences in labor market factors, health factors, marriage market factors, household production factors and costs of tertiary education on the gender gap in gross enrollment ratios with the following level-specification:

$$Y_{i,t} = \alpha_i + \underbrace{\beta_1 X1_{i,t-3} + \beta_2 X2_{i,t-3}}_{\text{labor market factors}} + \underbrace{\beta_3 X3_{i,t-3}}_{\substack{\text{marriage market}\\\text{factor}}} + \underbrace{\beta_4 X4_{i,t-22}}_{\text{health factor}} + \underbrace{\beta_5 X5_{i,t-3} + \beta_6 X6_{i,t-3}}_{\substack{\text{household production}\\\text{factors}}} + \underbrace{\beta_7 X7_{i,t-3} + \beta_8 X8_{i,t-3}}_{\text{cost factors}} + \delta_t + \zeta_{i,t} + \varepsilon_{i,t} \quad (6.1)$$

Where $Y_{i,t}$ is the female-male gender gap of gross enrollment ratios in tertiary education. Where $X1_{i,t-3}$ is the gender gap in labor force participation rates, $X2_{i,t-3}$ is the gender gap in the "earnings premium" to tertiary education (in logs), $X3_{i,t-3}$ is the crude divorce rate, $X4_{i,t-22}$ is the gender gap in life expectancy at birth, $X5_{i,t-3}$ is the fertility rate (in logs), $X6_{i,t-3}$ is the populationshare with tertiary degree of the parent's generation. $X7_{i,t-3}$ is the gender gap of foregone earnings (in logs) and $X8_{i,t-3}$ is the gender gap in PISA reading scores. In addition, α_i are country fixed effects, δ_t time fixed effects, and $\zeta_{i,t}$ is GDP per capita (in logs) as a country-year effect. X_{t-3} indicates that variable X is lagged by 3 years or 22 years in case of X_{t-22}.

The combination of time-series and cross-section dimensions of our data brings along an important set of advantages over simple cross-section or simple-time series data: First, it increases the number of observations and thereby allows to infer model parameters more accurately due to higher sample variability and more degrees of freedom. Second, it allows to better control for the effects of unobserved heterogeneity (Cameron and Trivedi, 2005). Equation 6.1 can be estimated efficiently and consistently using OLS, only if stationarity can be assured and if the covariance of the errors meets the Gauss-Markov assumptions. When this is not the case, OLS estimation reports inaccurate standard errors which cause inefficient and inconsistent estimates (Beck, 2008). Violation of these assumptions can result from the data's time-series dimension or from its cross-sectional dimension:

Endogeneity

One violation of the Gauss-Markov assumptions are error terms which are correlated with the dependent variable. A possible cause for this violation is endogeneity from reverse causality. If endogeneity is present, estimates are likely to be biased and inconsistent. Variables such as fertility and labor force participation, for instance, can suffer from reverse causality with respect to enrollment in tertiary education. We expect fertility rates at time t to influence enrollment in tertiary education at time t, however, also enrollment at time t is expected to affect fertility rates at time t. The same line of argumentation can be made for other explanatory variables such as labor force participation rates. A common and easy-to-implement approach to address reverse causality is the use of lagged explanatory variables. While for instance, enrollment in t affects fertility rates in t and t+x, enrollment in t does not affect fertility rates in t-x. In this dissertation, most explanatory variables are therefore lagged by three years. The number of three was chosen to simultaneously make the variables capture values of approximately the year in which the now enrolled students had made their investment decisions.

Non-Stationarity

An important assumption for the analysis of time series is stationarity (absence of unit roots). To check for stationarity of our variables, we apply the Im, Pesaran and Shin test which tests for unit roots in panel data. In contrast to other panel unit root tests, the IPS test allows for heterogeneous panels making it the best fit for our data. Following table A.6 in the appendix, we cannot reject the existence of unit roots for all variables. Hence, not all variables are stationary. Ignoring the existence of unit roots leads to wrong inference and to spurious regression results, unless the non-stationary variables cointegrate. We therefore also test for a cointegration relationship using the residual based Pedroni cointegration test. The test results are presented in table A.7 in the appendix. We cannot confirm the existence of a cointegration relationship between the non-stationary variables and conclude that a regression in levels leads not only to wrong inference, but also to spurious estimates. To render non-stationary variables stationary, we first difference the variables. We want to avoid regressions with some variables in levels and others in first differences and therefore apply first-differencing to all the variables of our level specification (equation 6.1).

Autocorrelation

Another issue related to cross-section time-series data is the increased likelihood of time dependencies leading to incorrect standard errors. Such time dependencies occur when values of a unit in one period depend on its values of another (close by) period. Conventional panel data models, however, assume that $Cov(\varepsilon_{i,t}, \varepsilon_{i,s}) = 0$ for $t \neq s$. Hence, if correlation over time is present, standard errors will not be correct. We test for autocorrelation in using the Wooldrige test for panel autocorrelation (Wooldridge, 2002). The test shows presence of autocorrelation in our level specification, but not when variables in first differences are used.

Heteroskedasticity

If heteroskedasticity is present, standard errors should be corrected for to ensure validity of the estimates (Hoechle, 2007). We test for panel level heteroskedasticity with a likelihood ratio test. With a large test statistic and a p-value close to zero, the test confirms the presence of heteroskedasticity. Hence we adjust for heteroskedasticity of the error terms.

Cross-Sectional Dependence

Cross-sectional correlation is likely to be present between countries which are economically close to each other and are affected by common shocks (Sarafidis, Yamagata, and Robertson, 2009). Since our sample consists of European countries, cross-sectional correlation cannot be ruled out. One approach to account for cross-sectional correlation is the inclusion of time dummies or cross-sectional demeaning of the data which allows for the elimination of common shocks (unit-invariant but time-variant) (Sarafidis, Yamagata, and Robertson, 2009). We model unobserved heterogeneity across time by including time fixed effects (δ_t) in our specification 6.1. However, time dummies can only account for cross-sectional correlations which are equal for every pair of cross-sectional units. If cross-sectional dependence varies across units, the inclusion of time dummies will not be sufficient. Therefore, we adjust standard errors using Driscoll-Kraay standard errors which simultaneously also account for heteroskedasticity and autocorrelation.

Heterogeneity

Besides common shocks, there may be factors which vary across countries, but not across time. To account for such unobserved heterogeneity, we include country fixed effects in specification 6.1. Nevertheless, since we must estimate equation 6.1 with variables in first differences instead of levels, we already account for unobserved heterogeneity across countries even when country fixed effects are not explicitly included in the specification or when the model is not estimated by a fixed effects model[1]. Adding country fixed effects to a model in first differences equals the introduction of country specific trends which are common across time periods.

[1] Including country dummies is equal to estimating the specification with a fixed effects model

Due to lack of stationary and non-cointegrating variables, an estimation of the level-specification shown in equation 6.1 leads to inconsistent and spurious regression results. We hence must estimate a first-difference-specification instead.

The final specification to be estimated looks as follows:

$$\Delta Y_{i,t} = \alpha_i + \underbrace{\gamma_1 \Delta X_{1_{i,t-3}} + \gamma_2 \Delta X_{2_{i,t-3}}}_{\text{labor market factors}} + \underbrace{\gamma_3 \Delta X_{3_{i,t-3}}}_{\substack{\text{marriage market}\\ \text{factor}}} + \underbrace{\gamma_4 \Delta X_{4_{i,t-22}}}_{\text{health factor}} + \underbrace{\gamma_5 \Delta X_{5_{i,t-3}} + \gamma_6 \Delta X_{6_{i,t-3}}}_{\substack{\text{household production}\\ \text{factors}}} + \underbrace{\gamma_7 \Delta X_{7_{i,t-3}} + \gamma_8 \Delta X_{8_{i,t-3}}}_{\text{cost factors}} + \delta_t + \eta_{i,t} + \varepsilon_{i,t} \quad (6.2)$$

Where Δ stands for the first differences of the labor market, marriage market, health, household production and cost variables of specification 6.1. α_i are country fixed effects, δ_t time fixed effects, and $\eta_{i,t}$ is the growth rate of GDP per capita (in logs) as a country-year effect. X_{t-3} indicates that variable X is lagged by 3 years or 22 years in case of X_{t-22}.

6.2 Results

Since data on income by gender and educational level, is only available starting in 2008, while Pisa scores by gender are comprehensively available only from 2003, we run our baseline regression for the period 2003-2014, excluding foregone earnings and the "earnings premium" of tertiary education from our model. These variables will later be added in a robustness regression based on a smaller sample. Our baseline sample hence consists of N=18 countries and T=12 years which leads to N=216 as overall number of observations. Among the 18 countries are the Nordic countries: Norway, Sweden, Denmark and Finland; the Western European countries: The Netherlands, Belgium, France, Ireland and Great Britain; the Southern European countries: Portugal, Spain, Greece and Italy and the Eastern European countries: Poland, Czech Republic, Hungary, Slovenia and Slovakia. Summary statistics of all variables in first differences for the pooled country sample and regional subgroups can be found in tables A.4 and A.5 in the appendix.

6.2.1 Baseline Regression

Table 6.1 shows different specifications of our baseline regression. In column (1) a pooled regression is presented to which year dummies are added in column (2). In column (3) we additionally add country fixed effects and in column (4) the growth rate of GDP per capita as a country-year effect. Since authors such as Becker, Hubbard, and Murphy (2010) state that the dispersion of cognitive and non-cognitive skills across genders rather than their average levels plays a role in explaining gender gaps in tertiary educational attainment, we also add the female-male gap of the standard deviation of PISA reading scores to our regression (see column (5)).

Table 6.1 shows that the R^2 of the pooled regression without year and country fixed effects (column (1)) is relatively low: only 10.4% of the variation in the change of the gender gap in tertiary enrollment can be explained by the explanatory variables in first differences (see column (1) of table 6.1). When country and year fixed effects are added, R^2 increases to 25.5% (within R^2), where the main increase comes from the addition of year dummies (compare columns (1), (2) and (3)). This allows for the conclusion that common time shocks among countries play their part in explaining the change in the gender gap of gross enrollment in tertiary education. Adding country fixed effects, increases the share only slightly (column (2) to (3)). This is reasonable since a regression in first differences already accounts for time-invariant country fixed effects. Hence, additionally adding country fixed effects allows to account for unobserved country trend effects which do not play a big role in explaining the gender gap in tertiary educational enrollment[2]. In regression (4) we additionally include the growth rate of GDP per capita in the regression. We include growth of GDP per capita as a country-year effect to model unobserved effects which vary across years and countries. Column (4) and (5) show that the growth rate of GDP per capita is indeed significant. This indicates that country-year specific factors play a part in explaining the gender gap in tertiary enrollment.

[2]Conclusions with respect to R^2, however, need to be made with care. Since we are looking at R^2 instead of the adjusted R^2, adding variables (here in form of year dummies) will increase the R^2 - no matter whether these variables have explanatory power. However, based on a F-test for joint significance of the year dummies, we can conclude that they are jointly significant and hence have explanatory power.

Table 6.1: Baseline Regression (T=12; N=18)

Dependent Variable: ΔGender Gap of GER	(1) OLS	(2) OLS	(3) OLS	(4) OLS-Baseline	(5) OLS
Δ Gender Gap of	-0.389*	-0.413*	-0.334	-0.271	-0.274
Labor Force Participation (age 25-64)$_{t-3}$	(0.148)	(0.171)	(0.172)	(0.182)	(0.181)
Δ Gender Gap of	0.276	0.143	-0.372	-0.665	-0.668
Life Expectancy at Birth$_{t-22}$	(0.717)	(0.708)	(0.694)	(0.869)	(0.879)
Δ Crude Divorce Rate$_{t-3}$	0.0370	-0.628	-0.904	-1.050	-1.067
	(0.565)	(0.779)	(0.551)	(0.596)	(0.654)
Δ Log Fertility Rate$_{t-3}$	10.84	8.752	8.441	9.133	9.267
	(6.002)	(8.061)	(6.144)	(6.606)	(7.007)
Δ Population Share With Tertiary Education	-0.119	-0.160	-0.0899	-0.0814	-0.0810
(Parent's Generation: age 45-59)$_t$	(0.135)	(0.105)	(0.0961)	(0.0924)	(0.0918)
Δ Gender Gap of	0.184***	0.0991**	0.177***	0.161***	0.154**
PISA Reading Score$_t$	(0.0189)	(0.0292)	(0.0327)	(0.0334)	(0.0383)
Δ Gender Gap of					-0.0297
s.d. of PISA Reading Score$_t$					(0.141)
Year Fixed Effects	no	yes	yes	yes	yes
Country Fixed Effects	no	no	yes	yes	yes
Δ Log GDP per capita$_t$				22.27**	22.54**
				(5.270)	(5.402)
_cons	0.336	0.989***	0.870***	0.431	0.428
	(0.234)	(0.201)	(0.187)	(0.212)	(0.217)
N	216	216	216	216	216
R^2	0.104	0.223	0.255	0.300	0.300

Driscoll-Kraay standard errors in parentheses.

For column (3), (4) and (5) the within R2 is presented.

Gender Gap always refers to the female-male gap.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Having shown that year fixed effects and country-year effects have explanatory power, we now analyze the estimated relationships between the explanatory variables and the dependent variable for our baseline regression (column (4)). We thereby put more focus on significance and direction of correlation and less on expressing the impact of explanatory variables on the dependent variables in specific numbers.

Our baseline regression (column (4)) shows a negative correlation between changes in the gender gap of labor force participation and the GER. An insignificant negative correlation can also be found with respect to the change in life expectancy at birth. This equals the findings of Becker, Hubbard, and Murphy (2010) who argue that gender differences in the benefits of education, including gender differences in health benefits, are unlikely to explain differences in tertiary enrollment. Our baseline regression further shows a negative correlation between the change in the divorce rate and the change in the female-male gender gap of the GER, as well as a positive correlation of the change in the fertility rate with the change in the female-male gender gap of the GER. The former one indicates the opposite of Pekkarinen (2008)'s argumentation that higher divorce rates act as an incentive for women to be financially independent and hence to invest more in tertiary education. However, it must be kept in mind, that the author argued in terms of levels, not changes of divorce rates. Nevertheless, neither changes in divorce rates, nor changes in fertility rates have explanatory power. The only significant variable is the change in the gender gap of PISA reading scores which proves to be positively correlated with the change in the gender gap of enrollment ratios: A one standard deviation increase in the change of the gender gap in PISA reading scores on average leads to an increase of approximately 0.33 percentage points in the change of the gender gap of the GER.

When adding the standard deviation of PISA reading scores to the baseline regression (column (5)) no major changes can be observed. The coefficient of the PISA score variable in levels stays positively significant and decreases only slightly in its absolute size. Furthermore, the change in the gender gap of the standard deviation of PISA reading scores carries a negative sign, but is not significant. Hence, gender differences in the average level of PISA reading scores, rather than in the average dispersion help to explain the changing gender differences in educational attainment.

6.2.2 Subgroups by Time Period - 2003-2007 vs. 2008-2014

As shown in chapter 3, gender differences in tertiary educational enrollment stagnated or even decreased during recent years in most countries. We therefore split the baseline sample into two time sub-groups: Subgroup 1 covers the years 2003-2007 for which the gender gap increased in all countries; Subgroup 2 covers the years 2008-2014 when it stagnated or decreased in some countries. Table 6.2 shows the regression results:

It is interesting that none of the explanatory variables is significant for the sample of the earlier sub-period. For sub-period 1, only the country-year effect (growth rate of GDP per capita) is significantly correlated with changes in the female-male gender gap of the GER. Hence, for the sample of times in which the gender gap increase was most advanced, none of the explanatory variables derived from the model of educational investment helps to explain the variation in the change of the enrollment gender gap. Instead, other country and year specific factors affect gender gap developments in tertiary education.

In the regressions based on the subsample for more recent years (column (2)) of table 6.2, on the contrary, the growth rate of GDP per capita is not significant, whereas the coefficient of the change in gender differences of PISA reading scores is significantly positive. Hence, gender differences in non-cognitive skills seem to play a role only in recent years when the gender gap increase slowed down in all countries. Another difference between the two sub-periods is the reversal of the direction of correlation with respect to the fertility rate: while the change in fertility rates is positively correlated with the enrollment gender gap for subsample 2 (2008-2014), it is negatively correlated for subsample 1 (2000-2007). Hence, the impact of changes in fertility rates on changes in the female male gender gap of the GER differs across time periods. Nevertheless, for none of the two sub-periods is the variable significant.

Table 6.2: Subgroups by Time Period: 2003-2007 and 2008-2014

Dependent Variable: ΔGender Gap of GER	(1) 2003-2007	(2) 2008-2014
Δ Gender Gap of Labor Force Participation (age 25-64)$_{t-3}$	-0.347	-0.00955
	(0.226)	(0.321)
Δ Gender Gap of Life Expectancy at Birth$_{t-22}$	0.634	-1.257
	(1.166)	(0.809)
Δ Crude Divorce Rate$_{t-3}$	-0.560	-1.127
	(0.688)	(1.133)
Δ Log Fertility Rate$_{t-3}$	-0.632	18.11
	(3.580)	(10.09)
Δ Population Share With Tertiary Education (Parent's Generation: age 45-59)$_t$	-0.178	0.0315
	(0.105)	(0.294)
Δ Gender Gap of PISA Reading Score$_t$	0.152	0.290**
	(0.0548)	(0.0667)
Year Fixed Effects	yes	yes
Country Fixed Effects	yes	yes
Δ Log GDP per capita$_t$	35.04*	27.51
	(9.259)	(14.09)
_cons	0.403	-0.527
	(0.272)	(0.274)
N	90	126
$withinR^2$	0.226	0.305

Driscoll-Kraay standard errors in parentheses

Gender Gap always refers to the female-male gap.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.2.3 Subgroups by Region: Western European, Nordic, Southern European, Eastern European

So far, we can summarize that mainly changes in the gender gap of average PISA scores are significant and positively correlated with changes in the gender gap of gross enrollment in tertiary education and that this positive correlation is particularly advanced for most recent years. Besides, time fixed effects and country-year effects play a role in explaining changes in the enrollment gender gap.

In a next step, we split countries into regional subgroups to identify potential differences between country groups. We define subgroups by region: Western European (WE), Nordic (N), Southern European (SE) and Eastern European (EE)[3]. Table 6.3 shows the results of the baseline regression for each country subgroup with and without the standard deviation of PISA reading scores respectively.

Overall, significant differences between country subgroups can be observed: While the changes in gender gaps of PISA reading scores were significant in the baseline regression, which was based on the sample of all 18 countries, they are significant and positive only for Nordic countries when the 18 countries are divided into regional subgroups (see column (3)). Adding the standard deviation of PISA reading scores (column (4)) does not alter this finding significantly, but reduces the impact of average PISA reading scores slightly.

Overall, the correlation between PISA scores and the enrollment ratios found in the baseline regression seems to be driven mainly by Nordic countries. For Western European countries, in contrast, rather gender differences in the dispersion of PISA reading scores than in their level have explanatory power with respect to the change in the gender gap of the GER: The change in the gender gap of the standard deviation of PISA reading scores is negatively significant on the 5% significance level (5% probability of committing a type I error). Furthermore, country-year effects play a role in Western European countries.

In Southern European countries (column (5) and (6)) changes in gender gaps of health benefits correlate positively with the dependent variable: A one standard deviation increase in the change of the gender gap of life expectancy at birth

[3]Western European: France, Belgium, Netherlands, Great Britain and Ireland; Nordic: Denmark, Sweden, Norway and Finland; Southern European: Portugal, Spain, Italy and Greece; Eastern European: Poland, Czech Republic, Slovakia, Hungary and Slovenia

leads to an increase in the dependent variable of approximately 0.5 percentage points.

For Eastern European Countries, in contrast, an increasing change of divorce rates goes along with a decreasing change in the gender gap of the GER (see column (7)). However, this finding is not robust to adding the change in the gender gap of the standard deviation of PISA reading scores (column (8)).

Table 6.3: Subgroups by Region: Western European, Nordic, Southern European and Eastern European

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔGender Gap of GER	WE I	WE II	N I	N II	SE I	SE II	EE I	EE II
Δ Gender Gap of	0.0411	0.0270	-0.0914	-0.0307	-0.486	-0.472	-0.0810	0.0162
Labor Force Participation (age 25-64)$_{t-3}$	(0.351)	(0.286)	(0.433)	(0.441)	(0.230)	(0.244)	(0.617)	(0.708)
Δ Gender Gap of	-1.813	-1.469	-0.613	-0.774	2.391**	2.459**	-0.819	-0.831
Life Expectancy at Birth$_{t-22}$	(0.873)	(0.905)	(1.232)	(1.246)	(0.690)	(0.638)	(1.558)	(1.546)
Δ Crude Divorce Rate$_{t-3}$	0.156	0.224	0.289	0.577	0.217	0.0927	-5.341*	-4.960
	(0.765)	(0.801)	(2.489)	(2.528)	(0.399)	(0.433)	(1.991)	(2.644)
Δ Log Fertility Rate$_{t-3}$	-15.18	-12.12	5.276	2.471	16.25	18.79	24.35	26.43
	(7.438)	(8.219)	(11.89)	(12.88)	(8.168)	(10.14)	(16.35)	(17.23)
Δ Population Share With Tertiary Education	-0.0792	-0.0553	-0.0168	-0.00118	0.437	0.449	-0.910	-0.952
(Parent's Generation: age 45-59)$_t$	(0.133)	(0.106)	(0.180)	(0.190)	(0.236)	(0.239)	(0.629)	(0.687)
Δ Gender Gap of	0.0964	0.0503	0.506**	0.491*	0.117	0.0700	0.159	0.249
PISA Reading Score$_t$	(0.0607)	(0.0679)	(0.152)	(0.170)	(0.0582)	(0.0670)	(0.271)	(0.377)
Δ Gender Gap of		-0.270*		0.135		-0.0994		0.224
s.d. of PISA Reading Score$_t$		(0.0983)		(0.197)		(0.101)		(0.752)
Year Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes
Country Fixed Effects	yes	yes	yes	yes	yes	yes	yes	yes
Δ Log GDP per capita$_t$	31.87*	37.58*	18.93	17.73	-3.819	-3.838	31.90	32.01
	(14.13)	(14.84)	(11.99)	(11.35)	(8.317)	(7.990)	(25.73)	(24.75)
_cons	0.964*	0.734	1.255**	1.276**	-0.247	-0.164	0.163	0.162
	(0.357)	(0.396)	(0.361)	(0.362)	(0.506)	(0.472)	(1.002)	(0.963)
N	60	60	48	48	48	48	60	60
R^2	0.583	0.632	0.590	0.595	0.667	0.674	0.520	0.523

Driscoll-Kraay standard errors in parentheses

Gender Gap always refers to the female-male gap.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Overall, we find important differences between regional country groups. This points towards the need of a more in-depth analysis of country groups or specific countries. For Western European and Nordic countries, gender differences in non-cognitive skills seem to play a role while for Southern European countries gender differences in health benefits seem to be important.

6.2.4 Including "Earnings Premium" and Foregone Earnings

In the next regression, we assess whether the financial returns to tertiary education on the benefit side of education and foregone earnings on the cost side of tertiary education help to explain gender gap developments of the GER.

Data on the "earnings premium" and foregone earnings is only available from 2008 onward. Therefore, as a comparison, in column (1) of table 6.4, we revisit the baseline regression (as it was seen in table 6.1) and in column (2) of table 6.4, we revisit the regression for the subperiod 2008-2014 in column (as it was seen in table 6.2). In column (3) we then add foregone earnings and the "earnings premium" of tertiary education as additional explanatory variables.

Table 6.4 shows no major differences between the three regressions. The main difference when reducing the sample to most recent years is the change of significance of the country-year effect GDP per capita (see difference between column (1) and (2)). When adding foregone earnings and the "earnings premium", no major changes occur (column (3)). The change in gender differences of PISA scores stays significant and positive throughout all specifications .

Column (3) further shows that foregone earnings carry a negative sign and the "earnings premium" of tertiary education a positive one, as would be expected. However, neither the change in gender differences of foregone earnings, nor the change in gender differences of the "earnings premium" have explanatory power. We hence can confirm on European cross-country level that changes in gender differences of foregone earnings and the college wage premium are not able to explain changes in gender differences in educational attainment.

Table 6.4: Adding "Earnings Premium" and Foregone Earnings

Dependent Variable: ΔGender Gap of GER	(1) Baseline	(2) 2008-2014	(3) 2008-2014 II
ΔGender Gap of Labor Force Participation (age 25-64)$_{t-3}$	-0.271	-0.00955	-0.0622
	(0.182)	(0.321)	(0.312)
ΔGender Gap of Life Expectancy at Birth$_{t-22}$	-0.665	-1.257	-1.449
	(0.869)	(0.809)	(0.831)
Δ Crude Divorce Rate$_{t-3}$	-1.050	-1.127	-1.016
	(0.596)	(1.133)	(1.109)
Δ Log Fertility Rate$_{t-3}$	9.133	18.11	16.56
	(6.606)	(10.09)	(10.17)
Δ Population Share With Tertiary Education (Parent's Generation: age 45-59)$_t$	-0.0814	0.0315	0.0159
	(0.0924)	(0.294)	(0.303)
ΔGender Gap of PISA Reading Score$_t$	0.161***	0.290**	0.263*
	(0.0334)	(0.0667)	(0.0732)
ΔGender Gap of Foregone Earnings$_{t-3}$			-1.414
			(3.585)
ΔGender Gap of "Earnings Premium"$_{t-3}$			4.998
			(3.390)
Year Fixed Effects	yes	yes	yes
Country Fixed Effects	yes	yes	yes
Δ Log GDP per capita$_t$	22.27**	27.51	27.67
	(5.270)	(14.09)	(13.46)
_cons	0.431	-0.527	-0.512
	(0.212)	(0.274)	(0.257)
N	216	126	126
$withinR^2$	0.300	0.305	0.316

Driscoll-Kraay standard errors in parentheses

Gender Gap always refers to the female-male gap.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.2.5 Enrollment Numbers as Outcome Variable

As mentioned in the descriptive part of this dissertation, the gross enrollment ratio is a somewhat noisy measure of enrollment as it includes over- and under-aged students. As a robustness check we therefore re-run the baseline regression using the female-male gender gap of enrollment numbers (in thousands and logarithms) of 20-24-year-old individuals. To account for the population size of 20-24-year-old men and women in a country and year, we add the population numbers of 20-24-year-old women and men (in thousands and logarithms) as additional control variables. Table 6.5 shows the regression results.

Table 6.5: Robustness Regression: Baseline With Enrollment Numbers Instead of Enrollment Ratios

Δ Gender Gap of log Enrollment (numbers, in thousands)	(1)	(2)
Δ Gender Gap of Labor Force Participation (age 25-64)$_{t-3}$	-0.00470	-0.00480
	(0.00392)	(0.00393)
Δ Gender Gap of Life expectancy at Birth$_{t-22}$	-0.0116	-0.0116
	(0.0121)	(0.0122)
Δ Crude Divorce Rate$_{t-3}$	-0.0136	-0.0141
	(0.00895)	(0.00961)
Δ Log Fertility Rate$_{t-3}$	0.193	0.197
	(0.103)	(0.103)
Δ Population Share With Tertiary Education (Parent's Generation: age 45-59)$_t$	0.000235	0.000259
	(0.000737)	(0.000807)
Δ Gender Gap of PISA Reading Score$_t$	0.00221**	0.00201*
	(0.000660)	(0.000661)
Δ Gender Gap of s.d. of PISA Reading Score$_t$		-0.000844
		(0.00187)
Δ Log of Male Population aged 20-24$_t$	-0.0216	-0.00271
	(0.381)	(0.373)
Δ Log of Female Population aged 20-24$_t$	0.0415	0.0206
	(0.334)	(0.330)
Year Fixed Effects	yes	yes
Country Fixed Effects	yes	yes
Δ Log GDP per capita$_t$	0.0464	0.0526
	(0.0918)	(0.0880)
_cons	-0.00480	-0.00489
	(0.00472)	(0.00470)
N	216	216
$within R^2$	0.200	0.201

Driscoll-Kraay standard errors in parentheses

Gender Gap always refers to the female-male gap.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

No major differences can be observed in comparison to the baseline regression (compare column (1) and (2) of table 6.5 with column (4) and (5) of table 6.1). For enrollment ratios as well as for enrollment numbers is the change in the gender gap of PISA scores the only significant variable which carries a positive sign. All other variables are insignificant also when enrollment numbers are used as dependent variable instead of enrollment ratios.

Furthermore, the changes in the population numbers of 20-24-year-old men and women are positively correlated in case of women and negatively in case of men as would be expected, but are not significant.

6.2.6 PISA Math Scores and Average of Reading and Math Scores

In a last robustness regression, we want to analyze whether findings with respect to PISA scores can be confirmed when PISA math scores or the average between reading and math scores is used instead of PISA reading scores. In table 6.6, we show all regressions with and without the standard deviation of PISA scores as additional explanatory variable. In column (1) and (2) of table 6.6 PISA reading scores are used, exactly as before in our baseline regression. In column (3) and (4), PISA math scores are used instead and in column (5) and (6) an average of PISA reading and PISA math scores is used.

Between the regressions for reading and the average of reading and math scores (column (1)-(2) and (5)-(6)) no significant differences can be observed: The change in the gender gap of PISA reading scores as well as of the average of reading and math scores is significantly positive while its standard deviation is negative, but insignificant. Hence, we can conclude, that the findings from our baseline regression are robust to using the average of math and reading scores as an explanatory variable instead of PISA reading scores.

With respect to math scores, on the contrary, gender differences in the dispersion rather than in average scores seems to play an explanatory role when both, the average score and the dispersion variable are added to the regression. Hence, whether gender differences in the dispersion or the average level of cognitive and non-cognitive skills matter, seems to depend on the discipline of PISA test scores used.

Table 6.6: Robustness Regression: Baseline With PISA Math Scores and Reading+Math Average

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)
ΔGender Gap of GER	PISA Reading I	PISA reading II	PISA Math I	PISA Math II	PISA I	PISA II
Δ Gender Gap of	-0.271	-0.274	-0.245	-0.249	-0.243	-0.257
Labor Force Participation (age 25-64)$_{t-3}$	(0.182)	(0.181)	(0.188)	(0.187)	(0.188)	(0.187)
Δ Gender Gap of	-0.665	-0.668	-0.696	-0.788	-0.672	-0.706
Life expectancy at Birth$_{t-22}$	(0.869)	(0.879)	(0.872)	(0.893)	(0.862)	(0.883)
Δ Crude Divorce Rate$_{t-3}$	-1.050	-1.067	-0.993	-0.962	-1.024	-1.067
	(0.596)	(0.654)	(0.606)	(0.628)	(0.599)	(0.631)
Δ Log Fertility Rate$_{t-3}$	9.133	9.267	9.100	9.273	9.559	9.931
	(6.606)	(7.007)	(6.455)	(6.230)	(6.600)	(6.596)
Δ Population Share With Tertiary Education	-0.0814	-0.0810	-0.0825	-0.0980	-0.0789	-0.0819
(Parent's Generation: age 45-59)$_t$	(0.0924)	(0.0918)	(0.105)	(0.114)	(0.0983)	(0.0977)
Δ Gender Gap of	0.161^{***}	0.154^{**}				
PISA Reading Score$_t$	(0.0334)	(0.0383)				
Δ Gender Gap of		-0.0297				
s.d of PISA Reading Score$_t$		(0.141)				
Δ Gender Gap of			0.135^{**}	0.0733		
PISA Math Score$_t$			(0.0389)	(0.0452)		
Δ Gender Gap of				-0.357^{**}		
s.d of PISA Math Score$_t$				(0.110)		
Δ Gender Gap of					0.177^{***}	0.135^{*}
PISA Score$_t$					(0.0322)	(0.0461)
Δ Gender Gap of						-0.0896
s.d of PISA Score$_t$						(0.0820)
Year Fixed Effects	yes	yes	yes	yes	yes	yes
Country Fixed Effects	yes	yes	yes	yes	yes	yes
Δ Log GDP per capita$_t$	22.27^{**}	22.54^{**}	22.38^{***}	24.01^{**}	22.06^{***}	23.33^{**}
	(5.270)	(5.402)	(4.915)	(5.980)	(4.943)	(5.466)
_cons	0.431	0.428	0.512^{*}	0.632^{*}	0.445	0.467^{*}
	(0.212)	(0.217)	(0.207)	(0.209)	(0.212)	(0.204)
N	216	216	216	216	216	216
R^2	0.300	0.300	0.290	0.314	0.300	0.306

Driscoll-Kraay standard errors in parentheses

Gender Gap always refers to the female-male gap.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

7 Discussion and Concluding Remarks

7.1 Overview of Limitations

When applying an individual decision making model to aggregated data, difficulties and limitations arise especially with respect to data availability and richness of data. Due to data restrictions, most of the costs and benefits of the educational investment model could not perfectly be measured with country-level data. As mentioned in the data description, it would have been ideal to have access to country-level data dis-aggregated not only by gender, but also by educational level to better measure the actual costs and benefits of tertiary education. Since such data is barely available, we had to rely on data dis-aggregated by gender only. Thereby, we rather captured correlations between overall gender gap trends in the dependent and the explanatory variables than the actual costs and benefits of tertiary education. We restricted certain explanatory variables, such as labor force participation, to specific age cohorts (age 25+) to limit the degree to which unwanted effects were captured by the variables. However, "unwanted" effects could not be ruled out completely and can be expected to have caused an underestimation rather than an overestimation of the correlation between the explanatory and dependent variable. Despite shortcomings with respect to the richness of the data, lack of data on cognitive and in particular on non-cognitive skills for a sufficiently long time period is another limitation. PISA scores, for instance, are not comprehensively available before 2003 and measure the achievement of 15-year-old pupils. Hence, to capture cognitive skills of now-enrolled students, it would have been necessary to lag today's PISA scores by at least 5 years. This, however, would have reduced the period of analysis significantly. Therefore, the findings of this dissertation should be tested for robustness using other and different measures of cognitive and non-cognitive skills, for instance TIMMS or PIRLS scores. Furthermore, the econometric approach of this dissertation, which had to be chosen due to non-stationarity and no cointegration, does not allow to draw conclusions on the long-run relationship between gender gaps in levels of costs and benefits of tertiary education and gender gaps in gross enrollment ratios. Nevertheless, our short-run analysis suggests that cognitive and non-cognitive skills do play a role in explaining gender gap developments. In contrast, neither gender gaps in the benefits of education nor fertility rates can explain part of the variation in gender gaps in tertiary educational enrollment.

7.2 Discussion of Results and Future Research

Our findings on cross-country level resemble those found by studies for the U.S. by Jacob (2002) and Becker, Hubbard, and Murphy (2010) who find that gender differences in the distribution of average levels and/or the dispersion of cognitive and non-cognitive skills help to explain the increasing female-male gender gap in higher education for the United States. Hence, our results can be taken as a good starting point for further in-depth analyses of the relationship between gender differences in PISA scores or other measures of cognitive and non-cognitive skills and gender gap developments in tertiary educational attainment. Since our analysis shows varying results for different country subgroups and GDP per capita as country-year effect proved to be significant in our baseline regression, the cross-country findings of this dissertation cannot be generalized or assigned to specific European countries, nor can they be used for policy recommendations on European or country level. It is interesting to note, however, that gender differences in the dispersion of PISA scores rather than in their average levels play a role for Western European countries which resembles the findings of Becker, Hubbard, and Murphy (2010) for the U.S. Hence, it would be interesting to analyze similarities and differences between the U.S. and Western European countries in more detail in future research. Furthermore, a comparison with

Nordic countries, for which gender differences in the average PISA reading score plays a role in our findings, would be an interesting addition. Overall, future research should use richer country specific individual-level data to be able to draw better conclusions on individual countries' developments. Should the impact of gender differences in cognitive and non-cognitive skills prove to be robust in future in-depth studies, cognitive and non-cognitive skills of boys could be stimulated with targeted policies to avoid high gender inequalities in the future. Nevertheless, since our descriptive analysis showed a slightly decreasing female-male gender gap in most recent years, the increasing gender gap in favor of women may only be a temporary phenomenon and might converge back towards gender equality even without policy intervention. Therefore, monitoring of future developments as well as more in depth studies are crucial prerequisites for possible policy recommendations on national level as well as on European level.

7.3 Concluding Remarks

This dissertation studied the increase in the female-male gender gap in tertiary educational attainment during recent decades on European cross-country level. It could be shown that a faster increase of female enrollment rates led to a gender gap reversal and a subsequent increase in the female-male gender gap in favor of women. Only in most recent years did the gap stagnate or start to decrease again. Using a first difference model to ensure stationarity, we analyzed whether gender differences in costs and benefits of tertiary education help to explain gender gap developments in tertiary enrollment.

We find that neither gender differences in the benefits of tertiary education, nor in fertility rates or in foregone earnings on the cost side of tertiary education, can help to explain the gender gap in gross enrollment ratios. In contrast, changes in gender gaps of PISA reading scores, which measure gender differences in cognitive and non-cognitive skills, are significantly correlated with changes in the gender gap of tertiary enrollment. Whether gender differences in the levels of PISA scores or in their variation play an explanatory role, varies by country subgroup and further depends on whether math or reading PISA scores are used to measure cognitive and non-cognitive skills.

We further find significant differences across country sub-groups: cognitive and non-cognitive skills seem to play an explanatory role only in Nordic and Western European countries, but not in Southern and Eastern European ones. For Southern European countries, we find that gender differences in health prospects and hence in the benefits of tertiary education are instead correlated with gender differences in enrollment ratios.

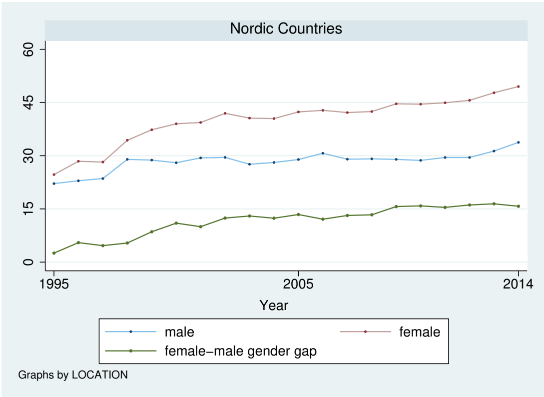
We found not only significant differences among country subgroups, but also concluded that the growth rate of GDP per capita which served as a country-year effect, helps to explain changes in the gender gap of gross enrollment ratios in tertiary education. Therefore, we cannot make generalizations based on our cross-country findings, but conclude that our findings with respect to PISA scores should be analyzed in more detail and with richer country specific data in future research. On the one hand, this could help to identify other country-year specific effects besides the cost and benefits of tertiary education, on the other hand it would allow for the use of richer micro data to better test the model of educational investment decisions and to identify for which countries cognitive and non-cognitive skills affect gender differences in education. Without such a more in-depth analysis, no policy recommendations can be made.

A Appendix

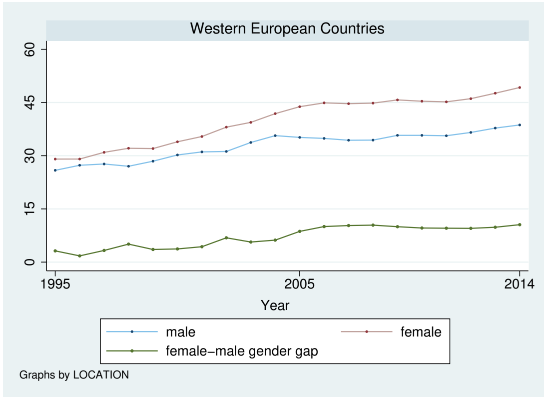
A.1 Chapter 3: Developments in Tertiary Educational Attainment

Table A.1: Gross Enrollment Ratio of Men and Women and its Change Over Time

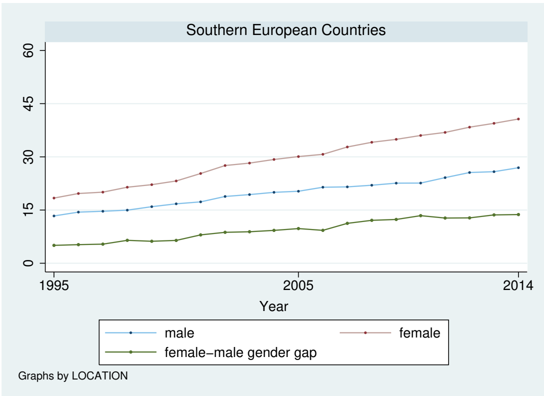
	1975 female GER ; male GER	1985 female GER ; male GER (female Δ) ; (male Δ)	1995 female GER ; male GER (female Δ) ; (male Δ)	2005 female GER ; male GER (female Δ) ; (male Δ)	2014 female GER; male GER (female Δ) ; (male Δ)
Nordic Countries:	20.19% ; 24.72%	31.13% ; 29.78% (10.94 pp) ; (5.06 pp)	57.21% ; 47.77% (26.08 pp) ; (17.99 pp)	97.30% ; 69.59% (40.09 pp) ; (21.82 pp)	89.98% ; 65.27% (-7.32 pp) ; (-4.32 pp)
Western Europe:	14.01% ; 24.35%	24.37% ; 28.58% (10.63 pp) ; (4.23 pp)	58.38% ; 45.87% (34.01 pp) ; (17.29 pp)	64.27% ; 57.12% (5.69 pp) ; (11.25 pp)	72.82% ; 56.86% (8.55 pp) ; (-0.26 pp)
Southern Europe:	12.78% ; 20.54%	21.77% ; 22.48% (8.99 pp) ; (1.94 pp)	43.35% ; 37.20% (21.58 pp) ; (14.72 pp)	76.12% ; 61.27% (32.77 pp) ; (24.07 pp)	87.13% ; 76.37% (11.01 pp) ; (15.10 pp)
Eastern Europe:	11.73% ; 12.66%	17.25% ; 16.46% (5.53 pp) ; (3.79 pp)	26.87% ; 22.57% (9.62 pp) ; (6.11 pp)	68.58% ; 50.30% (41.71 pp) ; (27.73 pp)	75.12% ; 52.95% (6.54 pp) ; (2.65 pp)



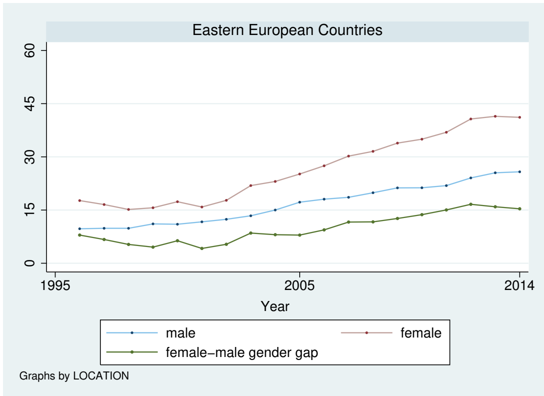
(a) Nordic Countries



(b) Western European Countries

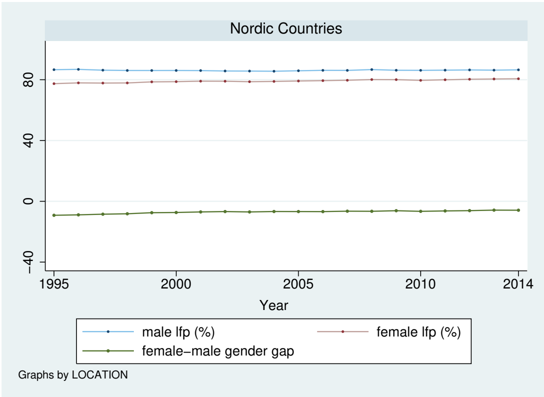


(c) Southern European Countries

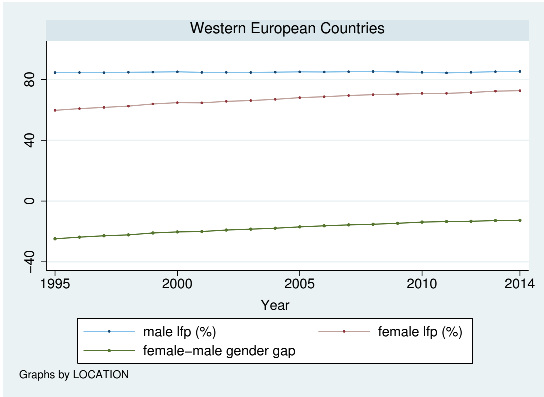


(d) Eastern European Countries

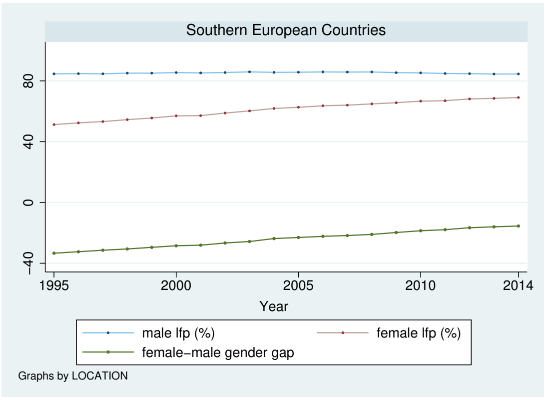
Figure A.1: Share of Population (Age 25-29) With Tertiary Education Over Time



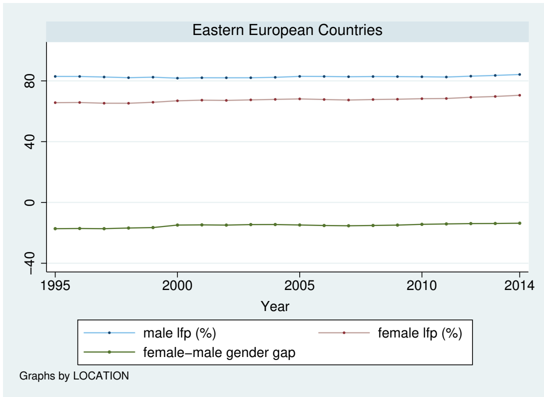
(a) Nordic Countries



(b) Western European Countries



(c) Southern European Countries



(d) Eastern European Countries

Figure A.2: Labor Force Participation Rate Over Time

A.2 Chapter 4: Theoretical Considerations

A.2.1 Derivations for the Becker at al. (2010) model

The Lagrangian looks like follows:

$$\mathscr{L} = U_1(x_1, l_1; H) + p(S,H)\beta U_2(x_2, l_2, S; H) + \mu[w_1 + \frac{p(S,H)w_2}{1+r} + \frac{p(S,H)M(S)}{1+r} - x_1 - \frac{p(S,H)x_2}{1+r} - w_1 l_1 - \frac{p(S,H)w_2 l_2}{1+r} - T(h) - w_1 h] \quad (A.1)$$

We get the FOC's when taking the derivatives with respect to x_1, x_2:

$$\frac{\delta \mathscr{L}}{\delta x_1}: \quad U_{1x} = \mu; \qquad \frac{\delta \mathscr{L}}{\delta x_2}: \quad \beta U_{2x} = \frac{\mu}{1+r} \quad (A.2)$$

combining these two, we get:

$$\mu = U_{1x} = \beta U_{2x}(1+r) \quad (A.3)$$

with respect to l_1 and l_2:

$$\frac{\delta \mathscr{L}}{\delta l_1}: \quad U_{21l} = \mu w_1; \qquad \frac{\delta \mathscr{L}}{\delta l_2}: \quad \beta U_{2l} = \frac{\mu}{1+r} \quad (A.4)$$

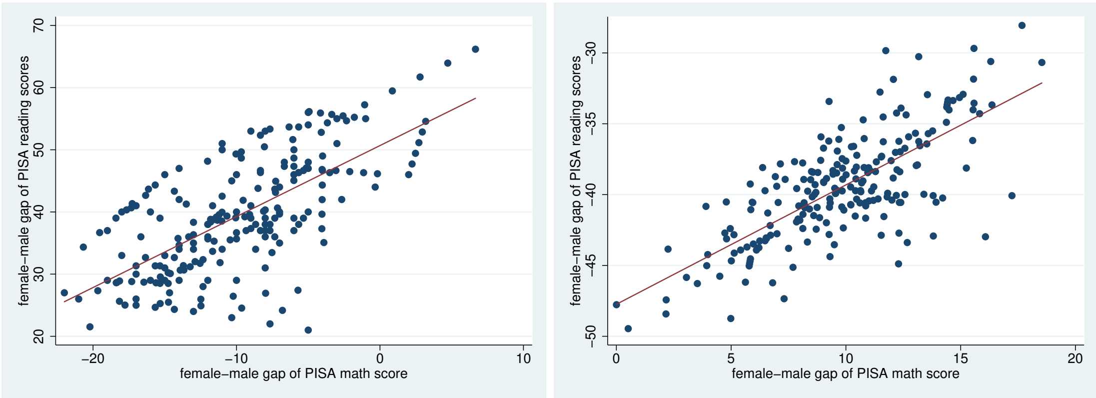
Deriving with respect to h we get:

$$\frac{\delta \mathscr{L}}{\delta h}: \quad p_S \beta U_2 F_h + p\beta U_{2S} F_h + \frac{\mu p_S F_h w_2}{1+r} + \frac{\mu p F_h w_{2S}}{1+r} + \frac{\mu p_S F_h M}{1+r} + \frac{\mu p M_S F_h}{1+r} - \frac{\mu p_S F_h x_2}{1+r} - \frac{\mu p_S w_2 l_2 F_h}{1+r} - \frac{\mu p w_{2S} l_2 F_h}{1+r} - \mu T_h - \mu w_1 \quad (A.5)$$

after having defined e_2 = hours worked in period 2 and hence $l_2 = 1 - e_2$ and dividing all by $\mu = U_{1x} = \beta(1+r)U_{2x}$ and F_h, this simplifies to $\frac{\delta \mathscr{L}}{\delta h}$: and hence we get equation 4.4 from chapter 4.

A.3 Chapter 5: Data Sampling and Variable Definition

A.3.1 Correlation of Gender Gaps in PISA reading and PISA math scores



(a) Pooled Data

(b) Country and Time Demeaned Data

Figure A.3: Scatterplot of female-male gap of PISA reading scores vs. female-male gap of PISA maths scores

A.3.2 Variable Sources

Table A.2: Variable Description and Source

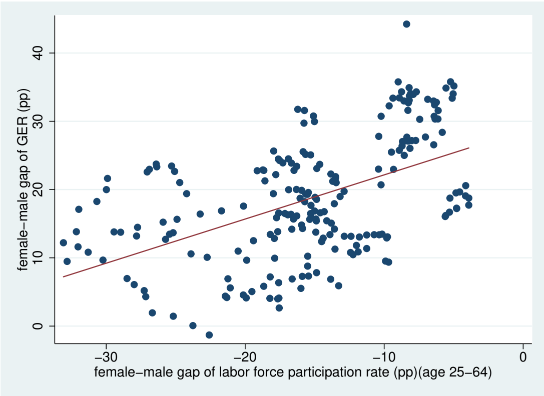
VARIABLE	DESCRIPTION	SOURCE
GROSS ENROLLMENT RATIO (GER)	Total enrollment in tertiary education (ISCED 5 to 8), regardless of age, expressed as a percentage of the total population of the five-year age group following on from secondary school leaving	UNESCO Institute for Statistics UNESCO ("Education: Gross enrolment ratio by level of education")
ENROLLMENT NUMBERS	Total enrollment in tertiary education (ISCED 5 to 8) of 20-24-year-old students (in numbers)	Eurostat OECD ("Enrolment by age")
LABOR FORCE PARTICIPATION RATE (AGE 25-65)	Labour force divided by the total working-age population. The working age population refers to people aged 15 to 64. This indicator is broken down by age group and it is measured as a percentage of each age group.	OECD Data OECD ("Labour force statistics by sex and age: indicators")
LIFE EXPECTANCY AT BIRTH	Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.	The World Bank WorldBank ("Woeld Development Indicators")
CRUDE DIVORCE RATE	The ratio of the number of divorces during the year to the average population in that year. The value is expressed per 1000 inhabitants.	Eurostat Eurostat ("Marriages and Divorces")
FERTILITY RATE	The total fertility rate in a specific year is defined as the total number of children that would be born to each woman if she were to live to the end of her child-bearing years years and give birth to children in alignment with the prevailing age-specific fertility rates. It is calculated by totaling the age-specific fertility rates as defined over five-year intervals.	OECD Data OECD ("Demographic references")
POPULATION WITH TERTIARY EDUCATION (AGE 45-59)	Population by educational attainment level presents data on the highest level of education successfully completed by the individuals of a given population. Here, it indicates the share of the population aged 45-49 in a specific year that holds a tertiary degree (ISCED 5-8). It is calculated as the number of 45-49-year-old people with tertiary degree divided by the total number of 45-49-year-old people in the population.	Eurostat Eurostat ("Population by educational attainment level (edat1)")
PISA SCORES	PISA tests the skills and Knowledge of 15-year-old students. Reading performance, for PISA, measures the capacity to understand, use and reflect on written texts in order to achieve goals, develop knowledge and potential, and participate in society. The mean score is the measure.	OECD Data OECD ("PISA: Programme for International Student Assessment")
INCOME WITH S (FOREGONE EARNINGS) ECONDARY EDUCATION	The income with secondary education is measured by the median equivalised income(PPS) of the age class 18-64 with Upper secondary and post-secondary non-tertiary education (ISCED levels 3 and 4)	Eurostat Eurostat ("Mean and median income by educational attainment level - EU-SILC survey")
"EARNINGS PREMIUM"	The financial return to tertiary education is measured as the difference of the median equivalised income (PPS) of the age class 18-64 with Tertiary education (ISCED levels 5-8) and the median equivalised income (PPS) with Upper secondary and post-secondary non-tertiary education (ISCED levels 3 and 4)	Eurostat Eurostat ("Mean and median income by educational attainment level - EU-SILC survey")
GDP PER CAPITA		The World Bank WorldBank ("Woeld Development Indicators")

A.3.3 Summary Statistics in Levels for Country Subgroups

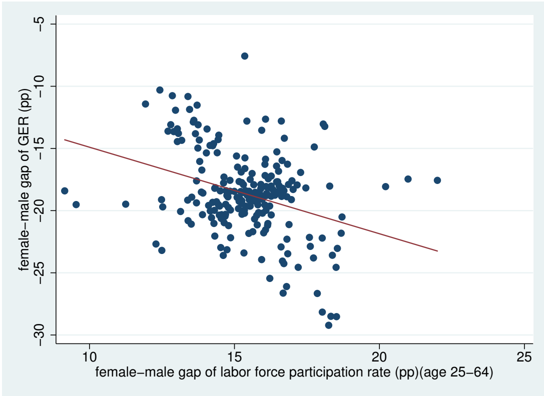
Table A.3: Summary Statistics in Levels (Country Subgroups)

Variable	Mean	Std. Dev.	Min.	Max.	N
Western European Countries					
Gender Gap of GER_t	12.234	4.778	3.994	20.015	60
Gender Gap of Labor Force Participation (age 25-64)$_{t-3}$	-16.82	4.451	-28.959	-9.763	60
Life Expectancy at $Birth_{t-22}$	6.582	0.945	5.4	8.300	60
Crude Divorce $Rate_{t-3}$	2.03	0.74	0.6	3.3	60
Log Fertility $Rate_{t-3}$	0.607	0.07	0.482	0.728	60
Population Share With Tertiary Education					
(Parent's Generation: age 45-59)$_t$	26.342	4.744	16.887	35.311	60
Gender Gap in PISA Reading $Score_t$	31.642	6.455	21	46.322	60
Gender Gap in Std.Dev. of PISA Reading $Score_t$	-8.354	3.25	-16.48	-0.483	60
Log GDP per $capita_t$	10.595	0.099	10.451	10.786	60
Nordic Countries					
Gender Gap of GER_t	27.33	6.258	16.052	35.789	48
Gender Gap of Labor Force Participation (age 25-64)$_{t-3}$	-6.703	1.658	-9.475	-3.91	48
Life Expectancy at $Birth_{t-22}$	6.608	0.969	5.4	8.48	48
Crude Divorce $Rate_{t-3}$	2.465	0.211	2.1	2.9	48
Log Fertility $Rate_{t-3}$	0.595	0.052	0.438	0.683	48
Population Share With Tertiary Education					
(Parent's Generation: age 45-59)$_t$	31.356	3.388	25.92	41.291	48
Gender Gap in PISA Reading $Score_t$	44.08	10.504	26	66.17	48
Gender Gap in Std.Dev of PISA Reading $Score_t$	-8.346	3.399	-15.803	-2	48
Log GDP per $capita_t$	10.706	0.174	10.476	11.026	48
Southern European Countries					
Gender Gap of GER_t	13.599	6.381	-1.304	23.732	48
Gender Gap of Labor Force Participation (age 25-64)$_{t-3}$	-23.092	7.092	-33.075	-9.679	48
Life Expectancy at $Birth_{t-22}$	6.572	0.51	5	7.38	48
Crude Divorce $Rate_{t-3}$	1.515	0.701	0.700	2.9	48
Log Fertility $Rate_{t-3}$	0.308	0.057	0.207	0.445	48
Population Share With Tertiary Education					
(Parent's Generation: age 45-59)$_t$	16.28	5.754	7.549	28.206	48
Gender Gap in PISA Reading $Score_t$	39.767	7.222	28.508	56	48
Gender Gap in Std.Dev. of PISA Reading $Score_t$	-12.58	3.655	-24.057	-7.810	48
Log GDP per $capita_t$	10.318	0.126	10.084	10.513	
Eastern European Countries					
Gender Gap of GER_t	22.191	8.309	2.658	44.24	60
Gender Gap of Labor Force Participation (age 25-64)$_{t-3}$	-14.791	3.199	-19.136	-7.442	60
Life Expectancy at $Birth_{t-22}$	8.034	0.536	7.15	9.26	60
Crude Divorce $Rate_{t-3}$	2.065	0.698	1.1	3.8	60
Log Fertility $Rate_{t-3}$	0.271	0.079	0.131	0.451	60
Population Share With Tertiary Education					
(Parent's Generation: age 45-59)$_t$	15.475	2.95	10.532	22.856	60
Gender Gap in PISA Reading $Score_t$	43.357	7.261	31	56.14	60
Gender Gap in Std.Dev. of PISA Reading $Score_t$	-8.856	3.425	-19.22	-4	60
Log GDP per $capita_{t-3}$	10.052	0.158	9.627	10.308	60

A.3.4 Scatter Plots - Pooled Data and Time and Cross-Sectional Demeaned Data

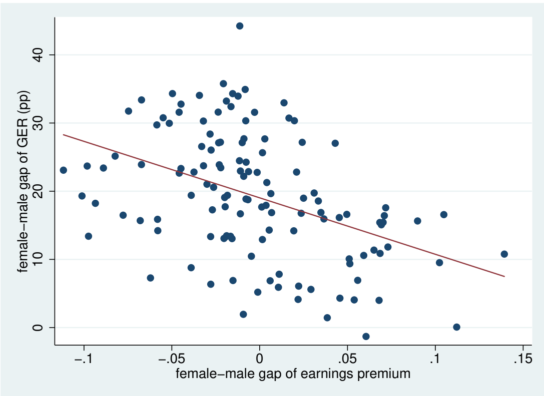


(a) Pooled Data

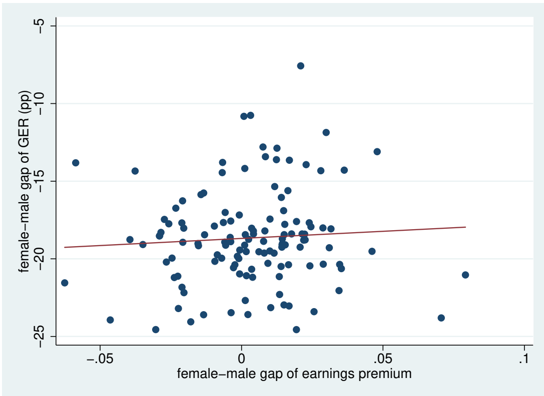


(b) Time and Country Demeaned Data

Figure A.4: Scatterplot of female-male gap of GER vs. female-male gap of labor force participation rate

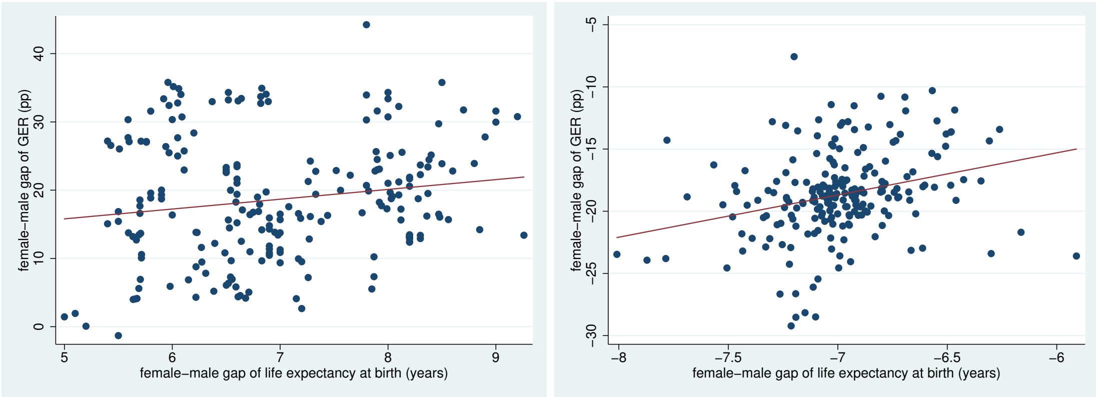


(a) Pooled Data



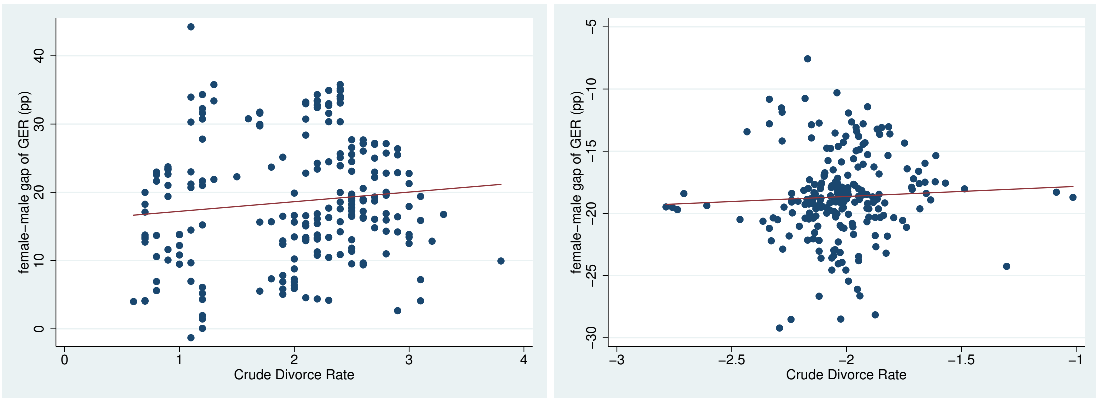
(b) Time and Country Demeaned Data

Figure A.5: Scatterplot of female-male gap of GER vs. female-male gap of "earnings premium"



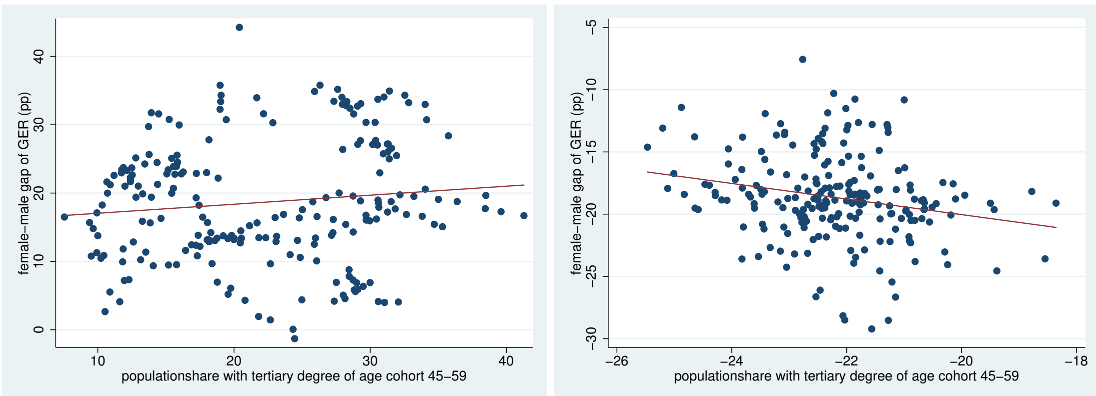
(a) Pooled Data **(b)** Time and Country Demeaned Data

Figure A.6: Scatterplot of female-male gap of GER vs. female-male gap of life expectancy at birth



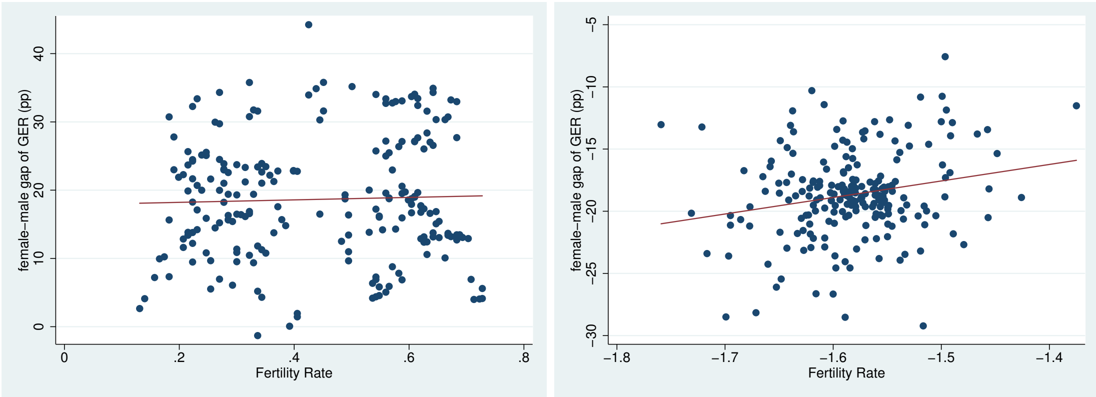
(a) Pooled Data **(b)** Time and Country Demeaned Data

Figure A.7: Scatterplot of female-male gap of GER vs. Crude Divorce Rate



(a) Pooled Data **(b)** Time and Country Demeaned Data

Figure A.8: Scatterplot of female-male gap of GER vs. share of the population aged 45-59 with tertiary degree



(a) Pooled Data

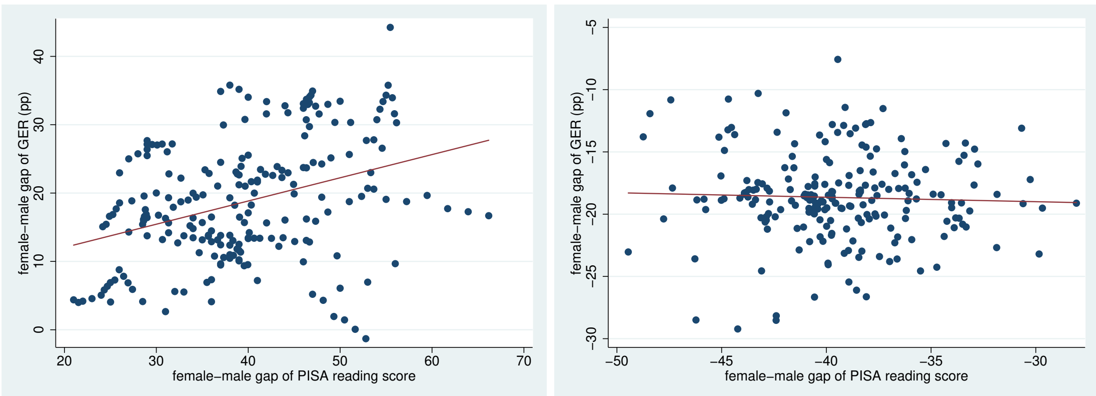
(b) Time and Country Demeaned Data

Figure A.9: Scatterplot of female-male gap of GER vs. fertility rates

(a) Pooled Data

(b) Time and Country Demeaned Data

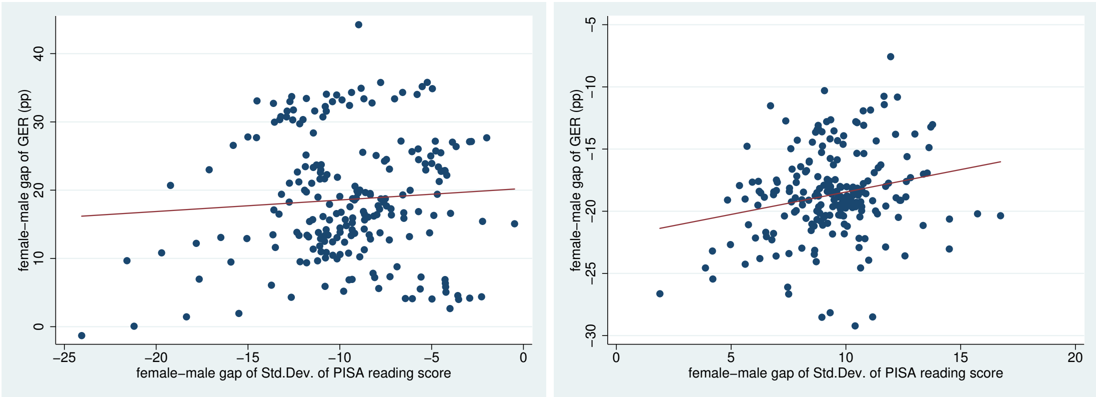
Figure A.10: Scatterplot of female-male gap of GER vs. female-male gap in foregone earnings



(a) Pooled Data

(b) Time and Country Demeaned Data

Figure A.11: Scatterplot of female-male gap of GER vs.female-male gap in PISA reading scores



(a) Pooled Data **(b)** Time and Country Demeaned Data

Figure A.12: Scatterplot of female-male gap of GER vs. female-male gap in Dispersion of PISA reading scores

A.3.5 Summary Statistics in First Differences

Table A.4: Summary Statistics in First Differences

Variable	Mean	Std. Dev.	Min.	Max.	N
Δ Gender Gap of GER$_t$	0.227	1.791	-10.294	8.465	216
Δ Gender Gap of Log Enrollment Numbers,					
age 20-24 (in thousands)$_t$	0.002	0.025	-0.145	0.126	216
Δ Gender Gap of Labor Force Participation (age 25-64)$_{t-3}$	0.436	0.688	-1.585	2.852	216
Δ Life Expectancy at Birth$_{t-22}$	0.004	0.214	-1.119	1	216
Δ Crude Divorce Rate$_{t-3}$	0.015	0.177	-0.6	1.2	216
Δ Log Fertility Rate$_{t-3}$	0.007	0.027	-0.072	0.103	216
Δ Population Share With Tertiary Education					
(Parent's Generation: age 45-59)$_t$	0.647	0.759	-3.95	2.947	216
Δ Gender Gap of PISA Reading Score$_t$	0.316	2.031	-4.333	6.333	216
Δ Gender Gap of Std.Dev. of PISA Reading Score$_t$	-0.121	1.237	-2.853	3.933	216
Δ Gender Gap of PISA Math Score$_t$	0.304	1.907	-5	4.667	216
Δ Gender Gap of Std.Dev. of PISA Math Score$_t$	0.045	0.877	-1.9	2.047	216
Δ Gender Gap of av. PISA Score$_t$	0.31	1.774	-4.667	5.5	216
Δ Gender Gap of Std.Dev. of av. PISA Score$_t$	-0.076	1.902	-4.023	5.023	
Δ Gender Gap of Foregone Earnings$_{t-3}$	-0.002	0.021	-0.097	0.09	126
Δ Gender Gap of Rate of Return to Tertiary Education$_{t-3}$	0.003	0.032	-0.144	0.102	126
Δ Log Male Population Numbers,					
age 20-24 (in thousands)$_t$	-0.006	0.025	-0.083	0.063	216
Δ Log Female Population Numbers,					
age 20-24 (in thousands)$_t$	-0.007	0.025	-0.1	0.059	216
Δ Female-Male Ratio of Log Population Numbers	0	0.001	-0.009	0.007	216
Δ Log GDP per capita$_{t-3}$	0.01	0.031	-0.094	0.102	216

The gender gap always refers to female-male values. PISA scores refer to the average of math and reading scores when not explicitly called math or reading scores.

Table A.5: Summary Statistics in First Differences (Country Subgroups)

Variable	Mean	Std. Dev.	Min.	Max.	N
Western European Countries					
Δ Gender Gap of GER_t	0.113	1.015	-3.147	2.358	60
Δ Gender Gap of Labor Force Participation (age 25-64)$_{t-3}$	0.626	0.548	-0.675	2.084	60
Δ Life Expectancy at $Birth_{t-22}$	-0.019	0.101	-0.32	0.34	60
Δ Crude Divorce $Rate_{t-3}$	-0.012	0.146	-0.4	0.5	60
Δ Log Fertility $Rate_{t-3}$	0.008	0.019	-0.037	0.045	60
Δ Population Share With Tertiary Education					
(Parent's Generation: age 45-59)$_t$	0.777	0.772	-1.252	2.377	60
Δ Gender Gap in PISA Reading $Score_t$	-0.008	1.836	-4.333	3	60
Δ Gender Gap in Std.Dev. of PISA Reading $Score_t$	-0.173	1.001	-1.42	1.743	60
Δ Log GDP per $capita_t$	0.007	0.022	-0.068	0.048	60
Nordic Countries					
Δ Gender Gap of GER_t	-0.043	1.255	-2.634	3.09	48
Δ Gender Gap of Labor Force Participation (age 25-64)$_{t-3}$	0.097	0.465	-1.138	0.820	48
Δ Life Expectancy at $Birth_{t-22}$	-0.057	0.163	-0.45	0.29	48
Δ Crude Divorce $Rate_{t-3}$	0.002	0.084	-0.2	0.2	48
Δ Log Fertility $Rate_{t-3}$	0.007	0.023	-0.066	0.05	48
Δ Population Share With Tertiary Education					
(Parent's Generation: age 45-59)$_t$	0.549	0.924	-3.95	2.103	48
Δ Gender Gap in PISA Reading $Score_t$	0.874	1.139	-2.333	2.333	48
Δ Gender Gap in Std.Dev. of PISA Reading $Score_t$	-0.218	0.893	-1.267	1.89	48
Δ Log GDP per $capita_{t-3}$	0.007	0.027	-0.091	0.05	48
Southern European Countries					
Δ Gender Gap of GER_t	-0.221	1.198	-2.703	2.736	48
Δ Gender Gap of Labor Force Participation (age 25-64)$_{t-3}$	0.97	0.758	-0.264	2.852	48
Δ Life Expectancy at $Birth_{t-22}$	0.013	0.202	-1.119	0.3	48
Δ Crude Divorce $Rate_{t-3}$	0.054	0.256	-0.5	1.2	48
Δ Log Fertility $Rate_{t-3}$	0.005	0.027	-0.066	0.062	48
Δ Population Share With Tertiary Education					
(Parent's Generation: age 45-59)$_t$	0.716	0.66	-0.405	2.452	48
Δ Gender Gap in PISA Reading $Score_t$	0.277	2.348	-3	6.333	48
Δ Gender Gap in Std.Dev. of PISA Reading $Score_t$	-0.057	1.668	-2.853	3.933	48
Δ Log GDP per $capita_t$	-0.004	0.031	-0.094	0.054	48
Eastern European Countries					
Δ Gender Gap of GER_t	0.917	2.747	-10.294	8.465	60
Δ Gender Gap of Labor Force Participation (age 25-64)$_{t-3}$	0.091	0.557	-1.585	1.324	60
Δ Life Expectancy at $Birth_{t-22}$	0.071	0.308	-0.9	1	60
Δ Crude Divorce $Rate_{t-3}$	0.02	0.183	-0.6	0.700	60
Δ Log Fertility $Rate_{t-3}$	0.008	0.034	-0.072	0.103	60
Δ Population Share With Tertiary Education					
(Parent's Generation: age 45-59)$_t$	0.542	0.659	-0.67	2.947	60
Δ Gender Gap in PISA Reading $Score_t$	0.224	2.422	-3.926	5	60
Δ Gender Gap in Std.Dev. of PISA Reading $Score_t$	-0.043	1.304	-2.05	2.107	60
Δ Log GDP per $capita_t$	0.026	0.035	-0.091	0.102	60

A.4 Chapter 6: Empirical Analysis

A.4.1 Unit Root and Cointegration Tests

Table A.6: Im, Pesaran and Shin Panel Unit Root Test

	intercept		intercept and trend	
	W-t-bar	p-value	W-t-bar	p-value
Dependent Variables				
GER, female-male gap	0.5487	0.7084	-0.2957	0.3837
Benefits: Labor Market Factors				
labor force participation rate, female-male gap	3.7922	0.9999	-5.8421	0.0000
median income, pps , female-male gap				
Benefits: Health Factors				
rate of survival until age 65 , female-male gap	-0.5362	0.2959	-1.6e+04	0.0000
Benefits: Marriage Market Factors				
crude divorce rate , total	-3.2054	0.0007	-3.1738	0.0008
Benefits: Household and Family Production Factors				
fertility rate , total	0.7805	0.2175	-1.6675	0.0477
share of population aged 45-59 with tertiary degree, total	-0.0999	0.4602	-6.0637	0.0000
Costs: Cognitive and Non-Cognitive Skills				
PISA score (reading), female-male gap	-0.4536	0.3251	1.0285	0.8481
Additional Controls				
GDP per capita (log)	1.3416	0.9101	-0.4400	0.3300

The test was conducted with intercept and with intercept and trend. Cross-sectional means were subtracted.

The optimal number of lags was chosen by minimizing the Aikaike Information Criteria with a maximum of 4 lags.

The H_0 of the IPS unit root test states: all the series have unit root

The H_a states: Some panels are stationary ("the fraction of panels that are stationary is nonzero") [1]

[1] The IPS test shows best power in data-sets with moderate N and large T. As T is relatively short in our data-set, the results have to be taken with caution. It should further be noted that unit root tests are often seen as controversial as they are based on specific asymptotic behavior of N and T and have rather low power if these asymptotics are not met. Furthermore, the formulation of the alternative hypothesis plays an important role. Pesaran, 2011 states, that the formulation of the alternative hypothesis in common panel unit root tests is controversial as it is based on the prior assumptions made about homogeneity or heterogeneity of the panel. For the IPS test, for instance, a rejection of the H_0 does not automatically imply a rejection of unit roots for all cross-section units.

Table A.7: Pedroni Cointegration Test

	Pedroni	
Test Stats.	panel	group
v	0.7507	.
rho	1.801	3.457
t	-.9701	-1.758
adf	-.3181	-1.65

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