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THE INFLUENCE OF SKILLS AND MAJORS ON FUTURE EARNINGS FOR GERMAN UNIVERSITY GRADUATES

A Thesis in

Educational Theory and Policy

by

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ABSTRACT

Even though it is well substantiated that higher education can improve students' earning potential, there is also a well-documented differential in earnings among US college graduates from different majors (Berger, 1988; Carnevale, Cheah & Hanson, 2015). In a study using 2012 Programme for the International Assessment of Adult Competencies (PIAAC) data, Ford and Choi (2018) found that students' levels of general cognitive skills (i.e., literacy and numeracy) significantly influenced within-major heterogeneity in earnings among U.S. college graduates, which adds nuance to the narrative about the relationship between majors and earnings. I build on and extend the Ford and Choi (2018) study by examining whether skills might also mediate the relationship between major and earnings in Germany, a country that uses relatively rigid ability-based tracking in childhood to place students into academic or vocational paths. While general cognitive skills have less of an impact on within-major heterogeneity in earnings in Germany than in the US, the reduced impact is not significant enough to indicate that a different selection mechanism might be at play in the German labor market. It is important to note that this study is descriptive in nature as well, and more research is required to examine whether there is any causal relationship between levels of general cognitive skills and labor market outcomes for university graduates.

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Problem Statement and Research Questions

Higher education is an important gateway for upward mobility all over the globe. As of 2015, tertiary-educated workers between ages 25-64 earned an average of 55% more than their peers who were educated up to the upper-secondary level (OECD, 2018). Despite this broad picture of advantage, however, there are many dimensions along which the earnings advantages of higher education are unequally distributed amongst individuals. For example, there are differences in earnings between students who complete different types of postsecondary programs: university graduates generally earn more over time than graduates of postsecondary vocational tracks and/or experience less wage depreciation over time (Golsteyn & Stenberg, 2017; Hanushek et al., 2017; Weber, 2014). There are earnings differentials even among students who earn the same type of postsecondary degree. It is well documented, for example, that college students with certain majors such as those related to science, technology, engineering, and math (STEM) tend to earn more than those who graduate with other majors (Berger, 1988; Carnevale, Cheah & Hanson, 2015; Finnie & Frenette, 2003).

Though many in the US take the relationship between college major and earnings for granted, a study by Ford and Choi (2018) using the 2012 Programme for the International Assessment of Adult Competencies (PIAAC) data introduced some nuance by bringing student skills into the equation. They found that students' levels of general cognitive skills had a significant influence on within-major heterogeneity in earnings and that highly skilled students from typically low-earning majors could earn more than lower skilled students from typically high-earning majors. The authors argued that their findings supported a "human capital framing of labor market returns: skills and competencies, rather than credential alone…[are] important in determining labor market returns" (p. 25).

A question, however, remains to be answered whether these findings hold in a country whose education system is very different from the system in the United States. In Germany, for example, the

education system sorts students into three separate “tracks” after fourth grade based on their demonstrated academic aptitude and only students in the highest track are eligible to obtain a university degree. Students in the other two tracks can obtain a variety of vocational postsecondary degrees that often, through direct coordination with employers through mechanisms such as apprenticeships, connect directly to occupations that are different from those that are available to university graduates (Mueller, Steinmann, & Ell, 1995). In this German context where students are tracked during childhood into vocational or academic postsecondary paths based, in part, on demonstrated levels of cognitive skill (despite being measured at a much earlier stage when there is a substantial potential for change), do cognitive skills differentiate earnings between university students of the same major as significantly as in the US case? It could be that the ‘signal’ of a certain credential (e.g., a university degree) in the labor market is more uniform when fewer students are given access to that credential in the first place and when the paths between certain degrees and certain occupations is more linearly defined.

To address this question, I will replicate the analyses Ford and Choi (2018) conducted with US data for Germany, using the 2012 PIAAC dataset. The specific research questions I will address are:

1. *Do general cognitive skills explain within-major heterogeneity in earnings among university graduates in Germany as they do in the United States?*
2. *How do general cognitive skills interact with specific skills and knowledge acquired in university majors to explain earnings? How do these results compare to those of the United States?*

Literature Review

Theoretical Framework: Human Capital Theory vs. Signaling Theory

Human capital theory argues that investments in education increase an individual's knowledge and skills – their human capital – which in turn leads to increases in their productivity and enhances their job performance (Becker, 1964; Cai, 2013). Ford and Choi's study is based on the idea of bringing actual measures of skills back into the concept of human capital as opposed to relying on education level as a proxy for skills when examining labor market outcomes.

In replicating Ford and Choi's analysis for Germany, a country with more rigid tracks into higher education than in the United States, I seek to uncover whether signaling theory – a competing theory which posits that employers, in the absence of perfect information about their potential employees, use levels of educational attainment as 'signals' about employee traits and abilities (Cai, 2013) – might better explain post-college labor market outcomes in economies where assumptions about students' abilities are baked into their educational trajectories at an early age.

This hypothesis is inspired by a study by Breen (2005), in which he extends the original economics-based signaling theory into a sociology-based theory that conceptualizes signaling at the level of the education system, not the individual. He posits that systems with higher levels of vocational education, where there are stronger ties between education institutions and employers, send clearer signals to employers about students' fit for specific jobs. While his study focused on finding evidence for this clearer signaling specifically for vocational students, it could be assumed that the smaller, more specialized higher education niche in those countries would lead to a clearer employment signal for college graduates as well. In line with this assumption, Heisig (2018) analyzed 2012 PIAAC data and found that there was high internal homogeneity in general cognitive skill levels within educational groups

(i.e., groups of individuals with similar education levels) in countries with strong ability-related tracking such as Germany, which, as Heisig states, bolsters the hypothesis that "stronger tracking increases the skill transparency (i.e., the signaling value) of educational degrees" (p. 27). If the earnings of college graduates in Germany are not significantly influenced by students' levels of general cognitive skills, my findings will also lend support to the idea that signaling theory is perhaps a more salient description of the mechanism by which labor market outcomes are determined in countries with strongly tracked educational systems.

United States Context: Earnings Differentials among Majors and the Impact of Skills on the Major-Earnings Relationship

In the United States, attending college is routinely messaged as the route to economic opportunity for all students. Abel and Dietz (2019) outlined how the college wage premium has grown from about 45% in the 1970s to almost 75% in more recent years, and college affordability proposals have abounded at both the state and federal levels based on the assumption that college is a prerequisite for success in the labor market (Harris, 2019; Smith, 2018). Since the US does not have a formally tracked education system, all students have the potential to attend college and reap the benefits of a college degree, which further fuels the rhetoric of college being the opportunity gateway for all.

Upon examination of college graduates' actual outcomes, however, there are many factors that influence the degree to which college leads to later economic success, such as choice of college major. A strong body of research has shown the stark differences in earnings that can be observed among graduates with different college majors, even demonstrating that the earnings differential between some majors is greater than the earnings differential between college graduates and high school graduates (e.g., Carnevale, Cheah & Hanson, 2015; Deming & Noray, 2019; Finnie & Frenette, 2003; Kim, Tamborini & Sakamoto, 2015; Thomas & Zhang, 2005). Across such studies, STEM majors are generally found to be

the most lucrative, both upon entry into the labor force and over the life course. For example, Carnevale, Cheah, and Hanson (2015) show that the average median annual wage for entry-level STEM majors was $14,000 higher than that of arts, liberal arts, and humanities majors. This difference grew to $25,000 when they examined median annual wages of non-entry-level workers (ages 25-59) from these fields of study. There are many variables that mediate the relationship between major and earnings, such as whether students work in an occupation related to their field of study and the rate at which a given field is impacted by technological change (Deming & Noray, 2019; Melguizo & Wolniak, 2012). One such mediating variable that Ford and Choi sought to examine in more depth was individuals' level of general cognitive skills.

Since an individual's level of cognitive skills is difficult to capture in full, the limited body of research that examines the impact of skill on the major-earnings relationships has relied on assessments such as the Armed Forces Qualification Test (AFQT) and pre-college assessments like the SAT and ACT. Arcidiacono (2014) found that math ability, as measured by the SAT, influenced a student's likelihood of sorting into a lucrative major, but also that natural science and business majors benefited from an earnings premium even after controlling for ability-based sorting. Paglin and Rufolo (1990), a study with similar aims, also found that students' SAT math scores influenced their likelihood of sorting into a high-earning field but did not find significant major-specific earnings premiums. Wolniak et al. (2008) assessed the impact of both pre-college academic ability, as measured by the ACT, and choice of major on future earnings for a large sample of alumni from 30 colleges. While ability had a small but significantly positive impact on earnings, graduation with specific majors was found to have a much greater effect on earnings independent of ability level.

While more studies exist that consider both a measure of cognitive ability and choice of college major when examining students' long-term earnings (e.g., Monks, 2000), the measure of cognitive ability is used as a control variable among other individual background characteristics instead of as an independent variable of interest. Consequently, Ford and Choi (2018) contributed to the literature by

directly examining the joint effect of cognitive skill and chosen field of study on earnings, finding that cognitive skill positively and significantly influenced within-major heterogeneity in earnings. By using PIAAC data, they also pioneered the use of an assessment that was meant to capture cognitive skills in a way that is relevant to different social and economic (employment) contexts instead of generic cognitive ability.

Germany Context: Earnings Differentials among Majors and the Impact of Skills on the Major-Earnings Relationship

Unlike the US, Germany has a highly structured education systems that features ability-based tracking starting in primary school. Based on grades and test scores in fourth grade, students are placed into one of three tracks, two vocational and one academic, and attend different schools for the rest of their education. While switching between tracks is possible after fourth grade, it is not common (LeTendre, Hofer, & Shimizu, 2003). In contrast to the US where attending college is seen as the gateway to opportunity to all, Germany's tertiary education participation rate is below the OECD average due, in part, to its robust vocational education and training system (OECD, 2019). The two vocational education tracks provide clear and regulated pathways to specific occupations, which are largely separate from careers pursued by university graduates. Thus, when considering the impact of skills and major on labor market outcomes for German university graduates, it is important to realize that the context in which they are educated and employed is much more segmented than that in the US, which could lead to interesting and unique differences.

The segment of the relevant research that focuses on German university students confirms that there is an earning differential among college majors in Germany as well, just like in the United States. Goerlitz and Grave (2012) studied the wage differential among majors and found that graduates from arts and humanities fields earned less than graduates from social sciences, natural sciences, and engineering

fields, both upon labor market entry as well as five to six years after graduation. Similar hierarchies in earnings among German university graduates from different fields of study were also identified by Wahrenburg and Weidl (2007) and Ammermueller and Weber (2005). Interestingly, other studies that revealed earnings differences among majors were actually focused on investigating the gender wage gap among German university graduates. While examining the gender wage gap, researchers found that a large portion of the gender-based wage inequality in Germany could be explained by field of study, with men more often studying in technical STEM fields and women tending to choose majors in education, social studies, and the humanities (Braakman, 2008; Francesconi & Parey, 2018; Machin & Puhani, 2003). This marked difference in earnings among students from different majors does not rule out the possibility that signaling theory is at play in the German labor market – it merely indicates that the level of the 'signal' that is relevant to employers might be at the level of the college major, not the level of the overall college degree. It is still relevant to examine whether skills have any influence on the major-earnings relationship. In fact, Goerlitz and Grave noted that their inability to "control adequately for the students' (specific) ability" was a limitation of their study.

Though I was unable to find studies that examine the effect of both major and skill levels on earnings for college graduates in Germany, a body of literature shows the positive impact that general cognitive skills seem to have on earnings. In a study of German workers, for example, Antoni and Heineck (2012) found that "a one standard deviation increase in numeracy is, on average, associated with a 6 percent increase in gross earnings of full-time employed workers, whereas there is an earnings differential of 3 percent for a standard deviation increase in literacy" (p. 17). In a study of the return to skills across 23 countries, Hanushek et al. (2015) found that higher levels of general cognitive skills were systematically correlated with higher wages in all countries included in the study. There was significant heterogeneity in the level of return across countries, however, and they found that Germany had one of the highest levels of return to skills, along with the United States and Ireland. While the existing research indicates that general cognitive skills positively influence earnings at the macro level in Germany, it

remains to be seen whether general cognitive skills will have an influence on within-major heterogeneity in earnings among college graduates as well.

Data, Methods, and Analysis Plan

Data

The dataset used for this study was the German data from the 2012 PIAAC survey. The specific data and specifications I used were modeled closely after the ones used in the Ford and Choi (2018) in order to enable a meaningful comparative analysis. As such, my analytical sample only included individuals who have graduated from a 4-year college or university. I excluded any individuals who were: not between the ages of 25-65, part-time workers, self-employed, or workers who are reportedly full-time but work less than 30 hours per week. To diminish the impact of outliers, I also excluded any individuals who are in the top 1% of earners. Individuals with missing values for any of the variables included in the analysis were also dropped. Ford and Choi were able to conduct their study with a final working sample of 970 respondents after making the exclusions noted above. The working sample for the Germany PIAAC data, after applying the exclusions above, consisted of 589 respondents. Though this working sample is smaller than Ford and Choi's US working sample, I still considered it large enough to continue with the analysis.

While this is not a data exclusion, Ford and Choi reclassified the nine fields of study from the PIAAC questionnaire into five more general categories by combining several fields into a broader Social Sciences category and combining the STEM fields, as defined by the U.S. Department of Homeland Security's classification of STEM majors, into one category. They conducted this recategorization in order to work around small sample sizes in individual fields of study, and I applied this same recategorization in order to obtain acceptable sample sizes for each field of study categorization. Though some of the field sample sizes were relatively small (e.g., the smallest field "Health" consisted of 44 respondents), I decided that since each field had more than 30 respondents the sample sizes were large

enough to meet the normality assumption of my intended Ordinary Least Squares (OLS) regression model (more details regarding the methodology used are provided in the next section).

Methods and Analysis Plan

For the analysis, I used a multiple regression model following Ford and Choi (2018). The main OLS equation to be estimated is noted below:

$$log(y_i) = \beta_0 + \gamma_{1j} Major_j + \beta_2 Skill_i + \beta_3 Gradschool_i + \gamma_{2j} Major_j * Skill_i + X_i + \varepsilon_i$$

The main dependent variable is individual earnings, which is measured by the log of the respondents' monthly income, represented by y_i. (Monthly income values exclude bonuses and were converted to 2012 US dollars.) The two independent variables, college major and level of general cognitive skills, are indicated by $Major_j$ and $Skill_i$ in the equation above. $Major_j$ indicates the academic major for respondents' highest educational degree, and the "teacher training and education science" major (referred to henceforth as "education") serves as the reference group. For the $Skill_i$ variable, the PIAAC scores for literacy and numeracy are used for separate models. (The regression will be run with the literacy scores and then run separately for the numeracy scores. This is because literacy and numeracy levels are highly correlated.) All ten plausible values for each skill will be utilized and the scores are standardized to have a mean of zero and a standard deviation of one across the analytic sample. The interaction between major and skill is represented by the $Major_j$ * $Skill_i$ variable in the equation. Specifically, this variable shows how the relationship between skills and earnings for a graduate with a certain major differs compared to that of the reference group. A vector of control variables is included as X_i in the equation, which includes demographic and socioeconomic characteristics of each individual including gender, race, parental education levels, work experience, immigrant status, and the degree of skill-use that takes place at work. $Gradschool_i$ is a dummy variable that has a value of 1 if an individual has a degree beyond a bachelor's degree and a value of zero if not.

I ran the model five times for each set of PIAAC skills (literacy and numeracy), starting with a simple linear regression that just includes the $Major_j$ variable and then adding on more variables with each iteration of the model. Ford and Choi conducted their analysis in this way in order to observe how the effects of each variable changed as more variables were added in, so I replicated this aspect of their study as well in order to obtain comparable results.

Results

In Table 1, I present descriptive statistics about the key variables of interest for the analytical sample that I use in the models. I provide the analogous comparison from the Ford & Choi (2018) US sample in the table as well. The US sample exhibits higher mean earnings as well as higher mean work experience. While the German sample has higher numeracy scores, literacy scores are fairly comparable in both countries, as is the age distribution of adults in each sample. The distribution of majors does not differ significantly between the US and German samples, though it should be noted that the percentage of German adults in the sample who attended graduate school is much higher than in the US sample (85.4% versus 40.8%.)

The regression results for the models that used the PIAAC numeracy scores for the $Skill_i$ variable are shown in Table 2 below, while the models that use the PIAAC literacy scores for the $Skill_i$ variable are shown in Table 3. Model 1 was the "baseline" model that only included field of study as the independent variable, and each progressive model added new variables, which will be described below. For ease of reference, the new variables that were incorporated in each version of each model are highlighted in the respective tables.

The baseline model (Model 1) indicates that STEM majors and social sciences majors have significantly higher earnings than education majors, while there is no such evidence for those who majored in humanities or health and welfare-related subjects. This changes slightly in Model 2 when numeracy and literacy skills are added into their respective models: the level of cognitive skills (numeracy or literacy) is the most significant factor that positively influences earnings, though graduating with a major from a STEM or health/welfare-related field still positively impacted earnings. The Model 2 results indicate that workers who scored one standard deviation higher in the PIAAC numeracy assessment earned, on average, 12% more than others who graduated with the same major and those who scored one standard deviation higher in the PIAAC literacy assessment earned, on average, 10% more than others who graduated with the same major. While these percentages are lower than the ones Ford and

Table 1. Descriptive statistics for analytic sample (weighted)

	Germany					United States				
Variable	**Mean**	**Std Dev.**	**Std Err.**	**Min**	**Max**	**Mean**	**Std Dev.**	**Std Err.**	**Min**	**Max**
Monthly income (dollars)	5290.12	2564.42	142.54	498.61	17451.51	6122.41	3573.19	25.70	247.00	21666.67
Numeracy	315.68	40.06	1.97	155.30	437.54	299.07	43.04	143.51	133.53	427.94
Literacy	306.48	37.26	1.84	161.31	412.81	307.28	38.02	162.90	149.83	425.60
Age	43.45	10.44	0.22	25.00	65.00	42.52	11.18	142.55	25.00	65.00
Work experience (yrs)	18.96	11.11	0.24	0.00	45.00	21.61	11.57	63.29	0.00	47.00

Variable	**Percentage**	**Std Dev.**	**Std Err.**	**Percentage**	**Std Dev.**	**Std Err.**
Major						
Education	14.43	0.34	0.01	14.01	0.35	9.57
Humanities	8.15	0.28	0.02	13.50	0.34	9.90
Social sciences	30.90	0.45	0.01	35.85	0.48	15.51
STEM	39.05	0.49	0.00	25.42	0.44	13.53
Health	7.47	0.26	0.02	11.21	0.32	10.88
Female	41.94	0.49	0.00	50.92	0.50	44.81
Graduate school	85.40	0.36	0.02	40.80	0.49	19.33
Immigrant	14.94	0.37	0.02	18.55	0.39	11.19
Parent's education						
less than high school	3.20	0.19	0.03	5.62	0.23	6.21
high school	40.64	0.49	0.00	36.49	0.48	18.97
above high school	55.48	0.50	0.00	57.89	0.49	31.85
N	589			970		

Note: Sampling weights applied in calculations of means and standard deviation values.
Source : PIAAC 2012, German data comes from author's calculations, US data from Ford & Choi (2018)

Choi observed for the US data (they observed an average earnings increase of 16.7% and 14.9% respectively for a single standard deviation increase in numeracy and literacy scores), these results indicate that my hypothesis about cognitive skills having less influence over earnings in a country with a more rigidly tracked education system than the US (i.e., Germany) is not robustly supported by these results.

In Model 3, I incorporated several control variables into the model: gender, work experience, graduate school attendance, immigrant status, and parental education. The positive and significant influences of health/welfare-related studies and cognitive skills on earnings are maintained in this model, though STEM-related studies no longer significantly impact earnings. It also becomes apparent that certain background characteristics, such as gender, work experience, and graduate school attainment, matter more for earnings than choice of major. Females earned less, on average, while those who attended graduate school earned more. Work experience also had a positive impact on earnings, though the negative coefficient for the squared work experience variable indicates that the impact of work experience on earnings decreases as years of experience increase. Ford and Choi observed similar impacts of gender, graduate school, and work experience on earnings in their analysis of US data, with the main difference being that field of study also still significantly impacted earnings after they added in their control variables.

Model 4 incorporates interaction effects between field of study and cognitive skill, as assessed by the PIAAC. The version of the model that uses numeracy scores for the $Skill_i$ variable does not reveal any significant interaction effects, meaning that numeracy skills do matter for earnings in general but that there is no evidence that numeracy skills influence earnings differently for individuals from different fields of study. The version of the model that uses literacy scores, on the other hand, reveals one interesting result. The coefficient for the interaction between literacy score and the humanities field of study was strongly significant and negative. It is impossible to interpret this result with any real clarity with just the data available from this study, but one possible explanation for this interaction effect could

be that humanities majors with especially strong literacy skills go into occupations with historically low or unreliable incomes, such as journalism. Due to the relatively small sample sizes in each major category (e.g., the number of adults who graduated with Humanities majors in this sample is 48), it is also possible that these interaction effects results are a consequence of low power.

On a comparative note, these findings about the lack of positive interaction effects between general cognitive skills and different fields of study for German university graduates contrast starkly with Ford and Choi's findings with the US data. For US college graduates, Ford and Choi found a significant and positive interaction effect between several fields of study (Humanities, Social Sciences, and STEM) and both literacy and numeracy skills, meaning that the returns to both literacy and numeracy skills are higher for students from these three fields of study than they are for graduates whose majors fell within the realms of Education or Health. Again, while it is difficult to discern the underlying reasons for this contrast, it could be that positions available in the US to Education and Health graduates do not reward skill as much as similar positions do in Germany. (For example, teachers with higher levels of general cognitive skills in Germany might be more likely to advance and receive higher compensation than similarly skilled teachers in the US.)

In Model 5, I incorporated variables that indicated whether a respondent used numeracy or literacy skills at work. Surprisingly, the coefficients relating numeracy skills at work and writing at work to earnings were both significant and negative, while there was no significant correlation between reading at work and earnings. These results would seem to indicate that individuals who use numeracy and writing skills at work get paid less, on average. It is possible that this counterintuitive finding could be due to the high level of correlation between numeracy/literacy skills and using numeracy/writing skills at work. As with Model 4, these results contrast with those from Ford and Choi's analysis of the US data. Their results revealed a positive and significant relationship between earnings and the use of numeracy skills at work, as well as between earnings and both reading and writing at work.

Table 2. OLS Regression on monthly earnings – Numeracy

	Germany					United States				
VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 1	Model 2	Model 3	Model 4	Model 5
Major										
Education (omitted)	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--
Humanities	0.010	-0.002	-0.008	-0.020	-0.007	0.104	0.041	0.144*	0.200**	0.229**
	(0.103)	(0.100)	(0.086)	(0.086)	(0.082)	(0.073)	(0.069)	(0.072)	(0.077)	(0.074)
Social Sciences	0.125*	0.080	0.063	0.072	0.071	0.327***	0.254***	0.340***	0.394***	0.378***
	(0.058)	(0.058)	(0.059)	(0.061)	(0.060)	(0.055)	(0.055)	(0.057)	(0.058)	(0.054)
STEM	0.154***	0.106**	0.049	0.062	0.069	0.342***	0.231***	0.309***	0.370***	0.323***
	(0.046)	(0.053)	(0.052)	(0.053)	(0.054)	(0.063)	(0.067)	(0.065)	(0.064)	(0.067)
Health and welfare	0.163	0.146*	0.157*	0.190**	0.176**	0.234***	0.231***	0.324***	0.384***	0.380***
	(0.088)	(0.083)	(0.083)	(0.082)	(0.083)	(0.084)	(0.083)	(0.069)	(0.083)	(0.083)
Numeracy (standardized)		0.120***	0.085***	0.047	0.056		0.167***	0.119***	-0.051	-0.020
		(0.029)	(0.028)	(0.068)	(0.069)		(0.025)	(0.026)	(0.045)	(0.038)
Numeracy at work					-0.109***					0.080***
					(0.025)					(0.021)
Female			-0.238***	-0.237***	-0.245***			-0.154***	-0.142***	-0.149***
			(0.041)	(0.043)	(0.041)			(0.044)	(0.043)	(0.042)
Work experience			0.042***	0.042***	0.039***			0.032***	0.033***	0.033***
			(0.011)	(0.011)	(0.010)			(0.007)	(0.007)	(0.007)
Work experience ^2			-0.001***	-0.001***	-0.001***			-0.001***	-0.001***	-0.001***
			(0.000)	(0.000)	(0.000)			(0.000)	(0.000)	(0.000)
Graduate school			0.189**	0.190**	0.170**			0.260***	0.254***	0.228***
			(0.074)	(0.074)	(0.069)			(0.043)	(0.042)	(0.044)
Immigrant status			0.010	0.005	0.018			0.018	0.019	0.026
			(0.066)	(0.067)	(0.064)			(0.065)	(0.065)	(0.064)
Parents' education										
Below high school (omitted)	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--
High school			0.045	0.039	0.081			-0.063	-0.069	-0.041
			(0.161)	(0.152)	(0.136)			(0.072)	(0.069)	(0.079)
Above high school			0.121	0.115	0.159			-0.038	-0.040	-0.008
			(0.151)	(0.140)	(0.126)			(0.079)	(0.074)	(0.081)
Major * Numeracy										
Education * Numeracy	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--
Humanities * Numeracy				-0.083	-0.131				0.180*	0.093
				(0.086)	(0.080)				(0.074)	(0.069)
Social Sciences * Numeracy				0.086	0.066				0.210***	0.176***
				(0.089)	(0.091)				(0.054)	(0.048)
STEM * Numeracy				0.026	-0.006				0.166**	0.130*
				(0.080)	(0.079)				(0.061)	(0.051)
Health * Numeracy				0.164	0.155				0.192	0.150
				(0.100)	(0.101)				(0.117)	(0.119)
Observations	589	589	589	589	589	974	974	974	974	925
R-squared	0.015	0.076***	0.243***	0.256***	0.300***	0.045	0.121	0.233	0.243	0.261

Notes: Least squares regression weighted by sampling weights
Standard errors in parentheses: *** p<0.001, ** p<0.01, * p<0.05
PIAAC 2012, German data comes from author's calculations, US data from Ford & Choi (2018)

Table 3. OLS Regression on monthly earnings – Literacy

	Germany					United States				
VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 1	Model 2	Model 3	Model 4	Model 5
Major										
Education (omitted)	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--
Humanities	0.010	0.001	-0.010	-0.029	-0.045	0.104	0.048	0.138	0.174*	0.214**
	(0.103)	(0.105)	(0.090)	(0.080)	(0.079)	(0.073)	(0.071)	(0.072)	(0.078)	(0.073)
Social Sciences	0.125*	0.091	0.061	0.067	0.070	0.327***	0.275***	0.344***	0.379***	0.398***
	(0.058)	(0.058)	(0.060)	(0.062)	(0.060)	(0.055)	(0.052)	(0.057)	(0.058)	(0.056)
STEM	0.154***	0.137***	0.061	0.070	0.066	0.342***	0.0284***	0.323***	0.363***	0.356***
	(0.046)	(0.049)	(0.051)	(0.052)	(0.053)	(0.063)	(0.064)	(0.064)	(0.063)	(0.062)
Health and welfare	0.163	0.142*	0.149*	0.158**	0.156**	0.234**	0.212**	0.310***	0.352***	0.353***
	(0.088)	(0.083)	(0.081)	(0.079)	(0.079)	(0.084)	(0.080)	(0.068)	(0.072)	(0.066)
Literacy (standardized)		0.105***	0.103***	0.055	0.045		0.149***	0.118***	-0.012	0.020
		(0.025)	(0.025)	(0.070)	(0.079)		(0.023)	(0.022)	(0.040)	(0.038)
Read at work					-0.012					0.068**
					(33.011)					(0.025)
Write at work					-0.104***					0.044*
					(0.028)					(0.017)
Female			-0.250***	-0.249***	-0.256***			-0.186***	-0.176***	-0.167***
			(0.040)	(0.041)	(0.042)			(0.042)	(0.042)	(0.038)
Work experience			0.043***	0.043***	0.043***			0.032***	0.033***	0.032***
			(0.010)	(0.011)	(0.010)			(0.007)	(0.007)	(0.007)
Work experience ^2			-0.001***	-0.001***	-0.001***			-0.001***	-0.001***	-0.001***
			(0.000)	(0.000)	(0.000)			(0.000)	(0.000)	(0.000)
Graduate school			0.198***	0.187**	0.167**			0.259***	0.256***	0.216***
			(0.072)	(0.073)	(0.070)			(0.042)	(0.041)	(0.045)
Immigrant status			0.026	0.025	0.073			0.046	0.053	0.083
			(0.064)	(0.064)	(0.064)			(0.064)	(0.064)	(0.057)
Parents' education										
Below high school (omitte	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--
High school			0.016	-0.016	0.016			-0.039	-0.045	-0.045
			(0.154)	(0.152)	(0.140)			(0.071)	(0.070)	(0.082)
Above high school			0.097	0.063	0.109			-0.025	-0.030	-0.045
			(0.145)	(0.141)	(0.129)			(0.080)	(0.077)	(0.086)
Major *Literacy										
Education * Literacy (omi	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--
Humanities * Literacy				-0.200**	-0.190*				0.136*	0.066
				(0.099)	(0.106)				(0.069)	(0.057)
Social Sciences * Literacy				0.078	0.077				0.160**	0.129*
				(0.089)	(0.095)				(0.056)	(0.055)
STEM * Literacy				0.062	0.062				0.114*	0.099*
				(0.079)	(0.086)				(0.052)	(0.050)
Health * Literacy				0.127	0.107				0.183	0.137
				(0.094)	(0.095)				(0.109)	(0.119)
Observations	589	589	589	589	589	974	974	974	974	956
R-squared	0.015	0.063***	0.255***	0.275***	0.320***	0.045	0.108	0.233	0.24	0.241

Notes: Least squares regression weighted by sampling weights
Standard errors in parentheses: *** p<0.001, ** p<0.01, * p<0.05
PIAAC 2012, German data comes from author's calculations, US data from Ford & Choi (2018)

Discussion

When considering my first research question (*Do general cognitive skills explain within-major heterogeneity in earnings in Germany as they do in the United States?)*, I hypothesized that the rigidly tracked structure of Germany's education system might lead employers to be driven more by signaling theory than human capital theory, which would lead to cognitive skills having less influence on within-major heterogeneity in earnings among German adults than among US adults. My analyses, the Model 2 and 3 results in particular, do indicate that general cognitive skills have less of an impact on within-major heterogeneity in earnings in Germany than in the US, but not to a degree that convinces me that the theoretical difference I propose in my hypothesis is supported. Skills still seem to strongly influence within-major heterogeneity in earnings among German college graduates. This general finding could perhaps be seen as a positive sign about the German labor market, that those with higher levels of skill are being rewarded with higher earnings for their skill, but further research is required before any causal relationship between general cognitive skills and earnings can be established.

For my second research question (*How do general cognitive skills interact with specific skill and knowledge acquired in majors to explain earnings? How do these results compare to those of the United States?)*, there is a starker contrast between German and US results. Unlike in the US, general cognitive skills do not appear to influence earnings differently for German individuals from different fields of study – the only exception being the significant and negative effect that higher literacy skills seem to have on earnings of humanities majors. This could be due to the low earning profiles of the types of jobs that highly skilled humanities majors tend to pursue, but further research is required to more clearly explain the mechanism behind this effect.

Overall, the findings from this study provide support for Ford and Choi's idea that discussions around human capital should include measures of skill whenever possible, instead of relying on levels of

educational attainment as a proxy for human capital. Even in education systems with more rigid tracking, such as Germany, it is clear that an individual's level of skill still has significant impact on their labor market outcomes. In terms of policy implications, this conclusion suggests that efforts to equitably develop German students' literacy and numeracy skills, even among students who qualified for the advanced academic educational track, could lead to more positive labor market outcomes for students with initially lower levels of these general cognitive skills. An interesting extension to this study could be to examine whether Germany's grade retention policy has an impact on the apparent relationship between skills of university graduates and labor market outcomes. It is typical in Germany for a student in Gymnasium – the high school equivalent for students on the advanced academic educational track – to have to repeat an entire grade if they fail two classes. Ostensibly, there is a connection between students who fail classes and students with lower levels of general cognitive skills, so it would be interesting to examine whether the relationship between skills and earnings is mediated by whether or not a student had to repeat an entire grade in Gymansium. Such a study could help illuminate the best approach to supporting struggling students on this academic track with minimal impact on their future labor market outcomes.

Another implication of this study stems from the findings related to a student's major. After numeracy/literacy skill level and key background variables such as gender, graduate school attendance, and work experience were factored into Model 3 of the analysis, a German university graduate's field of study was not found to have a significant impact on earnings. This runs counter to the findings from existing studies that assert that an earnings differential does exist for German university graduates from different majors. Since there are, to my knowledge, no other existing studies using adult cognitive skill measures to mediate the relationship between tertiary field of study and earnings in Germany, more research is needed to determine whether factoring in skill levels, in addition to typical demographic control variables, truly does nullify the perceived impact of major choice on labor market outcomes in Germany. This could be done either by using a different measure of cognitive skill levels to examine

university graduate earnings in Germany or by replicating this study using the 2012 PIAAC data for other countries with similar education and labor market structures, such as Austria or Denmark.

Conclusion

Though the education and labor market structures of the US and Germany are very different, my analysis suggests that cognitive skill levels have a similar impact on earnings for German college graduates as they do for US college graduates. German college graduates with higher levels of cognitive skills earn more than other graduates from the same field of study, though not to the same extent as their counterparts in the US. My hypothesis – that cognitive skills would not have significant impact on within-major heterogeneity in earnings of German college graduates due to the prevalence of signaling theory over human capital theory in Germany's rigidly tracked education and labor market systems – is therefore not strongly supported by my findings.

My examination of the interaction effects between college graduates' field of study and levels of cognitive skills, however, revealed an interesting contrast with Ford & Choi (2018)'s US findings. While US college graduates from the humanities, social sciences, and STEM fields enjoy higher returns to both literacy and numeracy skills than those graduates from education or health-related majors, such positive and significant interaction effects were not identified for any majors among German college graduates. This lack of interaction effects could stem from different compensation patterns for vocations linked to specific majors in the US versus in Germany or it could simply be due to the low power of the German sample used for this analysis. Further research is required to clarify this result. Since this study as a whole was descriptive in nature, further research is also needed to examine whether there is any causal relationship between levels of cognitive skills and earnings for German university graduates.

References

Abel, J.R., & Deitz, R. (2019). Despite rising costs, college is still a good investment. Retrieved from https://libertystreeteconomics.newyorkfed.org/2019/06/despite-rising-costs-college-is-still-a-good-investment.html.

Ammermueller, A., & Weber, A.M. (2005). Educational attainment and returns to education in Germany – An analysis by subject of degree, gender, and region (ZEW Discussion paper No. 05-17). Retrieved from SSRN website: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=711063.

Antoni, M., & Heineck, G. (2012). Do literacy and numeracy pay off? On the relationship between basic skills and earnings. Discussion Paper No. 6882. Institute for the suty of Labor: Bonn.

Arcidiacono, P. (2004). Ability sorting and the returns to college major. *Journal of Econometrics, 121*, 343-375.

Becker, G. S. (1964). Human capital: A theoretical and empirical analysis, with special reference to education. Chicago: University of Chicago Press.

Berger, M. C. (1988). Predicted future earnings and choice of college major. *Industrial & Labor Relations Review, 41(3),* 418–429.

Braakman, N. (2008). Non scholae, sed vitae discimus!: The importance of fields of study for the gender wage gap among Germany university graduates during labor market entry and the first years of their careers. Working Paper Series in Economics, No. 85. Institute of Economics, Leuphana Universitaet Lueneburg.

Breen, R. (2005). Explaining cross-national variation in youth unemployment: Market and institutional factors. *European Sociological Review, 21(2),* 125-134.

Cai, Y. (2013). Graduate employability: A conceptual framework for understanding employers' perceptions. *Higher Education, 65,* 457-469.

Carnevale, A. P., Cheah, B., & Hanson, A. R. (2015). The economic value of college majors. Washington, D.C.: Center on Education and the Workforce, Georgetown University.

Deming, D.J., & Noray, K. (2019). STEM careers and the changing skill requirements of work (NBER Working Paper No. 25065.) Retrieved from National Bureau of Economic Research website: https://www.nber.org/papers/w25065

Finnie, R., & Frenette, M. (2003). Earning differences by major field of study: evidence from three cohorts of recent Canadian graduates. *Economics of Education Review, 22(2),* 179–192.

Ford, K. and Choi, J. (2018). The Importance of Skills and Majors in Determining Future Earnings. Retrieved October 14, 2019 from PIAAC Gateway website: http://piaacgateway.com/researchpapers. Washington, DC.

Francesconi, M., & Parey, M. (2018). Early gender gaps among university graduates. *European Economics Review, 109,* 63-82.

Goerlitz, K., & Grave, B.S. (2012). Wage differentials by field of study: The case of German university graduates. Ruhr Economic Papers, No. 316. Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI): Essen. http://dx.doi.org/10.4419/86788363

Golsteyn, B.H.H. & Stenberg, A. (2017). Earnings over the life course: General versus vocational education. *IZA Institute of Labor Economics: Discussion Paper Series. IZA DP no. 10593.*

Hanushek, E.A., Schwerdt, G., Widerhof, S., & Woessmann, L. (2015). Return to skills around the world: Evidence from PIAAC. *European Economic Review, 73,* 103-130.

Hanushek, E.A., Schwerdt, G., Woessmann, L., & Zhang, L. (2017). General education, vocational education, and labor-market outcomes over the lifecycle. *Journal of Human Resources, 52*(1), 48-87.

Harris, A. (2019, February 26). The college-affordability crisis is uniting the 2020 Democratic candidates. *The Atlantic.* Retrieved from https://www.theatlantic.com/education/archive/2019/02/2020-democrats-free-college/583585/.

Heisig, J. P. (2018). Measuring the signaling value of educational degrees: Secondary education systems and the internal homogeneity of educational groups. *Large-scale Assessments in Education,* 6-9.

Kim, C., Tamborini, C.R., & Sakamoto, A. (2015). Field of study in college and lifetime earnings in the United States. *Sociology of Education, 88*(4), 320-339.

LeTendre, G.K., Hofer, B.K. & Shimizu, H. (2003). What is tracking? Cultural expectations in the United States, Germany, and Japan. *American Educational Research Journal, 40*(1), 43-89.

Machin, S., & Puhani, P.A. (2003). Subject of degree and the gender wage differential: evidence from the UK and Germany. *Economics Letters, 79*(3), 393-400.

Melguizo, T., & Wolniak, G.C. (2012). The earnings benefits of majoring in STEM fields among high achieving minority students. *Research in Higher Education, 53,* 383-405.

Monks, J. (2000). The returns to individual and college characteristics: Evidence from the National Longitudinal Survey of Youth. *Economics of Education Review, 19*, 279-289.

Mueller, W., Steinmann, S., & Ell, R. (1995). Education and labour market entry in Germany. *Mannheimer Zentrum fuer Europaische Sozialforschung (MZES).*

Organisation for Economic Co-operation and Development. (2018). Education Indicators in Focus #62: How does the earnings advantage of tertiary-educated workers evolve across generations? Paris: OECD Publishing.

Organisation for Economic Co-operation and Development. (2019). Education at a glance 2019: Country note – Germany. Paris: OECD Publishing.

Paglin, M., & Rufolo, A.M. (1990). Heterogeneous human capital, occupational choice, and male-female earnings differences. *Journal of Labor Economics, 8*(1), 123-144.

Smith, A. A., (2018, September 26). Free-college realities. *Inside Higher Ed.* Retrieved from https://www.insidehighered.com/news/2018/09/26/free-college-proposals-shift-fit-state-needs-and-emulate-successful-examples

Thomas, S.L., & Zhang, L. (2005). Post-baccalaureate wage growth within four years of graduation: The effects of college quality and college major. *Research in Higher Education, 46*(4), 437-459.

Wahrenburg, M., & Weldi, M. (2007). Return on investment in higher education: Evidence for different subjects, degrees and gender in Germany. Frankfurt: Goethe University.

Weber, S. (2014). Human capital development and education level. *International Journal of Manpower, 35(5),* 613-642.