Horizontal Stratification of Higher Education: The Relative Importance of Field of Study, Institution, and Department for Candidates' Wages

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Abstract

Studies typically find large variation in labor market outcomes not only between educational levels, but also among individuals with a higher education. However, the importance of different types of horizontal divisions in higher education is mostly treated in separate literatures. In this paper, we use multilevel models and an outcome-based approach to investigate the relative importance of institution (college), department, and field of study in the Norwegian labor market. We find that the effects of field of study on wages are generally strong. The overall effects of institution are also quite large, but they emerge to a considerable extent at the level of departments; the effects of institution over and above the effects of department are small. We also show that the effects of horizontal divisions are greater at the graduate than at the undergraduate level, and that the effects of horizontal divisions increase over individuals' work careers.

Keywords

outcome-based approach, horizontal stratification, field of study, institution, department

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INTRODUCTION

Horizontal divisions within higher education are increasingly important in the labor market (Gerber and Cheung 2008) and for the social stratification process (Lucas 2001; Marginson 2016). In recent decades, the number of students in higher education has expanded dramatically (Schofer and Meyer 2005) to include more than 50 percent of birth cohorts in a number of industrialized countries (Perkin 2007; Trow 2007). These students enter a system of higher education characterized by increasing horizontal differentiation in terms of fields of study, institutions, and types of institution (Perkin 2007). Thus, students with a higher education are increasingly heterogeneous with regard to both the type of qualifications and the quality of these qualifications.

Consequently, horizontal dimensions may have become more important than the vertical dimension, i.e., between individuals with and without higher education (Kim, Tamborini, and Sakamoto 2015), which has implications for the literature on the returns to education. Additionally, the least prestigious institutions have absorbed a large share of the growing number of students from disadvantaged backgrounds (Davies and Guppy 1997), and family background affects fields of study in higher education (van de Werfhorst, de Graaf, and Kraaykamp 2001). Horizontal differentiation within higher education may thus be an important aspect of the social stratification process (Marginson 2016).

A number of studies investigate the effects on labor market outcomes of horizontal divisions within higher education, focusing on the effects of either field of study or institution (college quality) (Gerber and Cheung 2008). These studies typically find large labor market differences between individuals with a higher education (Altonji, Blom, and Meghir 2012). Indeed, students enrolling in low-paying fields of study or institutions may even be better-off monetarily by not enrolling in higher education at all (Altonji, Kahn, and Speer 2014).

Studies examining both field of study and institution conclude that an individual's

choice of field appears to matter considerably more than choice of institution (e.g., Grove and Hussey 2011). However, field of study and institutional quality are mostly treated in separate literatures (Eide, Hilmer, and Showalter 2015). On the one hand, the college quality literature mostly relies on established college rankings (e.g., Brewer, Eide, and Ehrenberg 1999) or on measures of specific quality dimensions, such as the average test scores of admitted students (Dale and Krueger 2002). Fields of study, on the other hand, are often treated as nominal categories (e.g., science, humanities) (Reimer, Noelke, and Kucel 2008) or in terms of the types of qualifications they are supposed to provide (van de Werfhorst and Kraaykamp 2001). Thus, the effects of different horizontal divisions are not easily comparable.

A small number of studies consider both field of study and institution effects (Grove and Hussey 2011; James et al. 1989; Loury and Garman 1995; Triventi 2013). However, even these studies typically employ methods that do not make institution and field effects directly comparable. An exception is the study of Norwegian data by Kirkeboen, Leuven, and Mogstad (2016), which treats both fields and institutions as nominal categories. However, they use an estimation approach that only allows them to examine a highly selective subpopulation of the total undergraduate and graduate population, and they do not provide measures of the overall importance of institution and field of study effects.

In this paper, we add to the literature by comparing the effect sizes of different horizontal divisions within higher education using population-wide Norwegian register data. We accomplish this by turning to a so-called outcome-based approach. This approach has gained popularity in the teacher quality literature in the last decade (Hanushek and Rivkin 2012). Essentially, the idea is to estimate each single teacher's effect on the outcome variable (typically a test score), and then to use the dispersion of these effects as an overall measure of the impact of teacher quality. By using a random effects model, we employ a similar approach. Our main contribution is to apply the outcome-based approach simultaneously to the wage

effects of fields of study and of institutions, thus allowing us to connect the two distinct literatures and to provide a quantitative comparison of the *relative* importance of these effects.

The paper also adds to the literature in several other ways, substantively and methodologically. First, the college quality literature has generally treated educational institutions as homogeneous entities, and has largely neglected the possibility of substantial within-institution quality variation, specifically across departments (Black and Smith 2006). Given their relatively decentralized structure, the department level is likely to be particularly important in research universities (Altbach 2011). In this paper, we investigate how graduates' wages vary at both the level of the institution as a whole and at the department level.

Second, the level of aggregation of fields of study differs widely from study to study (Altonji, Blom, and Meghir 2012). Most studies distinguish between roughly 10 categories (Reimer, Noelke, and Kucel 2008), although some include only four very broad categories (Loury and Garman 1995), and others more than 50 (Altonji, Kahn, and Speer 2014). From a methodological point of view, particularly with regard to comparison between studies, it is important to determine how sensitive the results are to the level of aggregation, and to determine how many categories are necessary. We investigate the consequences of degree of aggregation by comparing results using 9, 54, and 133 field of study categories.

Third, we investigate whether the effects of horizontal divisions change over individuals' work careers. Strong effects of horizontal divisions early in individuals' labor market careers suggest that employers use horizontal divisions to screen job applicants, while effects emanating only later suggest that employers learn about individuals' productivity over time (Arcidiacono, Bayer, and Hizmo 2010). Finally, little is still known about the effects of field of study at the graduate level (Altonji, Blom, and Meghir 2012). In this paper, we compare the effects of horizontal divisions within higher education at the undergraduate and graduate levels.

The specificity of the Norwegian case influences the findings in this paper. Compared to the United States, we expect that field of study will matter relatively more than institution in Norway. First, Norway has a mainly publicly financed higher education system, and as a result, the quality differences between institutions are likely modest compared with countries like the US. Second, Norway has a large public sector, and the wage structure is considerably more compressed in the public than in the private sector (Barth and Røed 1999). The correspondence between field of study and sector of employment is strong in Norway, which is likely to strengthen the relative effects of field of study on wages.

A limitation of this paper is that we cannot take students' selection into various institutions and fields of study fully into account (Altonji, Arcidiacono, and Maurel 2016; Brand and Xie 2010). Thus, the parameters estimated cannot be given a direct causal explanation. However, we attempt to take selection into account as far as possible by controlling for a broad range of student characteristics (e.g., parental schooling and earnings, immigrant background, grade point average (GPA) from upper secondary education). In particular, control for upper secondary GPA means that our model is similar to the type of value-added model that has been found to perform well in studies of teacher effects (Guarino, Reckase, and Wooldridge 2015). Additionally, we implement a strategy suggested by Dale and Krueger (2002), based on data on the students' college applications.

THEORETICAL ISSUES

The theoretical interpretation of field of study effects has received little attention. An exception is the work of van de Werfhorst and Kraaykamp (2001), suggesting a typology of skills (i.e., economic, cultural, communicative, and technical) that various fields of study provide to different extents. This theory can be seen as a further development of human capital theory, in which the field of study determines the kind of human capital a student acquires.

Alternatively, field of study effects might be theorized in terms of other general theories of the effects of education, such as signaling theory (Weiss 1995). In that case, choice of field of study provides information about students' preexisting qualities or skills (Kim, Tamborini, and Sakamoto 2015). Reimer, Noelke, and Kucel (2008) argue that because of educational expansion, less able students are increasingly being sorted into less academically challenging fields. As the mean ability in these fields declines (but not in other, more prestigious fields), the signaling value of these fields of study also declines.

Finally, some field of study effects may be interpreted in light of theories of social closure (Weber 1978). According to such reasoning, privileged groups employ mechanisms such as educational credentialing or licensing to close off competition to certain occupations (e.g., medicine) (Collins 1979). By restricting the supply of candidates, and thereby generating a scarcity of qualified individuals, occupational groups maximize their rewards (Weeden 2002).

Theoretically, there are several reasons to expect the institution to affect success in the labor market. Institutions differ in the quality of the academic faculty, the ability and motivation of the peers, and the resources available, and should be expected to differ in their effectiveness in increasing the students' human capital (Zhang 2005). Employers may also use the institution as a signal of an individual's productivity (Arcidiacono, Bayer, and Hizmo 2010; Weiss 1995).

An individual may benefit from attending an elite institution for reasons unrelated to productivity. According to Rivera (2012), hiring in the elite labor market is not only about skill sorting, but also a process of cultural matching (see also Rivera 2011). When elite employers hire, they prefer competent candidates that are culturally similar to themselves with regard to leisure pursuits, experiences, and self-presentation (Rivera 2012). Having attended similar institutions is one such mark of cultural fit (Rivera 2011). Social networking is also likely to be unrelated to productivity. An individual who attends an elite institution may develop

networks with other students and faculty (Gerber and Cheung 2008) as well as potential future employers (Rivera 2011; Tholen et al. 2013).

THE EMPIRICAL LITERATURE

The common approach in the literature on field of study effects is to report the estimated payoff to each specific field, with field being more or less broadly defined (for reviews, see Altonji, Blom, and Meghir 2012; Gerber and Cheung 2008). This literature covers several countries and demonstrates widely different payoffs to the various fields. Typically, students with engineering, business, science, or mathematics majors fare better than average, while students in humanities, education, and social sciences fare less well (Gerber and Cheung 2008). Although there are some indications that the effects of field of study are most pronounced immediately after graduation, the research on this subject is scarce (Pascarella and Terenzini 2005).

In contrast to the field of study literature, mainly estimating the overall variation between fields, studies of institutions focus on effects of specific indicators of quality, such as overall college rankings, the research productivity of the academic staff, or the average GPA of the student body. The bulk of evidence suggests that the payoff to higher education institutions is small (for reviews, see Gerber and Cheung 2008; Zhang 2005), especially immediately after graduation (Borgen 2014; Thomas and Zhang 2005).

There are some exceptions to this typical finding of small payoff to institutions. For instance, Brewer, Eide, and Ehrenberg (1999) find that a graduate from an elite private university earns almost 40 percent more than one from a bottom-ranked public university. However, other studies find no payoff to institutions at all (Long 2008; Loyalka, Song, and Wei 2012), or a payoff only for a subset of the students (Dale and Krueger 2002). These latter studies use methods such as regression discontinuity designs or instrumental variables, which

may correct for selection bias to a greater extent than the standard control variable approach used in most studies. They conclude that the observed effects of institution are explained largely by students' pre-higher education characteristics.

Two international comparisons find divergent effects of field of study in Norway. In a comparative study, van de Werfhorst (2004) found mainly small effects of field of study on wages, but this was after adjusting for public sector employment. In Triventi (2013), on the other hand, field of study seems to be if anything more important in Norway than in Spain, Italy, and Germany. Triventi (2013) also estimate the effect of a composite measure institution quality, which turned out to be relatively small. Non-comparative studies of Norway also find only small effects of similar specific measures of institutional quality (Borgen 2014, 2015).

As noted above, Kirkeboen, Leuven, and Mogstad (2016) provide comparable estimates of both field of study and institution effects in Norway. By exploiting application data and a regression discontinuity design (RDD) to obtain instrumental variable (IV) estimates, this study also improves on the previous literature by taking into account potential bias due to differential selection on unobserved individual characteristics. As the authors note, however, the generalizability of the results may be problematic (Kirkeboen, Leuven, and Mogstad 2016: 1061) as they exclude approximately 73 percent of their entire population of students in higher education, and particularly those in programs in which everyone (with a completed secondary education) are accepted. A very large number of study programs accept all applicants (60 percent of all programs in 2004).¹ By excluding the least selective programs, the relative payoffs to attending less selective institutions and fields are very likely exaggerated and the overall variation among institutions and fields in Norwegian higher education is underestimated.

LIMITATIONS IN THE LITERATURE

Most studies of the payoff to field of study investigate total effects of these fields (representing each field with a dummy variable), while studies of the payoff to institutions usually investigate the effects of specific institutional characteristics. Using theoretically oriented indicators may help in unpacking mechanisms, but is less useful if one wants to compare the importance of different horizontal dimensions. A comparison between the total variation in one case and the variation accounted for by a set of measured characteristics on the other will necessarily be biased. Accounting for anything approaching the total variation among educational institutions by means of measured characteristics is unrealistic as it requires detailed knowledge of what characteristics matter and how they interact with each other, as well as error-free measures of these characteristics (Hanushek and Rivkin 2006).

Another limitation is that the literature generally treats educational institutions as homogeneous entities, thus neglecting the possibility of substantial within-institution quality variation, specifically among different departments. The quality of the departments may vary considerably with regard to, for instance, peer quality and academic prestige. Particularly for new institutions, focusing on a single or a few select flagship departments is one strategy to increase their institutional ranking (Altbach and Salmi 2011) .

Thus, institutions may be ranked differently depending on the field of study, and vice versa (Black and Smith 2006), implying that the wage premium associated with, say, economics may vary between institutions, and that the wage premium associated with an institution may vary between fields. As far as we are aware, only one study has investigated the effects of department. This study finds mostly small effects in Finland (Suhonen 2014); however, the effects of the institution as a whole are also very small in Finland.

Previous studies of horizontal divisions have typically been largely descriptive and have not attempted to test specific hypotheses about the processes by which these divisions come about, and this is true of the present study as well. However, examination of how the

variation in field of study and institution effects develop over time may be informative with regard to the ability of various theories to explain horizontal differences.

Following Arcidiacono, Bayer, and Hizmo (2010), we suggest that *increasing* institution or field of study effects over the career are consistent with the assumptions that these effects reflect true productivity differences, and that field of study or institution are not adequately considered by employers initially. Sizable effects after some years in the labor market are also consistent with human capital theory (although this theory does not necessarily imply growing effects over time). Weak initial effects increasing over time are not, however, in line with signaling or credentialist theories. From the perspective of signaling theory, *declining* institution or field of study effects would suggest that employers use horizontal divisions as signals (but that they may have too much faith in them). Finally, *constant* effects over time are consistent with human capital theory, assuming fully informed employers. Constant effects would also be in line with credentialist theory, suggesting that credentials are valued, irrespective of productivity.

THE NORWEGIAN CONTEXT

The education system in Norway comprises three main levels: primary and lower secondary education, upper secondary education, and higher education. Between the ages of 6 and 16 years, all Norwegians attend 10 years of compulsory primary and lower secondary education. Almost all Norwegians subsequently enroll in an academic or vocational track in upper secondary school, although about 30 percent never graduate. The academic alternative has a duration of three years and results in a University and College Admission Certification with which students are eligible to apply for higher education.

About 90 percent of students in Norway attend public higher education institutions. There are no tuition fees at Norwegian public institutions, and all students are eligible for public

financial support (grants and subsidized loans). The public higher education institutions are also in most cases the most prestigious ones, including the four traditional universities of Oslo, Trondheim, Bergen, and Tromsø, and the leading business school, the Norwegian School of Economics. The Norwegian Universities and College Admission Service (NUCAS) coordinates admission to undergraduate programs at all public institutions, as well as a few private ones. Students apply to institutions and detailed fields of study simultaneously by providing a ranked list of preferred fields of study at one or several institutions, and NUCAS ranks the students almost exclusively by their GPA from upper secondary school.² Each student is accepted only to the highest-ranked field of study and institution for which he/she is qualified.

In Norway, higher education is to some extent a two-tier system with research universities on the one hand and university colleges on the other. The research universities are mainly organized in terms of traditional academic disciplines (physics, political science, philosophy, etc.) and are primarily oriented toward master's degrees (or PhD studies, which in Norway typically require a master's degree first), although there are also some professional schools (law, medicine, and graduate engineering). The university colleges, on the other hand, primarily provide professional (or semiprofessional) bachelor-level degrees (engineering, teaching, nursing, etc.) and are organized in terms of these. Traditionally, these profession-oriented studies took place in independent schools, but these schools have been merged into larger, combined university colleges, mainly in the 1990s. The two-tier system is now breaking down, however, as many university colleges devote considerable resources to research and have become or aspire to become universities (Kyvik 2008).

The Norwegian labor market is characterized by a large public sector, relatively low unemployment rates, and a centralized wage-setting system. As a consequence, the wage structure is compressed (Kahn 1998). Returns to education are considerably lower than in the US (60 percent lower according to a recent World Bank paper (Montenegro and Patrinos 2014)),

but results on how Norway compares with other European countries are not consistent (Montenegro and Patrinos 2014; Psacharopoulos and Patrinos 2004). The Norwegian public sector constitutes roughly one-third of all employment and the returns to education are lower in the public sector than in the private sector (Barth and Røed 1999).

A compressed wage structure is assumed to reduce employers' scope for rewarding institutional quality (Holmlund 2009), which may explain why the differences between institutions are smaller than in countries with greater wage inequality, such as the US. The compressed wage structure is also likely to contribute to small wage differences between fields of study, at least compared to the US. Thus, the compressed wage structure will affect the absolute effects of field of study and institution, but probably not the relative importance of these horizontal divisions.

However, other factors may lead to field of study being relatively more important than institution in Norway. First, because the higher education system in Norway is mostly public, differences in quality between institutions are modest. Second, there are large differences in private sector employment by field of study among the higher educated in Norway (Næss 2008). The wage structure is considerably more compressed in the public than in the private sector, and the private sector has a less centralized wage-setting system and more use of individual wage setting (Barth and Røed 1999). The combination of a relatively large public sector and a strong correspondence between field of study and public sector employment is likely to strengthen the wage effects of field of study relative to those of institution.

DATA AND VARIABLES

We use population-wide data from linked administrative records. We have information on all Norwegian citizens born between 1955 and 1984; the data also include individuals born before 1955, but only if these are siblings or spouses of individuals born between 1955 and 1984.

Information about wages is available for the years 2003–2012.

We use the information on all individuals who enrolled in higher education and for whom we have information on GPA from upper secondary school, i.e., all individuals who applied for admission to public higher education through NUCAS in the years 1997–2004.³ We observe the GPA for about 75 percent of all new students in higher education in these years.

We distinguish between undergraduate degree level (0) and graduate degree level (1). Students who continue to study at the doctoral level are excluded from the analysis. Students are recorded with the highest educational level in which they have enrolled. Students failing to complete any degree are recorded with the value 0 on educational level. To distinguish these students from those who obtained an undergraduate degree, we condition on whether the degree is completed (see the Empirical Strategy section).⁴ Table 1 provides the characteristics of this sample. The average student was born in 1976, and enrolled in the last study program in 2001; 19 percent of the students have a graduate degree and 76 percent completed their education.

Table 1

The outcome variable in the main analyses is the log of hourly wages. We construct hourly wages by dividing the total yearly Consumer Price Index (CPI) adjusted (with 1998 as the base year) income from wages and salaries by the total of settled work hours in the same year.⁵ In the main analysis, we use the average of wages in the fourth, fifth, and sixth year after graduation as the outcome variable.⁶ When examining changes over the work career, we use annual data for students included in the main analysis, and follow them from years 1 through 8.

The treatment variables are institution, department, and field of study. There are 79 educational institutions (universities and colleges) in Norway. The classification of fields of

study is based on the Norwegian Standard Classification of Education (NSCE). The second digit of this classification distinguishes between nine *broad* fields, the second and third digits between 54 *narrow* fields, and the second to fourth digits between 133 *detailed* fields. We employ all three levels of aggregation in the analyses. Department is defined by the cross-classification of narrow field of study and institution.

We include several control variables. First, we include controls for other aspects of the higher education obtained. The year the individual enrolled in his/her last higher education program is measured using dummies. Graduate degree is measured using a dummy with a graduate degree as 1. Degree completion is measured using a dummy with completed education as 1.⁷

Second, we include control for individual background characteristics. We include first-, second-, and third-degree terms of the GPA from upper secondary school. Gender is a dummy with female as 1. Birth order and number of siblings are used as continuous variables (with seven or more coded as six), and both first and second order terms are included. We measure year of birth using dummies. County of residence at age 16 is measured using 21 dummies (one dummy for each of the 19 counties in Norway, plus unknown county and abroad). We distinguish between the following immigration backgrounds: born in Norway of two Norwegian-born parents, immigrated, born in Norway of two immigrants, born outside Norway of one Norwegian-born parent, born in Norway of one foreign-born parent, and born outside Norway of two Norwegian-born parents.

Third, we control for social origin. Mother's and father's level of education are both represented by 10 dummies, based on the first digit in the NSCE. Mother's and father's relative earnings are computed by ranking earnings in percentiles within the birth cohort of the individual, and are used as continuous variables (first- and second-order terms).

Finally, in some models we include controls based on information from higher

education applications. The average prestige of each individual's top three choices of institution is computed by calculating the average GPA among first-year students at all institutions and subsequently taking the average of individuals' top three choices of institution. The average prestige of the individual's top three choices of field of study is computed in the same manner.

EMPIRICAL STRATEGY

The Outcome-Based Approach

Our empirical strategy builds on the outcome-based approach common in the teacher quality literature and recently also applied in analyses of field of study effects (Altonji, Kahn, and Speer 2014). Hanushek and Rivkin (2012) describe the basic idea in this literature, as summarized in equation 5 in their publication:

$$A_G = (1 - \theta)A_{G-1} + \tau_j + \mathbf{S}\boldsymbol{\phi} + \mathbf{X}\boldsymbol{\gamma} + \varepsilon \quad (1)$$

In this equation, achievement A in grade G is a function of prior achievement (depreciated at a constant rate θ), with an effect associated with each teacher j (τ_j), a vector of school and peer factors ($\mathbf{S}$), a vector of family and neighborhood inputs ($\mathbf{X}$), and random noise (ε). From this equation, researchers are mainly interested in the individual teacher effects (τ), assuming that they reflect teacher quality. The variation of these effects is commonly described by the standard deviation, σ_j , which is thus the parameter of primary interest. This standard deviation is adjusted, using for instance the empirical Bayes shrinkage estimator, as any measurement error will inflate the variance and thereby also lead to upward bias in the estimated standard deviations of the teacher effects (Hanushek and Rivkin 2012).⁸

The outcome-based approach can also be used to describe the distribution of other

effects, such as the effects of institution, department, and field of study.⁹ Let us consider institution as an example. Instead of estimating the effects of specific institutional characteristics, we estimate the standard deviation of the institution-specific effects using a random effects model. Formally, this standard deviation demonstrates the percentage change in wages by movement of one standard deviation in the distribution of the institution effects. More informally, we will mostly refer to this standard deviation as the advantage of attending an institution that pays one standard deviation above the mean or simply as the effect of attending a high-paying institution. This advantage can be compared with the advantage of attending a field of study that pays one standard deviation above the mean.

Model Specifications

Equation (1) can be estimated as a standard random effects ANCOVA or multilevel model with students as lower-level units and teachers as higher-level units. Our case is more complicated, since individuals are clustered in both educational institutions and fields of study. Moreover, institutions are not nested within fields, or vice versa. The presence of non-nested groups (or clusters) calls for a cross-classified multilevel model (Rabe-Hesketh and Skrondal 2008). The simplest model considers wages as a function of field and institution effects (along with controls), but does not consider the department level.

$$y_{ijk} = \beta_0 + \mathbf{x}_{ijk}\boldsymbol{\beta} + I_j + F_k + \epsilon_{ijk} \quad (2)$$

In this model, y is log(wages), β_0 is the intercept, $\mathbf{x}$ are the control variables, ϵ is the individual error term, and I and F are the institution and field of study random intercepts, respectively. The subscripts i , j , and k are for individual, institution, and field of study, respectively. The individual controls include information about educational background,

individual background, and social origin (see the Data and Variables section). For our purposes, the crucial parameters are the standard deviation of the institution random intercept (σ_j) and the standard deviation of the field of study random intercepts (σ_k).

An important limitation of (2) is that the variation between institutions is assumed to be identical for all fields and vice versa. Thus, it does not take into account that an otherwise good institution may have a poor mathematics department, or that an otherwise average institution may excel in economics. This assumption is relaxed when we include department (D , with subscript l) as a separate level nested within both field of study and institution:¹⁰

$$y_{ijkl} = \beta_0 + \mathbf{x}_{ijkl}\boldsymbol{\beta} + I_j + F_k + D_l + \epsilon_{ijkl} \quad (3)$$

From model (3), we obtain the standard deviation of the institution random intercepts (σ_j), the field of study random intercepts (σ_k), and the department level random intercepts (σ_l).¹¹ Thus, model (3) differentiates between random variation at the level of the institution as a whole and at the department level, allowing for the possibility that both these parameters are needed to capture the total effect of institutional factors.

The results below indicate that model (3) is clearly superior to model (2), and in subsequent analyses, we rely mainly on that model. We investigate whether the aggregation of field of study impacts the results by estimating model (3) using nine broad categories for field of study, 54 narrow categories for field of study, and 133 detailed categories for field of study. We examine whether the effects of horizontal stratification depend on educational level by estimating model (3) separately for the undergraduate and graduate levels.

In order to see whether the effects of field of study, institution, and department change over the course of graduates' work careers, we estimate model (3) separately for each of the first eight years after graduation. An advantage of this approach is that it makes no assumption

about the specific functional form of such change over time. A disadvantage, however, is that it is also quite inefficient in statistical terms and does not allow a simple direct test of the development over all eight years. In Appendix Table A7, we therefore also pool the data for all years and model the variation due to field of study, institution and department, respectively, as functions of experience (*exp*). Since the model now contains up to eight observations per individual, a random intercept on individuals (*P*) is included.

$$y_{ijkl} = \beta_0 + x_{ijkl}\beta + \delta \exp_{ijkl} + I_j + I_j \exp_{ijkl} + F_k + F_k \exp_{ijkl} + D_l + D_l \exp_{ijkl} + P_i + \epsilon_{ijkl} \quad (4)$$

In (4), the random slopes for experience are taken into account by means of interaction terms of institution, department, and field of studies, respectively, on the one hand and experience on the other hand. They demonstrate whether the dispersion in wages among different fields, institutions, and departments increases (positive coefficients), decreases (negative coefficients), or remains the same (zero coefficients).

All models except (4) are estimated using the maximum likelihood *mixed* procedure implemented in *Stata*, version 14.1. Model (4) is estimated with the Monte Carlo Marko Chain (MCMC) procedure in *MLwiN* (run from *Stata* with the *runmlwin* command).

Selection Bias

Individuals with the best earnings prospects may choose the most lucrative fields and institutions, which, if unaccounted for, will lead to positively biased effects of the most lucrative fields and institutions and negatively biased effects of the least profitable fields and institutions. With regard to institutional quality, the literature provides some evidence of this speculation, as studies with more sophisticated control for selection seem to yield smaller effect estimates (Gerber and Cheung 2008).

Since we have data on applications, use of admission cutoffs as instrumental variables seem like an attractive option to deal with omitted variable bias (Kirkeboen, Leuven, and Mogstad 2016). As noted above, however, this would lead to exclusion of a large part of the population, especially of those enrolled in programs that accept all applicants (60 percent of all study programs in 2004). Since we are interested in the overall dispersion of institution and field effects, a disproportionate exclusion of those who applied to the presumably weakest institutions and least popular fields is problematic. A control variable approach is therefore better suited in the present case.

In all models, we condition on a set of observed covariates that may create selection bias. To test the robustness of the main results, we use an approach inspired by Dale and Krueger (2002). They suggest that students reveal relevant unobserved traits and preferences through their higher education applications, and use information from applications to generate indicators of students' unobserved endowments and ambitions.¹² Based on this idea, we measure the average prestige (as measured by GPA among first-year students) among individuals' top three choices of institution and top three choices of field of study, and add these variables (first- and second-order terms) as control variables in the model specifications in (2) and (3).¹³ This approach is similar to that of Dale and Krueger (2002), except that they only consider individuals' preferences for institution and not also for field of study.

We also test the robustness of the results by examining sensitivity to inclusion of observed individual and parental characteristics, including lower secondary GPA (Appendix Table A4). Potentially unobserved confounding variables are likely correlated with observed variables such as lower secondary GPA and parental earnings. Thus, lack of sensitivity to included control variables indicates that the results are also unlikely to be strongly affected by (still) omitted variables (Altonji, Arcidiacono, and Maurel 2016).

Besides omitted variable bias, another potential issue is regional wage differences. In

particular, the estimates of the effect of institution may be sensitive to regional wage differences, since each institution is typically located within a single local labor market. In the main analyses, we account for the geographical selection into institutions by conditioning on the county where the student grew up.

We also perform additional analyses in which we conditioned on whether individuals work in the same county as where the institution is located, and obtain the same results as in the main analyses (Appendix Table A2). These findings suggest that the effects of institutions are not caused by regional labor market differences. However, the analyses should be interpreted with caution, since the institution attended may influence place of residence. By conditioning on where individuals work, we may therefore eliminate some of the treatment effect. Moreover, conditioning on a post-treatment variable may cause endogenous selection bias (Elwert and Winship 2014).

A limitation of this paper is that we do not take sorting on comparative advantage into account (Brand and Xie 2010). The findings of Kirkeboen, Leuven, and Mogstad (2016) suggest that there is a tendency for individuals to choose fields in which they have a comparative advantage. Borgen (2015) finds a similar tendency in the literature on institutions, while Brand and Halaby (2006) find the opposite; students who typically attend non-elite institutions have the highest returns to attending elite institutions.

RESULTS

Main Results

Main results are presented in Table 2; the coefficients of the control variables are provided in Appendix Table A3. The model with only field of study and institution effects suggests that both these dimensions of horizontal stratification within higher education matter for students' labor market outcomes (Table 2, column 1). Including department in the model, however,

reveals that wages vary primarily at the department level (Table 2, column 2) and only to a minor extent at the level of the institution as a whole. Thus, the Institution-Field-Department model is clearly superior to the Institution-Field model, and we will concentrate on the former in the remaining analyses in this paper.

According to the results in column 2, attending a high-paying field increases wages by roughly 9 percent, whereas the premium associated with a high-paying institution is only 2 percent. The low value of the latter estimate does not suggest, however, that educational institutions in general are unimportant, but only that the effect is primarily produced at the department level. Thus, the wage premium associated with a high-paying department is about 6 percent.

Table 2

Appendix Table A4 show that field and department estimates are overall little affected by the inclusion of any of the control variables. The estimate of between institution variation drops markedly when we control for program level and completion, and also when we control for parental and individual characteristics (apart from GPA). However, the between institution variation is not sensitive to the additional inclusion of the individual's own lower secondary GPA.

Because non-employed individuals do not have wages, approximately 5 percent of the observations are excluded from the main results in Table 2. To check the robustness of the results, we also use earnings (annual labor market income) as outcome variable, and include non-employed individuals (see Appendix Table A6). When including the non-employed, the total effect of institution (overall institution level and department level) is of the same size as the field of study effects. Additionally, a larger part of the institution effect operates at the

overall institutional level.

The horizontal variation due to field of study and department seems to be large compared with vertical differences within higher education (level and completion) in Norway (see Appendix Table A3). Our analyses suggest that individuals with a graduate degree have 14 percent higher wages than those with an undergraduate degree. The average effect of education completion is an increase in wages of 7 percent. If we contrast these vertical effects with the horizontal effects, e.g., if we compare a person majoring in a field and in a department one standard deviation below the average with a person majoring in a field and in a department one standard deviation above the average, the latter has 33 percent higher wages.¹⁴

We also compute predicted values (Best Linear Unbiased Predictions, BLUP) for the various fields, see Appendix Table A5. Generally, the BLUPs are highly correlated with the unadjusted field-specific mean wages, with a Pearson's r of .89.¹⁵ Medicine has the highest BLUP, followed by transport and communication, pharmacy, safety and security, and earth sciences (geology, etc.). The fields with the lowest BLUPs are kindergarten teacher, agriculture, languages, religion, and literature.

Level of Aggregation for the Classification of Fields

Our results indicate that a rather crude classification of field of study may slightly underestimates the effect (Table 3). With field of study grouped in nine broad fields, as is the case in most studies, the effect of attending a high-paying field is about 8 percent. Using 54 narrow fields, the payoff is about 9 percent. With 133 detailed groups, the estimated effect of field is 10 percent.

Table 3

The classification level of fields has a somewhat stronger impact on the estimation of the department effects, which decline from 9 to 5 percent. This suggests that within broad fields of study, high-paying departments tend to offer (sub)fields that are also highly paid. Studies that do not adequately control for field of study may accordingly exaggerate the effects of department (or institution, if a model without the department level is estimated).¹⁶

Undergraduate and Graduate Levels

The estimated effect of all three horizontal dimensions of higher education are greater at the graduate than at the undergraduate level (Table 4). However, the difference between the levels is significantly different from zero only with regard to field of education. Attending a high-paying field increases wages by roughly 7 percent at the undergraduate level and by about 11 percent at the graduate level. An important similarity between the undergraduate and graduate levels is that within each of them the estimated effects of field on the one hand and institution plus department on the other are of similar magnitude.

Table 4

Changes across Individuals' Work Career

Separate analyses for each of the first eight years after graduation are presented in Table 5 and Figure 1. Pairwise t-tests of year 8 versus year 1 are significant for field ($t=2.82$) and institution ($t=2.28$), but not for department ($t=1.31$). This is not a good test, however, because it discards the information from the remaining years (which reduces the power of the test). Additionally, it does not take into account that the estimates for the two years are partly based on the same individuals and thus not independent (which is likely to bias the t-ratios away from zero). We therefore also estimate a pooled model with data from all years, treating number of years since

graduation as a continuous variable (Appendix Table A7). In this model, the t-ratios for the coefficients measuring change over time in the standard deviations are all well above any conventional critical value ($t=5.36$ for institution, $t=8.33$ for field, and $t=9.33$ for department). A disadvantage of this model, however, is that it does not accommodate the specific nonlinearities that seem to be present according to Figure 1. In interpreting the results, we therefore rely mainly on the year wise analyses.¹⁷

Figure 1 shows considerable variation among both fields and departments even in the first year after graduation. The variation among fields increases quite strongly from the first to the second year after graduation, and more modestly in subsequent years. With regard to department variation, there is also an increasing tendency, but it is weak and not significant when only comparing estimates for one and eight years of experience.¹⁸

The estimated variation on the institutional level is very small early in the occupational career. It even seems to decline from the first to the second year, but this may well be random noise. The variation increases over the subsequent years, however, and by eight years, the variation at the institution level is about the same as the variation at the department level. When considered together, the total effect of institution and department is of about the same size as the effect of field both at the beginning of the career and after eight years.

Table 5 and Figure 1

Analyses Using Application Data

In the main analyses, we condition on a wide set of control variables to minimize selection bias. To mitigate bias further, we perform additional analyses using data on college applications. Columns 1 and 2 in Table 6 are replications of the analyses presented in Table 2, except for excluding individuals with unavailable application data.

Table 6

Controlling for the prestige of the institutions and fields of study to which individuals apply (i.e., the “self-revelation model”) leads to minimal changes in the estimates (Table 6, columns 3 and 4). When including the department level, the effects of institution, field, and department are roughly 2, 9, and 6 percent, respectively, in both column (2) and column (4). Thus, the main conclusion of reasonably large effects of both field and department are upheld.

DISCUSSION

This paper compares the effects of the two main sources of horizontal divisions within higher education, namely field of study and educational institution. As in other studies, we find relatively strong effects of field of study (Gerber and Cheung 2008). However, in contrast to the conclusions reached in most other studies (e.g. Dale and Krueger 2002; Long 2008), the results suggest that there are also considerable payoffs to institutions. To be sure, the effect of institution is often small in models that also allow for variation at the department level (although increasing with experience). However, our interpretation of these models is not that the institution attended is unimportant, but rather that the institution effects operate to a considerable extent at the department level.

Most studies of fields of study investigate the total effects of these fields (representing each field with a dummy variable), while studies of institutions usually investigate the effects of specific institutional characteristics. The outcome-based approach used in this paper enables a direct comparison of the overall importance of different horizontal divisions. In most of the models, the effects of institution (including the department level) are weaker than the field of study effects. Nevertheless, the difference is smaller than one would expect based on research

investigating effects of specific institutional characteristics internationally (Gerber and Cheung 2008) and in Norway (Borgen 2014).

This finding also differs from the results in Kirkeboen, Leuven, and Mogstad (2016). Using Norwegian administrative data and representing institutions with dummy variables, they find small institutional effects compared to field of study. However, their estimation method leads to exclusion of more than 70 percent of the student population including all students attending non-selective study programs; the results are therefore not generalizable to Norwegian higher education as a whole and not directly comparable to the results in this paper.

The relatively large effects of department (or department plus institution) in the outcome-based approach compared with the effects of specific institutional characteristics in most previous research point to important limitations in the extensive literature investigating the effects of institution. Some researchers argue that measurement error in quality indicators may bias the effects downward, and suggest methods that reduce this bias (Black and Smith (2006). However, it may also very well be that the standard quality indicators simply cannot account for anything approaching the total variation among educational institutions as this would require detailed knowledge of exactly which characteristics matter and how they interact with each other (Hanushek and Rivkin 2006). The outcome-based approach we use in this paper circumvents this problem and enables a direct comparison of the overall importance of different horizontal divisions.

This is not to say that an outcome-based approach is inherently superior to one focusing on specific measured characteristics. An important limitation of the outcome-based approach is that it tells us little, if anything, about the specific processes by which differences between fields and institutions arise. Use of indicators of specific institutional characteristics have some merit in unpacking mechanisms, but the small effects of institution obtained with this approach have often led to the misleading conclusion that institution is unimportant (Dale and Krueger

2002). The strength of the outcome-based approach is to identify the size of the total effects. Using this approach, we demonstrate that there are considerable payoffs to field of study on the one hand, and department and institution on the other. Future research should supplement the outcome-based approach with methods that are able to unpack the mechanisms by which these payoffs emerge.

Previous studies have treated educational institutions as homogeneous entities, not taking into consideration the possibility of substantial within-institution quality variation. However, it has been suggested that the quality of departments varies widely within institutions, and that institutions may be ranked differently depending on the field of study (Black and Smith 2006). Our findings provide the first systematic and quantitative evidence that there is indeed considerable heterogeneity within institutions, and that graduates' later wages tend to vary more at the department level than at the overall institutional level, at least in the first years after graduation. Accordingly, future research should take account of both the overall institution and the department level.

In the previous literature, the level of aggregation of fields of study varies widely from study to study (Altonji, Blom, and Meghir 2012). Our findings suggest that the effects of field of study are slightly smaller when using crude classifications. This means that within broad fields of study, individuals with different subfields obtain somewhat different payoffs. It also suggests that most studies slightly underestimate the effects of field of study, since they commonly use very crude classifications. A further finding is that wages vary more because of horizontal divisions at the graduate level than at the undergraduate level.

The horizontal variation due to field of study and institution tends to increase across individuals' work careers, suggesting that studies on early labor market outcomes may underestimate the effects of horizontal divisions within higher education. From a theoretical point of view, this pattern is hard to explain as an outcome of credentialism because it is not

clear why credentials should be less rewarded early in the career. Increasing field of study and institution effects also seem to be inconsistent with signaling theory, as one might expect institution and field to be if anything particularly important as signals early in the career when information on individuals' true productivity is scarce. A possible explanation for increasing variation over time is that institution and field reflect true productivity differences, but that employers do not sufficiently consider these differences initially. Over time, employers learn about their workers' true productivity and adjust the rewards.

The estimated effect of department is considerably larger than the effect of the institution as a whole shortly after graduation, but the increase over time is weaker and close to zero in the year wise analyses. We can only speculate why. One possibility is that a good professional network is important for access to well-paid jobs at the start of the occupational career, and that the quality of such networks is to a large extent determined at the level of departments.

Our analyses are limited to one country, and only future research can tell whether the findings—above all the finding that institution (including department) has a sizeable effect, and in some models, an almost equally large effect as field of study—can be generalized to other settings. Norway has some unique characteristics compared to many countries, such as a mostly publicly financed higher education system and a compressed wage structure. We find it unlikely however, that institution or department is particularly important in Norway, at least compared to the US. If anything, the particular characteristics of the Norwegian case seem likely contribute to a small effect of institution compared to that of field of study. First, there is a relatively strong correspondence between field of study and private sector employment. Secondly, a publicly financed higher education system should limit quality differences between institutions. Studies using traditional indicators of institutional quality also suggest that the effects of these are mostly small in Norway (Borgen 2014, 2015). Thus, finding sizeable total

effects of institution in the Norwegian case further supports our main conclusion that the literature, consisting mainly of studies from the US, underestimates the relative importance of institution for wages (whether this operates mainly on the level of departments or at the overall institutional level).

Since we relied on a control variable strategy, omitted variable bias (and most likely positive bias) in the variance parameter estimates cannot be ruled out. It is reassuring, however, that the findings with regard to fields and departments are not sensitive to the inclusion of measured individual and parental characteristics, including lower secondary GPA and the measures based on application data suggested by Dale and Krueger (2002). The estimate for institution is less stable, but even this is quite unaffected by control for GPA and application characteristics. As suggested by several authors, lack of sensitivity to included control variables may serve to strengthen our confidence that the results are unlikely to be strongly affected by (still) omitted variables (Altonji, Arcidiacono, and Maurel 2016).

A limitation common to most studies investigating horizontal divisions in higher education, is that we are unable to take selection on comparative advantage into account. Some studies have found selection on comparative advantage with regard to field of study (Kirkeboen, Leuven, and Mogstad 2016) and institution (Borgen 2015b, Brand and Halaby 2006), but more research on this topic is needed, including whether selection on comparative advantage is stronger for field or institution.

ABOUT THE AUTHORS

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ENDNOTES

- ¹ Calculated by the authors from information on the website of The Norwegian Universities and College Admission Service (accessed February 24, 2018):
https://www2.samordnaopptak.no/arkiv/statistikk/04/poeng_supp_04.html
- ² Admission to the graduate level is based on undergraduate degree grades.
- ³ Individuals who enrolled in a higher education before 1997 are included in the analysis sample if they applied to a higher education program between 1997 and 2004. Excluding individuals who enroll before 1997 does not change the results (Appendix Table A8). Excluding students who enroll in higher education late does not change the results (Appendix Table A9).
- ⁴ Including only individuals with a completed degree does not change the results.
- ⁵ Using settled instead of actually worked hours introduces some assumedly random measurement error, as do lags in reported changes in settled hours. These factors also lead to unrealistically low or high values of the wage variable in a few cases. In the analyses, we therefore exclude the one percent with the lowest and highest wage values. This exclusion has minimal impact on the main results (results available upon request). However, predictions for specific fields are more sensitive to this exclusion, and these are arguably more informative without the impact of the extreme values.
- ⁶ For individuals with less than three years of observed wages, the variable is constructed using data for only two years or one year. The estimation results are almost identical if individuals without complete data are excluded. Results are available upon request.
- ⁷ Without the variables educational level and degree completion, the effects of institution in model specification (3) is higher (0.0418 vs. 0.0182).
- ⁸ The terminology in the economics of education literature for these teacher effects is “fixed effects.” The terminology is confusing because these adjustments imply that the “fixed”

effects are really treated as random, and would be referred to as such in the ANOVA and multilevel model literatures.

- ⁹ A few studies have used an outcome-based approach to examine horizontal stratification of higher education, but without simultaneous analysis of both institution-based and field-based stratification (Altonji, Kahn, and Speer 2014; Thomas 2000).
- ¹⁰ Since we operationalize department by cross-classifying institutions and fields, Equation (3) is identical to a model with an interaction between institution and field (Shi, Leite, and Algina 2010).
- ¹¹ In addition to models (2) and (3), we estimated two- and three-level nested random intercept models with fixed effects on either institution or field of study. These models provide similar results as the main models. See Appendix Table A1.
- ¹² They also use a matching estimator, which provides similar results (Dale and Krueger 2002).
- ¹³ All control variables used in the other models are still included, among them the individual's own GPA.
- ¹⁴ $100 * (e^{(.0856+.0584)*2} - 1)$.
- ¹⁵ The correlation of the “Mean” column and the “BLUP” column in Appendix Table A5.
- ¹⁶ We also estimated Model (1) in Table 2 with 9, 54 and 133 fields. The standard deviations for institution level variation were .0851, .0748, and .0479, respectively.
- ¹⁷ We also estimated a pooled model with a dichotomous version of experience (1-4 years versus 5-8 years). The t-ratios for changes in the dispersion due to field, institution, and department were 7.81, 4.78, and 10.40, respectively.
- ¹⁸ As suggested by one of the reviewers, we have also examined whether changes across individuals' work career is similar for those who remain with the same employer and those who do not, and they are. Results are available upon request.

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AUTHOR NOTES

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TABLES

Table 1. Sample Characteristics

Variable	N	Mean	SD	Min	Max
Log wages	107655	5.313	0.417	4.427	7.266
Log earnings	113755	12.766	0.587	5.809	15.941
Enrolment year (dummies in the regressions)	113778	2001.163	2.209	1997	2004
Graduate level	113778	0.194	0.396	0	1
Completed degree	113778	0.745	0.436	0	1
GPA	113778	40.251	6.434	11.500	60
Gender	113778	0.605	0.489	0	1
Birth order	113778	1.869	1.001	0	6
Number of siblings	112910	1.860	1.109	0	6
Year of birth (dummies in regressions)	113778	1976.254	5.834	1944	1987
County (when 16 years old, Østfold as ref.)					
Østfold	113778	0.049	0.215	0	1
Akershus	113778	0.082	0.275	0	1
Oslo	113778	0.055	0.228	0	1
Hedmark	113778	0.042	0.200	0	1
Oppland	113778	0.040	0.196	0	1
Buskerud	113778	0.048	0.213	0	1
Vestfold	113778	0.044	0.205	0	1
Telemark	113778	0.038	0.192	0	1
Aust-Agder	113778	0.027	0.161	0	1
Vest-Agder	113778	0.040	0.197	0	1
Rogaland	113778	0.084	0.277	0	1
Hordaland	113778	0.102	0.303	0	1
Sogn og Fjordane	113778	0.031	0.172	0	1
Møre og Romsdal	113778	0.071	0.257	0	1
Sør-Trøndelag	113778	0.065	0.247	0	1
Nord-Trøndelag	113778	0.039	0.193	0	1
Nordland	113778	0.060	0.238	0	1
Troms	113778	0.036	0.186	0	1
Finnmark	113778	0.018	0.133	0	1
Abroad	113778	0.008	0.091	0	1
Unknown	113778	0.020	0.142	0	1
Immigration background					
No immigrant background	113778	0.914	0.281	0	1
Immigrant	113778	0.025	0.157	0	1
Norwegian-born to immigrant parents	113778	0.006	0.080	0	1
Foreign-born, one Norwegian-born parent	113778	0.007	0.082	0	1
Norwegian-born, one foreign-born parent	113778	0.036	0.187	0	1
Foreign-born to Norwegian-born parents	113778	0.011	0.106	0	1
Father's level of education					
No education	111459	0.001	0.036	0	1
Primary	111459	0.002	0.039	0	1

Lower secondary	111459	0.177	0.382	0	1
Some upper secondary	111459	0.276	0.447	0	1
Full upper secondary	111459	0.193	0.394	0	1
Postsecondary nontertiary	111459	0.039	0.193	0	1
Undergraduate	111459	0.198	0.399	0	1
Graduate	111459	0.102	0.302	0	1
Postgraduate	111459	0.008	0.089	0	1
Unspecified	111459	0.005	0.071	0	1
Mother's level of education					
No education	112509	0.002	0.040	0	1
Primary	112509	0.002	0.050	0	1
Lower secondary	112509	0.223	0.416	0	1
Some upper secondary	112509	0.382	0.486	0	1
Full upper secondary	112509	0.099	0.299	0	1
Postsecondary nontertiary	112509	0.024	0.154	0	1
Undergraduate	112509	0.242	0.428	0	1
Graduate	112509	0.021	0.142	0	1
Postgraduate	112509	0.001	0.032	0	1
Unspecified	112509	0.004	0.067	0	1
Mother's earnings	111698	54.155	27.526	5	99
Father's earnings	109450	54.084	27.838	0	99

Table 2. Effects of Institution, Department, and Narrow Fields of Study on log Wages

	(1)	(2)
Institutional level	0.0748 *** (0.0094)	0.0182 *** (0.0079)
Field level	0.0951 *** (0.0098)	0.0856 *** (0.0096)
Department level		0.0584 *** (0.0036)
N	102611	102611

Note: The reported coefficients are standard deviations of the random intercepts (see equations (2) and (3)). See the Data and Variables section for a description of the control variables. Standard errors in parentheses. Significance: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests).

Table 3. Effects of Broad Fields of Study, Narrow Fields of Study, and Detailed Fields of Study

	(1)	(2)	(3)
Institutional level	0.0126 *** (0.0090)	0.0182 *** (0.0079)	0.0135 *** (0.0064)
Field level	0.0755 *** (0.0198)	0.0856 *** (0.0096)	0.1020 *** (0.0083)
Department level	0.0861 *** (0.0036)	0.0584 *** (0.0036)	0.0488 *** (0.0032)
Number of fields of study	9	54	133
N	102611	102611	102611

Note: The reported coefficients are standard deviations of the random intercepts. See the Data and Variables section for a description of the control variables. Standard errors in parentheses. Significance: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests).

Table 4. Effects of Institution, Department, and Narrow Fields of Study by Educational Level

	Undergraduate	Graduate	t-test difference
Institutional level	0.0155 *** (0.0086)	0.0444 *** (0.0149)	1.6799
Field level	0.0704 *** (0.0084)	0.1130 *** (0.0141)	2.5956 **
Department level	0.0454 *** (0.0037)	0.0590 *** (0.0076)	1.6089
N	82258	20353	

Note: The reported coefficients are standard deviations of the random intercepts. See the Data and Variables section for a description of the control variables. Standard errors in parentheses.
Significance: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests).

Table 5. Effects of Institution, Department, and Narrow Fields of Study Each of the Eight First Years After Graduation

	First year	Second year	Third year	Fourth year	Fifth year	Sixth year	Seventh year	Eighth year
Institutional level	0.0167 * (0.0067)	0.0100 (0.0116)	0.0109 (0.0128)	0.0164 (0.0112)	0.0221 ** (0.0082)	0.0257 * (0.0102)	0.0386 ** (0.0122)	0.0482 *** (0.0121)
Field level	0.0551 *** (0.0070)	0.0785 *** (0.0089)	0.0826 *** (0.0093)	0.0836 *** (0.0094)	0.0907 *** (0.0100)	0.0905 *** (0.0101)	0.0931 *** (0.0104)	0.0903 *** (0.0103)
Department level	0.0486 *** (0.0038)	0.0498 *** (0.0038)	0.0540 *** (0.0037)	0.0544 *** (0.0038)	0.0546 *** (0.0036)	0.0582 *** (0.0037)	0.0565 *** (0.0043)	0.0558 *** (0.0040)
N	68917	81144	90602	93813	92905	86282	76590	63595

Note: The reported coefficients are standard deviations of the random intercepts. See the Data and Variables section for a description of the control variables. Standard errors in parentheses. Significance: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests).

Table 6. Testing the Robustness of the Effects of Institution, Department, and Narrow Fields of Study Using Application Data

	(1)		(2)		(3)		(4)	
Institutional level	0.0714	***	0.0207	***	0.0679	***	0.0181	***
	(0.0091)		(0.0078)		(0.0088)		(0.0073)	
Field level	0.0951	***	0.0863	***	0.0905	***	0.0838	***
	(0.0098)		(0.0097)		(0.0094)		(0.0095)	
Department level			0.0581	***			0.0567	***
			(0.0036)				(0.0035)	
Application prestige controls	No		No		Yes		Yes	
N	99145		99145		99145		99145	

Note: The reported coefficients are standard deviations of the random intercepts. Columns (3) and (4) report results with control for applications, (1) and (2) are without this control. See the Data and Variables section for a description of the control variables and the Empirical Strategy section for a description of the application model. Standard errors in parentheses. Significance: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests).

Figures

Figure 1. Estimated Dispersion in Wages between Fields, Institutions, and Departments over the First Eight Years of Individuals' Work Careers. Based on Table 5.

Appendix: Supplementary tables

Table A1. The effects of institution, department, and fields of study in two- and three-level random intercept models with fixed field or institution effects

	(1)	(2)	(3)	(4)	(5)
Institutional level	0.0719 *** (0.0090)			0.0190 *** (0.0082)	
Field level		0.0933 *** (0.0096)			0.0857 *** (0.0097)
Department level			0.0552 *** (0.0029)	0.0521 *** (0.0033)	0.0611 *** (0.0032)
Narrow field fixed effects	Yes	No	Yes	Yes	No
Institution fixed effects	No	Yes	No	No	No
N	102611	102611	102611	102611	102611

Note: The reported coefficients are standard deviations of the random intercepts. See the Data and Variables section for a description of the control variables. Columns (1), (3), and (4) include 52 fields of study dummies. Column (2) includes 75 institution dummies. Standard errors in parentheses. Significance: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests).

Table A2. The effects of institution, department, and fields of study after controlling for where students work

	(1)	(2)
Institutional level	0.0744 *** (0.0094)	0.0228 *** (0.0081)
Field level	0.0946 *** (0.0097)	0.0851 *** (0.0096)
Department level		0.0573 *** (0.0036)
N	102600	102600

Note: The reported coefficients are standard deviations of the random intercepts (see equations (2) and (3)). See the Data and Variables section for a description of the control variables. The models in this table also include control for whether students work in the same county as where the institution is located (dummy variable). Standard errors in parentheses. Significance: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests).

Table A3. Coefficients and standard errors for variables included in the models estimated in Table 2

	(1)		(2)	
Graduate level	0.1342***	(0.0054)	0.1300***	(0.0057)
Completed degree	0.0638***	(0.0034)	0.0630***	(0.0034)
GPA	0.0031***	(0.0003)	0.0031***	(0.0003)
GPA ²	0.0002***	(0.0000)	0.0002***	(0.0000)
GPA ³	-0.0000	(0.0000)	-0.0000*	(0.0000)
Gender	0.0106***	(0.0029)	0.0143***	(0.0030)
Immigration background (ref. no immigration background)				
Immigrant	-0.0303*	(0.0123)	-0.0307*	(0.0122)
Norwegian-born to immigrant parents	0.0038	(0.0165)	0.0052	(0.0164)
Foreign-born with one Norwegian-born parent	-0.0052	(0.0175)	-0.0048	(0.0175)
Norwegian-born with one foreign-born parent	-0.0044	(0.0066)	-0.0029	(0.0066)
Foreign-born to Norwegian-born parents	-0.0098	(0.0115)	-0.0104	(0.0114)
Father's level of schooling (ref. no education)				
Primary	-0.0357	(0.0481)	-0.0380	(0.0480)
Lower secondary	-0.0379	(0.0352)	-0.0391	(0.0351)
Some upper secondary	-0.0340	(0.0352)	-0.0351	(0.0351)
Full upper secondary	-0.0356	(0.0352)	-0.0372	(0.0351)
Postsecondary nontertiary	-0.0238	(0.0357)	-0.0260	(0.0356)
Undergraduate	-0.0407	(0.0353)	-0.0427	(0.0351)
Graduate	-0.0374	(0.0354)	-0.0390	(0.0353)
Postgraduate	-0.0548	(0.0379)	-0.0577	(0.0377)
Unspecified	-0.0502	(0.0400)	-0.0526	(0.0399)
Mother's level of schooling (ref. no education)				
Primary	0.0033	(0.0419)	0.0002	(0.0418)
Lower secondary	-0.0192	(0.0330)	-0.0179	(0.0329)
Some upper secondary	-0.0190	(0.0330)	-0.0178	(0.0329)
Full upper secondary	-0.0245	(0.0331)	-0.0230	(0.0330)
Postsecondary nontertiary	-0.0329	(0.0338)	-0.0303	(0.0337)
Undergraduate	-0.0196	(0.0331)	-0.0181	(0.0329)
Graduate	-0.0236	(0.0342)	-0.0217	(0.0341)
Postgraduate	-0.0389	(0.0506)	-0.0374	(0.0504)
Unspecified	-0.0215	(0.0381)	-0.0198	(0.0379)
Mother's earnings	0.0002***	(0.0001)	0.0002***	(0.0001)
(Mother's earnings) ²	0.0000	(0.0000)	0.0000	(0.0000)
Father's earnings	0.0002***	(0.0001)	0.0002***	(0.0001)
(Father's earnings) ²	0.0000***	(0.0000)	0.0000***	(0.0000)
Year of birth				
1951	0.0570	(0.0928)	0.0674	(0.0925)
1952	-0.0128	(0.0907)	-0.0043	(0.0904)
1953	0.0428	(0.0883)	0.0518	(0.0881)
1954	0.0281	(0.0870)	0.0288	(0.0868)
1955	-0.0223	(0.0846)	-0.0186	(0.0844)
1956	-0.0213	(0.0836)	-0.0166	(0.0834)

1957	0.0031	(0.0838)	0.0046	(0.0836)
1958	0.0186	(0.0862)	0.0164	(0.0860)
1959	0.0266	(0.0861)	0.0242	(0.0858)
1960	0.0382	(0.0859)	0.0378	(0.0856)
1961	0.0213	(0.0857)	0.0176	(0.0855)
1962	0.0251	(0.0854)	0.0240	(0.0852)
1963	0.0169	(0.0853)	0.0163	(0.0851)
1964	0.0375	(0.0852)	0.0361	(0.0850)
1965	0.0431	(0.0851)	0.0392	(0.0849)
1966	0.0315	(0.0850)	0.0285	(0.0848)
1967	0.0441	(0.0849)	0.0412	(0.0847)
1968	0.0446	(0.0848)	0.0427	(0.0846)
1969	0.0545	(0.0847)	0.0498	(0.0845)
1970	0.0678	(0.0846)	0.0650	(0.0844)
1971	0.0878	(0.0845)	0.0839	(0.0843)
1972	0.0841	(0.0844)	0.0815	(0.0842)
1973	0.0862	(0.0843)	0.0820	(0.0841)
1974	0.0903	(0.0842)	0.0875	(0.0840)
1975	0.1008	(0.0842)	0.0982	(0.0840)
1976	0.0935	(0.0841)	0.0909	(0.0839)
1977	0.1056	(0.0841)	0.1032	(0.0839)
1978	0.1065	(0.0841)	0.1037	(0.0839)
1979	0.1049	(0.0841)	0.1024	(0.0839)
1980	0.1097	(0.0841)	0.1063	(0.0839)
1981	0.1071	(0.0842)	0.1044	(0.0839)
1982	0.1081	(0.0842)	0.1056	(0.0840)
1983	0.0943	(0.0843)	0.0934	(0.0841)
1984	0.0837	(0.0844)	0.0804	(0.0842)
1985	0.0690	(0.0852)	0.0643	(0.0850)
1986	0.1048	(0.1608)	0.1123	(0.1603)
Number of siblings	0.0148***	(0.0036)	0.0147***	(0.0036)
(Number of siblings) ²	-0.0011	(0.0007)	-0.0011	(0.0007)
Birth order	-0.0004	(0.0048)	0.0004	(0.0048)
(Birth order) ²	-0.0005	(0.0010)	-0.0007	(0.0010)
Enrollment year (1997 as ref.)				
1998	0.0213**	(0.0066)	0.0218***	(0.0066)
1999	0.0504***	(0.0059)	0.0521***	(0.0060)
2000	0.0758***	(0.0064)	0.0774***	(0.0064)
2001	0.0894***	(0.0063)	0.0900***	(0.0063)
2002	0.1065***	(0.0063)	0.1075***	(0.0063)
2003	0.1186***	(0.0060)	0.1185***	(0.0060)
2004	0.1111***	(0.0063)	0.1126***	(0.0064)
County (when 16 years old. Østfold as ref.)				
Akershus	0.0129	(0.0076)	0.0115	(0.0075)
Oslo	0.0179*	(0.0083)	0.0162*	(0.0083)
Hedmark	-0.0074	(0.0088)	-0.0086	(0.0088)

Oppland	0.0143	(0.0088)	0.0112	(0.0088)
Buskerud	0.0100	(0.0085)	0.0085	(0.0084)
Vestfold	0.0031	(0.0087)	0.0034	(0.0086)
Telemark	0.0085	(0.0091)	0.0065	(0.0091)
Aust-Agder	0.0105	(0.0100)	0.0073	(0.0100)
Vest-Agder	0.0213*	(0.0092)	0.0207*	(0.0091)
Rogaland	0.0381***	(0.0080)	0.0407***	(0.0079)
Hordaland	0.0124	(0.0078)	0.0120	(0.0077)
Sogn og Fjordane	0.0046	(0.0097)	0.0061	(0.0097)
Møre og Romsdal	0.0100	(0.0082)	0.0098	(0.0081)
Sør-Trøndelag	-0.0121	(0.0083)	-0.0106	(0.0082)
Nord-Trøndelag	-0.0047	(0.0094)	-0.0055	(0.0093)
Nordland	-0.0052	(0.0086)	-0.0043	(0.0085)
Troms	0.0030	(0.0099)	0.0013	(0.0097)
Finnmark	0.0059	(0.0120)	0.0045	(0.0119)
Abroad	-0.0111	(0.2239)	-0.0116	(0.2231)
Unknown	0.0136	(0.0238)	0.0095	(0.0237)
Constant	5.0369***	(0.0959)	5.0334***	(0.0951)
N	102611		102611	

Note: This table shows coefficients and standard errors for variables included in the random intercept models in Table 2, based on equations (2) and (3). Columns 1 and 2 in this table correspond to columns 1 and 2 in Table 2. Standard errors in parentheses. Significance: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests).

Table A4. Effects of institution, department, and narrow fields of study on log wages with different sets of control variables.

	(1)	(2)	(3)	(4)
Institutional level	0.0736*** (0.0117)	0.0461*** (0.0107)	0.0226*** (0.0088)	0.0182*** (0.0079)
Field level	0.0973*** (0.0109)	0.0853*** (0.0096)	0.0871*** (0.0098)	0.0856*** (0.0096)
Department level	0.0717*** (0.0040)	0.0592*** (0.0038)	0.0603*** (0.0037)	0.0584*** (0.0036)
Program level and completion	No	Yes	Yes	Yes
Individual and parental characteristics	No	No	Yes	Yes
GPA	No	No	No	Yes
N	107655	107655	102611	102611

Note: The reported coefficients are standard deviations of the random intercepts (see equation (3)). See the Data and Variables section for a description of the control variables. Standard errors in parentheses. Significance: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests).

Table A5. Descriptive means of log wages for each field and best linear unbiased predictions (BLUP) of the field random effects, based on model in column (2) in Table 2. Standard errors in parentheses.

NSCE category	Mean	se(Mean)	BLUP	se(BLUP)	Rank (Mean)	Rank (BLUP)
11 Languages	5.193	-0.012	-0.087	-0.021	44	47
12 Literature and librarianship	5.201	-0.016	-0.076	-0.034	42	45
13 History and philosophy	5.203	-0.009	-0.064	-0.021	41	42
14 Religion	5.212	-0.023	-0.086	-0.027	40	46
15 Music, dance and drama	5.292	-0.023	-0.034	-0.025	22	31
16 Visual art and crafts	5.246	-0.02	-0.058	-0.025	32	38
19 Humanities and arts, other	5.143	-0.011	-0.046	-0.025	46	34
21 Pre-school-/kindergarten teacher education	5.126	-0.005	-0.105	-0.015	48	49
22 Primary and lower secondary teacher education	5.226	-0.004	-0.018	-0.014	38	24
23 Specific subject and vocational teacher training	5.228	-0.007	-0.031	-0.015	36	26
24 Pedagogy	5.287	-0.016	-0.021	-0.027	23	25
25 Supplementary education for teachers	5.14	-0.018	-0.033	-0.022	47	30
31 Political science	5.268	-0.01	-0.036	-0.02	27	33
32 Sociology	5.265	-0.018	-0.06	-0.029	28	39
33 Human geography	5.331	-0.026	-0.014	-0.036	18	23
34 Economics	5.381	-0.019	-0.007	-0.034	11	21
35 Media and information	5.315	-0.009	0.017	-0.019	19	13
36 Psychology	5.352	-0.012	-0.002	-0.029	15	20
37 Law	5.448	-0.007	0.005	-0.028	5	16
38 Social anthropology	5.249	-0.026	-0.068	-0.037	31	44
39 Social sciences and law, other	5.279	-0.023	0.011	-0.031	25	15
41 Business and administration	5.348	-0.004	0.019	-0.013	16	12
42 Wholesale and retail sales and marketing	5.275	-0.007	-0.009	-0.025	26	22
44 Hotel, travel and tourism	5.198	-0.011	-0.054	-0.023	43	37
51 Biology	5.256	-0.013	-0.046	-0.021	30	35
52 Physics and chemistry	5.389	-0.012	0.045	-0.021	9	9
53 Mathematics and statistics	5.343	-0.026	0.012	-0.034	17	14

54 Information and computer technology	5.283	-0.004	-0.001	-0.013	24	19
55 Electrical, electronic, mechanical and machine subjects	5.44	-0.004	0.123	-0.016	6	6
56 Earth sciences	5.592	-0.017	0.125	-0.027	2	5
57 Building and construction	5.387	-0.006	0.058	-0.018	10	8
58 Manufacturing and extraction	5.22	-0.024	-0.035	-0.041	39	32
59 Natural sciences, vocational and technical subjects, other	5.366	-0.011	0.04	-0.021	13	10
61 Nursing and caring	5.38	-0.003	0.119	-0.012	12	7
62 Social services	5.23	-0.006	-0.032	-0.017	34	28
63 Medicine	5.838	-0.008	0.311	-0.027	1	1
64 Dental health	5.399	-0.02	0	-0.034	7	18
65 Therapy	5.227	-0.01	-0.062	-0.027	37	41
66 Pharmacy	5.563	-0.02	0.142	-0.032	3	3
67 Veterinary medicine	5.295	-0.027	-0.068	-0.052	21	43
68 Sport and physical education	5.265	-0.018	-0.031	-0.026	29	27
69 Health, welfare and sport, other	5.295	-0.009	0.02	-0.021	20	11
71 Fisheries and aquaculture	5.355	-0.029	0.003	-0.044	14	17
72 Agriculture	5.115	-0.03	-0.093	-0.049	49	48
74 Forestry	5.17	-0.03	-0.049	-0.038	45	36
79 Primary industries, other	5.23	-0.029	-0.062	-0.043	35	40
81 Transport and communications	5.484	-0.014	0.214	-0.025	4	2
82 Safety and security	5.391	-0.008	0.138	-0.034	8	4
99 Unspecified subject group	5.235	-0.017	-0.033	-0.025	33	29

Note: Only fields with at least 100 observations are included in the table.

Table A6. The Effects of Institution, Department, and Fields of Study on Annual Earnings (in 1,000 NOK) in column (1) and (2) and on Log Annual Earnings in column (3) and (4).

	(1)		(2)		(3)		(4)	
Institutional level	64.63	***	38.24	***	0.1505	***	0.1173	***
	(6.060)		(7.846)		(0.0167)		(0.0194)	
Field level	65.98	***	54.37	***	0.1554	***	0.1419	***
	(6.624)		(5.911)		(0.0159)		(0.0154)	
Department level			34.44	***			0.0730	***
			(1.753)				(0.0047)	
N	108250		108250		108227		108227	

Note: The reported coefficients are standard deviations of the random intercepts. See the Data and Variables section for a description of the control variables. Note that log annual earnings give substantial weight to differences in the bottom of the earnings distribution caused by differences in work hours. Individuals with zero earnings are included in the analyses. Standard errors in parentheses. Significance: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests).

Table A7. Changes in the effects of institution, department, and narrow fields of study over the work career

Institutional level	0.0249 (0.0066)
Institution*experience	0.0075 (0.0014)
Corr. intercept and slope, institution	-0.1855 (0.3088)
Field level	0.0560 (0.0073)
Field*experience	0.0125 (0.0015)
Corr. intercept and slope, field	-0.2833 (0.1591)
Department level	0.0449 (0.0037)
Department*experience	0.0056 (0.0006)
Corr. intercept and slope, department	0.0390 (0.1389)
N	422607

Note: The reported coefficients are standard deviations of the random intercepts. MCMC estimation using MLwiN. See the Data and Variables section for a description of the control variables. The models in this table also include experience and the interaction of experience with the graduate level dummy. Standard errors in parentheses.

Table A8. Effects of institution, department, and narrow fields of study on log wages in the full sample (column 1) compared to a sample restricted to students who enroll in higher education for the first time between 1997 and 2004 (column 2).

	(1)	(2)
Institutional level	0.0182 *** (0.0079)	0.0179 *** (0.0075)
Field level	0.0856 *** (0.0096)	0.0866 *** (0.0100)
Department level	0.0584 *** (0.0036)	0.0565 *** (0.0037)
N	102611	81550

Note: The reported coefficients are standard deviations of the random intercepts (see equation (3)). See the Data and Variables section for a description of the control variables. Standard errors in parentheses. Significance: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests).

Table A9. Effects of institution, department, and narrow fields of study on log wages in the full sample (column 1) compared to a sample restricted to students aged 27 or younger (column 2) and students aged 25 or younger (column 3) when enrolling in their last education.

	(1)	(2)	(3)
Institutional level	0.0182 *** (0.0079)	0.0206 *** (0.0084)	0.0210 *** (0.0092)
Field level	0.0856 *** (0.0096)	0.0890 *** (0.0100)	0.0885 *** (0.0100)
Department level	0.0584 *** (0.0036)	0.0570 *** (0.0038)	0.0559 *** (0.0040)
N	102611	84601	74411

Note: The reported coefficients are standard deviations of the random intercepts (see equation (3)). See the Data and Variables section for a description of the control variables. Standard errors in parentheses. Significance: * $p < .05$, ** $p < .01$, *** $p < .001$ (two-tailed tests).