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Demand and Supply Effects and Returns to College Education: Evidence from a Natural Experiment with Engineers in Denmark[*]

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Abstract:

The demand and supply model predicts that a larger relative net supply of a particular educational group will negatively affect its relative earnings. To test this, we use the opening Aalborg University as a natural experiment because it created a shock to the supply of electrical and construction engineers in Denmark in the 1980s. The results show that when the supply of electrical and construction engineers peaked their wages dropped relative to a comparison group of chemical engineers, which Aalborg University did not supply at the time. Hence, we conclude that even earnings of engineers who are in high demand are susceptible to supply effects.

Keywords: Demand and Supply Effects, Returns to College Education, Human Capital Earnings Function, Natural Experiment, Engineers

JEL: J20, I26, J24, C99

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I. Introduction

Education is an important factor in modern societies. From a societal perspective, education can serve to maintain and enhance prosperity and growth, and estimates of returns to education are therefore of central interest to policymakers who wish to expand the educational system in light of the anticipated returns. From an individual perspective, education can potentially improve one's skills and knowledge, and if used to raise productivity, it increases employment opportunities and can be converted into higher wages.

However, a sudden change in the educational system can have an adverse effect on returns to education, even in very prosperous sectors of the labor market, such as the technical market. The case of engineers is of particular interest since engineers' education is science, technology, engineering, and mathematics (STEM) education. STEM is believed to play a key role in competitiveness and future economic prosperity (Wendler et al. 2010; Klein, Rice, and Levy 2012). As such, STEM education reflects excess demand (Goldin and Katz 2008; Lacey and Wright 2009) and is therefore usually not considered to be very sensitive to supply-side effects. Using the case of engineers, we show that an exogenous shock to the supply of electrical and construction engineers created by the opening of a new university in Denmark that offered degrees in electrical and construction engineering had an adverse effect on the annual earnings for electrical and construction engineers, at least in the short term. This result implies that even in a specialized market in which the demand is very high, returns to education decrease if changes in the educational system create a sudden increase in the supply of a particular skill group. Previous studies have shown that supply and demand affect returns to education (Katz and Murphy, 1992; Angrist, 1995; Card and Lemieux, 2001). However, we make a key contribution to the literature by showing that the wages of specific educational groups, i.e., engineers, who are expected to be in high demand, c.f. Wilson (2009), are also susceptible to supply effects. In this respect, we add to the analysis of the importance of general equilibrium effects when estimating returns to education (Heckman, Layne-Farrar, and Todd 1996).

Since the pioneering work of Becker (1962, 1964/1993) and Mincer (1958, 1962, 1974), who formulated the now-standard human capital earnings function, which explains individual wages as a function of education and labor market experience, many empirical studies have confirmed the relationship between education and labor market returns (Card 1999 and Aakvik et al. 2010). College graduates command higher wages, experience less unemployment, and secure better jobs than their less educated counterparts (Hout 2012). Research on returns to college education has carefully and often ingeniously addressed whether this result holds in the presence of various challenges to the exogenous selection assumption (also known as the no-confounding assumption). These studies used various research designs to mitigate the effect of nonrandom selection on unobservable factors, such as individual-level innate ability, including in twin studies and sibling fixed effects (Angrist and Krueger 1991; Ashenfelter and Krueger 1994; Altonji and Dunn 1996; Behrman, Rosenzweig, and Taubman 1996; Ashenfelter and Rouse 1998; Rouse 1999; Duflo 2001; Heckman and Vytlacil 2001; Estrada et al. 2017). If a sufficiently large number of people enroll in the same graduate program, thereby increasing the supply of suitable candidates within this particular skill group, then the competition for jobs will increase, resulting in a lower price of labor within the skill group; consequently, employment rates and wages will drop. This effect is also known as a general equilibrium effect (Heckman et al. 1999), as opposed to a partial equilibrium effect, which is typically, estimated using a variant of the standard earnings function.

Previous empirical studies have shown that wages respond to the supply of skilled labor (Fallon and Layard 1975; Angrist 1995; Johnson 1997; Topel 1997; Card and Lemieux 2001, Leuven et al. 2004 and Manacorda et al. 2010). Studies providing empirical evidence in favor of the demand and supply model have included the study by Angrist (1995), who used a natural experiment with rapid educational expansion in the West Bank and Gaza Strip from 1981 to 1991 to study how a swiftly increasing supply of skilled labor affects the wage premium for highly skilled labor. Interestingly, the study provided evidence that the rapid expansion of higher education lowered the wage premium of highly skilled labor from 1981 to 1991, thus showing that a rapid increase in the supply of skilled labor can decrease the monetary returns to education.

In this paper, to examine supply effects, we use high-quality Danish register data and exploit a natural experiment in a part of the closed Danish labor market,[1] in which the supply of electrical and construction engineers spiked following the opening of a new university. Typically, newly graduated engineers from one field of study compete for similar jobs, implying that electrical engineers, construction engineers and chemical engineers compete for different jobs in the labor market. In addition, it is often the case that young and old candidates are not perfect substitutes due to differences in labor market experience. Hence, they are likely not competing with each other for the same jobs, especially given very low overall unemployment rates, especially in the period from 1981 to 1988 that we are studying.[2] Therefore, we do expect that the number of new graduates affected only their present and subsequent earnings and not those of experienced engineers. In summary, the estimated effects concern only the starting earnings and employment of new graduates.

[1] By a closed labor market, we mean that governmental and professional restrictions limit, and in some cases prevent, migration across borders. We believe that this characterization applies to the pre-EU Danish labor market in the 1980s, in which degrees received only limited recognition across borders. That the Danish labor market is "closed" makes our experiment "cleaner," since supply and demand effects from neighboring countries are less relevant.

[2] The demand for engineers was generally high in the period from 1981 to 1988, with some of the lowest unemployment rates among all graduates. Official Statistics show that the general rates of unemployment for engineers compared to other occupational groups were between 2.3 and 4.2 percent in the period from 1981 to 1988 (3.4 percent in 1981, 4.1 and 4.2 percent in the subsequent two years, and then 3.3 percent in 1984 and 2.6, 2.5 and 3.2 percent in the subsequent three years) (cf. Statistics Denmark 1990).

Here, we follow studies that have investigated whether and to what extent returns to college education vary by type of degree (Grogger and Eide 1995; Brewer, Eide, and Ehrenberg 1999; Light and Strayer 2004). Until the mid-1970s, only one university in Denmark supplied engineers. However, during this period, a new university, Aalborg University (AAU), was founded and predominantly offered engineering programs. As we later show, this event created a sudden exogenous increase in the supply of electrical and construction engineers in the mid-1980s. In particular, the supply of newly graduated electrical engineers increased by 50 percent within a few years, and the supply of construction engineers increased by 100 percent within in the same period. Conversely, chemical engineers were not supplied by the new university, and the supply of this type of engineers therefore remained stable. Accordingly, if supply effects are important for returns to education, recently graduated electrical and construction engineers should have experienced a drop in wages and/or employment rates because of the exogenous increase in the supply of construction engineers. Given that, AAU did not have a chemical engineering program at the time and that there was no other spike in the supply of this group, we use chemical engineers as a comparison group. We find that the earnings of electrical engineers decreased around the time that they entered the labor market from AAU, i.e., in 1986. We further find that the earnings of construction engineers and, to some extent, their employment rates dropped, with the most marked effect in 1984 as the supply of construction engineers peaked. This finding provides evidence that a sudden exogenous increase in the supply of a particular skill group in high demand can negatively affect the returns to this particular type of education.

To mitigate the potential problem of lower quality students entering construction and electrical engineering programs, which might arise if lower ability students self-selected into the additional student places created by AAU's opening, we estimate individual fixed effects models. Fixed effects models control for time-invariant baseline differences between individuals, such as innate ability.

Moreover, to alleviate bias regarding variation in the quality of education, which might arise if the immature AAU provided a substandard education for a certain amount of time, we estimate separate models solely for Technical University of Denmark (DTU) engineers. Here, we follow studies that investigated whether returns to attending highly selective or elite colleges are greater than for those attending less selective colleges (Dale and Krueger 2002; Dale and Krueger 2014). Using only electrical, construction, and chemical engineers from DTU, which arguably did not change its quality during the period of investigation, we still find evidence of a wage drop around 1984.

Further, we investigate whether the earnings drop is sensitive to social background, following a longstanding tradition in previous studies (e.g., McIntosh and Munk 2007). We find that the effect of the exogenous supply shock was, in fact, sensitive to social background, thus providing evidence that a change in the supply of skilled labor affects candidates from lower social backgrounds more than candidates from higher social backgrounds. We interpret this result as an effect of social networks with access to job opportunities that vary by social background (Lin et al. 1981).

Finally, we follow electrical engineers prior to the exogenous supply shock to test for the parallel trend, i.e., that the earnings and employment patterns for electrical and chemical engineers were developing similarly prior to the expansion of supply of electrical engineers. In doing so, we find no indications of violations of the parallel trend assumption. In this way, we advance the identification of the estimated supply effects.

This paper proceeds as follows. Section 2 presents a simple theoretical framework to evaluate the relationship between the supply and earnings for skilled labor. Section 3 outlines the background of the study and explains how we use the opening of AAU to conduct a natural experiment. Section 4 discusses the data and variables and describes the empirical strategy, which allows us to identify the effects of the exogenous supply shock of construction and electrical engineers. Section 5 presents the results. Section 6 concludes the study.

II. Supply and Returns to an Engineering College Degree

In this section, we briefly introduce a simple theoretical framework for understanding the earnings dynamics that are empirically estimated in the paper. We study a situation in which we have two skill groups that are not perfect substitutes of one another. Following Katz and Murphy (1992) and Angrist (1995), we posit that the wage for a skill group covaries negatively with the supply of this skill group.

More specifically, imagine that we have two skill groups: denoted electrical/construction engineers on one side and all chemical engineers on the other. They enter the production function in a constant elasticity of substitution (CES) manner:

$$Y = \left[A L_{tr}^{\frac{\sigma-1}{\sigma}} + B L_{crtl}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma-1}{\sigma}} \tag{1}$$

where Y is the total output, L_{tr} is the supply of the treatment group (electrical/construction engineers), and L_{crtl} is the supply of the comparison group (chemical engineers). A and B are technical input parameters, and σ is the elasticity of substitution between electrical/construction engineers and chemical engineers. A special comment is required about the technical input parameters. The proposed model is static. However, we assume that skill-biased technological progress will change both A and B positively (such that skill-biased technological change increases the wage rate for engineers in general; Acemoglu (1998)).

Under the assumption of competitive labor markets, the wage rate for electrical/construction engineers is simply given by the marginal product of electrical/ construction engineers, $\partial Y / \partial L_{tr}$. Calculating the logs yields

$$\ln w_{tr} = \frac{\sigma - 1}{\sigma} \ln A + \frac{1}{\sigma - 1} \ln \left[A^{\frac{\sigma-1}{\sigma}} + B^{\frac{\sigma-1}{\sigma}} \frac{L_{crtl}}{L_{tr}} \right] \tag{2}$$

from which we find that $\partial \ln w_{tr} / \partial L_{tr} < 0$ when $\sigma < 1$. Hence, if electrical/ construction engineers and chemical engineers are not fully substitutable, an exogenous increase in the supply of electrical/construction engineers will lead to a decrease in the wage rate for electrical/construction engineers relative to chemical engineers. Therefore, in the following, when we examine the wages[3] of electrical/construction engineers and use chemical engineers as a comparison group to study the effect of an exogenous increase in the supply of electrical/construction engineers, we expect the increase in supply to negatively affect the wage rate of electrical/construction engineers. This expectation holds only when electrical/construction engineers and chemical engineers are not perfect substitutes. Hence, we can expect to find wage effects only in cases in which engineers are not perfect substitutes across types.

If the change in technology parameter A is positive, then it will alleviate the negative wage effect of the increase in labor supply over time. Hence, in the case of skill-biased technological changes, the wage effect might be transitory. Our empirical analysis investigates this issue.

[3] Due to data limitations, we cannot study wages but only annual earnings. However, since we also study employment, for we find very limited effects, we are able to speak about wage effects from the annual earnings estimates.

Finally, our model assumes a wage-clearing labor market. In the case of possible search frictions or other limitations to wage clearing, we might also find transitory effects on the employment rate for electrical and construction engineers vis-à-vis other engineers.

III. Background: The opening of Aalborg University as a Natural Experiment

Before the opening of AAU, the only place to receive a Master's degree in engineering in Denmark was Polytechnic University, which was founded in 1829 and is located in Denmark's capital, Copenhagen. Later, Polytechnic University changed its name to the Technical University of Denmark (DTU), which is how it is known today. Initially, the school offered two types of engineering programs: chemical engineering and mechanical engineering. Construction engineering was added in 1857, and electrical engineering was added in 1903, thus completing the list of the four traditional types of engineering. From 1829 to 1974, DTU was the only place to receive a Master's degree in engineering in Denmark. Thus, "Master's of Engineering" (cand.polyt.), stipulated as a five-year program, was a generic term for candidates from DTU.

However, in 1957, the Danish Engineering Academy (DEA) was founded, and it opened a department in Aalborg in 1966. The DEA offered only undergraduate programs, or a Bachelor's of Engineering, and graduates are known as "Diploma engineers".[4] Further, in 1974, AAU was founded with DEA as an important component, and beginning in 1974, AAU offered an MSc program in engineering, thus becoming the first institution of higher education in Denmark apart from DTU to train "Master's of Engineering" students. That there were now two institutions of higher education offering MScs in engineering resulted in an increase in the supply of engineers in the early and mid-1980s.

[4] A "Diploma in Engineering" is a shorter, more practically oriented educational program than that required for a Master's of Engineering. There are two types of Diploma (practical) engineers in Denmark: Academy engineers (akademiingeniører) and Technicum engineers (Teknikumingeniører).

The first MScs in engineering from AAU graduated in the early 1980s. However, it was not until the mid-1980s that the supply of construction engineers momentarily increased, due to a buildup of students delaying their enrollment in anticipation of the opening of the MSc engineering program at AAU. In addition, the reason for the relatively long time span from the opening of the MSc program to the increase in the number of graduates was because an MSc in engineering in the 1970-1980s took on average approximately 1-3 more years of study than the formally stipulated five-year program.[5]

AAU did not provide educational programs for all types of engineers from the beginning. In fact, until the mid-1980s, only construction engineers graduated from AAU. Importantly, AAU did not train chemical engineers before the mid-1990s. We can therefore think of this situation as a natural experiment that we can exploit to estimate the causal effect on income of increasing the supply of engineers. Because the opening of AAU significantly increased the supply of construction and electrical engineers and did not change the supply of chemical engineers, we assume that construction and electrical engineers are affected by the exogenous supply shock[6], while chemical engineers form a suitable comparison group because they should be unaffected by the supply shock of construction and electrical engineers.[7] Furthermore, we assume that, conditional on the baseline differences between construction/electrical engineers and chemical engineers, as well as year-to-year fluctuations, the earnings development of construction, electrical and chemical engineers would have shown similar patterns in the absence of the exogenous shock to the supply of construction engineers.

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[5] We note that the opening of the MSc program at AAU was a time-consuming process and did not reflect any current issues in the engineering labor market.

[6] Beginning in 1984, AAU also provided mechanical engineers to the market; however, we do not observe a spike in the supply of this group of engineers. Therefore, we only use construction and electrical engineers as treatment groups.

[7] We note that mechanical engineers are likely to be affected by the supply shock of construction engineers and electrical engineers because they partially share labor markets since they are more substitutable. The wage effects would then effectively be smaller when using not perfectly substitutable comparison groups, as stated in the theory section. Therefore, we restrict our comparison group to chemical engineers.

Although we can reasonably form two "treatment groups" and a comparison group, as argued above, we must assume that the timing of graduation is independent of labor market conditions, i.e., that no students deliberately postponed graduation due to labor market conditions. When we examine the supply of electrical/construction and chemical engineers in greater detail, we discover that the supply of construction engineers showed a spike in 1984, and the supply of electrical engineers showed a sudden increase from 1984 onward, with a spike in 1987.[8] Fig. 1 shows the supply of engineers by type from AAU and DTU from 1981 to 1988.

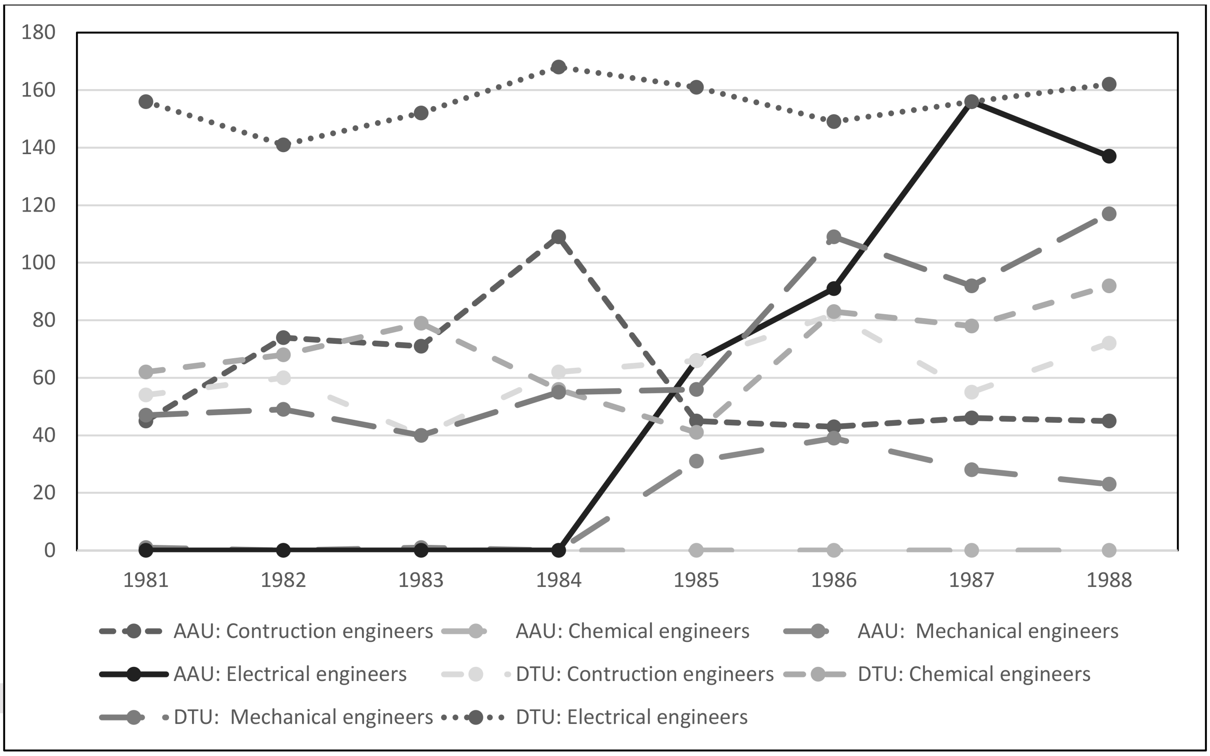

Fig. 1. The supply of engineers in each year from AAU and DTU over the period from 1981-1988.
Note: Years of observations are represented on the x-axis, and the number of graduated engineers is represented on the y-axis. The period from 1981 to 1988 is the observation period in which we are examining earnings and employment effects.

[8] These spikes might, at least in part, be due to the strategic behavior of students postponing their graduation to await better labor market conditions. For strategic behavior to pose a time-varying selection issue, it must apply differently to electrical/construction engineers, compared to chemical engineers. However, this case might be true for construction engineers. The construction sector is more susceptible to business cycle effects, and since employment in 1984 indeed was better than in preceding years, the spike in the supply of construction engineers in 1984 might, at least in part, be due to the strategic behavior of the students to a larger extent than it was for chemical engineers. For electrical engineers, we can test dynamic selection effects by testing for parallel trends. This test is not possible for construction engineers. We should therefore bear this caveat in mind when interpreting results for construction engineers.

Fig. 1 reveals that the supply of construction engineers showed an increase from 1981 to 1984, with a pronounced spike in 1984 and a clear decrease after 1984. This increase was particularly driven by candidates from AAU, while the supply of chemical engineers actually decreased beginning in 1983. The momentary increase in the number of construction engineers in 1984 was the result of a graduation wave of several cohorts of students who attended the new AAU in the late 1970s and typically took more than 5 years of study to obtain their MSc degrees. Accordingly, given that supply effects are important, we should see a difference between the earnings and employment rates of construction and chemical engineers between 1981 and 1984.[9] As shown in Fig. 1, it is also evident that, from 1984 onward, the supply of electrical engineers increased markedly because AAU began supplying this type of engineer. The supply continued to increase until 1988, with the relative increase being the largest initially. Therefore, we should also expect to see a difference between the wages and employment rates of electrical and chemical engineers.

IV. Data, Variables and Empirical Strategy

For the analyses, we use high-quality register data from Denmark collected annually by Statistics Denmark. In Denmark, all residents have a unique personal identification number, which makes it possible to merge information from several different administrative registers. Information on annual earnings and employment rates is obtained from employers and is normally used for administrative tax purposes. Information about education is collected from educational institutions. Accordingly, we are able to create a sample containing all Master's in engineering students who received their degrees in the period from 1981 to 1988.

[9] Note that the supply of chemical engineers decreases at the same time that it increases for construction engineers. This fact will tend to reinforce any wage differentials between the two groups of engineers.

The impact of supply shocks is evaluated by examining annual earnings and rates of employment in the period from 1981-1988. Because we use register data, we avoid measurement error due to self-reporting.[10] Moreover, full information about annual earnings is available; i.e., earnings are not top coded, as is often the case with U.S. data. Furthermore, because the administrative registers contain information about everyone living in Denmark, we do not risk earnings-selective attrition, which might arise from survey data.

Annual earnings are measured as yearly taxable earnings, including fringe benefits and severance pay. If an individual had not graduated in the year of observation, the individual's earnings is set to missing—even if he or she had observable earnings—to avoid bias from observing student job earnings or similar earnings that bias earnings estimates downward.

The rate of employment is measured in per mille. It is calculated as $1000-((U/W)\cdot 1000)$, where U is the net unemployment in weeks during the work year and W is the number of weeks in the work year, excluding holidays in the relevant year. The variable thus takes values from 0 to 1000 in each year.

Labor market experience is approximated from information about pension payments and is measured in per mille per annum. We have divided this measure of labor market experience by 1000 to avoid scaling problems in the models. Accordingly, an individual who has a value of 5.5 on the labor market experience variable has 5.5 years of labor market experience.

We control only for labor market experience because we estimate individual fixed effects models that effectively sweep out all baseline observed and unobserved differences between individuals, including innate ability.

[10] Although there is no measurement error due to self-reporting, measurement error in the graduation year cannot be excluded entirely since educational institutions report graduation rates to Statistics Denmark.

Table 1 shows descriptive statistics for electrical, construction, and chemical engineers. The differences among electrical, construction, and chemical engineers in terms of wage and employment rates are negligible. However, most of the differences are statistically significant due to the large sample sizes. The largest differences among the three groups are that a larger proportion of chemical engineers are female and have parents with a college education.

Table 1. *Descriptive statistics*

	Construction engineers (Treatment group 1)			Electrical engineers (Treatment group 2)			Chemical engineers (Comparison group)		
	Obs.	Mean	SD	Obs.	Mean	SD	Obs.	Mean	SD
Wage	4375	206115.10	102954.40	6520	211740	111483.70	2382	201342.60	102668.70
Employment rate	4230	946.17	131.58	6293	952.91	125.75	2284	942.21	149.92
Ln(earnings)	4173	12.11	0.76	6209	12.12	0.79	2262	12.10	0.77
Ln(employment rate)	4218	6.84	0.23	6287	6.84	0.24	2280	6.82	0.35
AAU	4375	0.52	0.50	6520	0.15	0.36	2382	-	-
Labor market experience	4230	2.75	1.85	6293	2.78	1.90	2284	2.89	1.88
Parent(s) with a college education	3885	0.39	0.49	5645	0.45	0.50	2048	0.53	0.50

Empirical and Identification Strategy

To empirically examine the effect of the sudden increase in the supply of electrical and construction engineers on their relative earnings and employment rates, we follow Angrist (1995) and use an augmented earnings function that allows returns to education to depend on the timing of graduation. Because the supply of construction engineers peaked in approximately 1984, and the supply of electrical engineers increased after 1984, with a peak in 1987, these increases in supply should have caused their earnings and employment rates to decrease relative to those of chemical engineers during this period.

To identify this effect, we assume that, except for baseline differences and year-to-year fluctuations, electrical, construction, and chemical engineers' earnings and employment rates would have developed in a similar pattern to a control group of chemical engineers in the absence of changes in the supply of construction engineers in approximately

1984 and electrical engineers after 1984. To justify this assumption for electrical engineers, we use two empirical strategies. First, we use that we have data on the earnings and employment of electrical engineers (but not of construction engineers) prior to the supply shock to test the parallel line assumption. We do so by testing whether the earnings of electrical engineers deviated systematically from the wages of the comparison group of chemical engineers prior to the supply shock of electrical engineers in 1985-1987.

Further, in section 5.6, we show that, in comparison with chemical production, electronic production activity developed in a stable and increasing pattern during the period of investigation, suggesting that the decrease in the earnings and employment rates of electrical engineers cannot be attributed to business cycle volatility specifically affecting the sectors important for electrical engineers. We are able to demonstrate similar demand-side conditions for construction engineers, excluding that business cycle effects generate the earnings effect and the employment effect, except for the supply shock of construction engineers.

Furthermore, because AAU did not train chemical engineers during the study period, we observe that the comparison group of chemical engineers did not experience any unusual changes in supply during the study period.

In addition to the year-to-year volatility in the general demand and supply for engineers, which are absorbed by year fixed effects, one could argue that increases in the demand and supply of electrical and construction engineers could potentially spill over to other types of engineers. However, we assume that the demand for electrical and construction engineers does not spill over to chemical engineers because electrical, construction, and chemical engineers are specialized within highly different fields of engineering and thus compete for different jobs (see also section 2). One might argue that the exogenous selection assumption is likely to be violated. This situation arises if engineers with higher unobserved ability choose to study at DTU because it is a mature institution with a good reputation, whereas engineers with low unobserved ability chose AAU because it was a new and untested institution and therefore was assumed to be "easier" to graduate. To render the exogenous selection assumption more credible, we allow for individual fixed effects in our empirical model. We can now identify the effect of the increased supply shock of electrical and construction engineers with equation 1, which is largely similar to the strategy employed by Angrist (1995) to estimate the effect of an increased supply of college graduates on returns to schooling and found profound effects. In our case, we have the following:

$$\text{Ln}\,(y_{it}) = \gamma_i + \tau_t + \pi_t \cdot \tau_t \cdot TR_i + \delta' \boldsymbol{EXP}_{it} + \varepsilon_i \tag{3}$$

where *i* indexes individuals and *t* indexes time. $Ln(y_{it})$ is the natural log of annual earnings standardized to 1988 DKK and the log of employment rates, respectively. γ_i are individual fixed effects that absorb unobserved time-invariant differences between individuals who affect earnings and employment rates. τ_t is a time fixed effect absorbing wage and employment rate variation as the result of year-to-year volatility in the general demand for engineers. TR_i is a treatment group indicator equal to 1 if individual *i* is an electrical/construction engineer. Note that the indicator TR_i is time invariant and consequently drops out of the fixed effect estimation. The interaction term $\tau_t \cdot TR_i$ captures earnings deviations across time for electrical engineers and construction engineers, compared to chemical engineers. EXP_{it} is labor market experience, and ε_{it} is an error term.

The parameters of interest are the vector of coefficients, π_t, which identifies the time-varying marginal effects of being a construction or an electrical engineer, which we interpret as supply effects. We want to estimate equation 1 for each graduation year, allowing us to address how the employment rates and earnings of each graduation year group are affected in each calendar year after entering the labor market.

Note how the test for parallel trends (or no pretreatment period effects) between the treatment group (electrical engineers) and the comparison group (chemical engineers) amounts to testing whether π_t is zero in pretreatment periods.

To summarize, our identification comes with nonparametric group-specific time trends (interaction terms), indicating that we can identify earnings differences between the groups.

We estimate separate equations for electrical versus chemical engineers and construction versus chemical engineers. If we find that electrical and construction engineers have lower earnings and lower employment rates than chemical engineers around the supply shock, conditional on year-to-year fluctuations and individual characteristics, one might still argue that this result arises only because electrical and construction engineers from AAU received their diplomas from a new and untested institution without DTU's reputation. This assumption is equivalent to arguing that the supply shock would affect only the wage and employment rates of construction and electrical engineers from AAU and not those of electrical and construction engineers from DTU. Therefore, we exclude engineers from AAU and re-estimate equation 1 with only engineers from DTU to check whether engineers from DTU remain unaffected by the increased supply shock.

Finally, we expect that the effect of the supply shock might have socially heterogeneous effects, so we expect that the supply shock of construction and electrical engineers will have a stronger, negative impact on the earnings and employment rates of construction and electrical engineers with parents who do not have a history college education. To test this notion, we re-estimate equation 1 separately for individuals who have at least one parent with a college education.

V. Results

Results for Electrical Engineers Versus *Chemical Engineers*

Table 2 presents the results of the fixed effects estimations of the returns to an electrical engineering degree (in terms of log earnings) specific to the year of observation and year of graduation. The individual fixed effects control for unobserved, time-invariant baseline differences between individuals and thus eliminate potential quality of student bias, which could arise if low-ability students were selected into the newly opened AAU, perhaps resulting in exaggerated results because lower ability students would likely have earned lower wages and suffered lower employment rates, even in the absence of an exogenous supply shock.

Table 2 provides evidence of a marked annual earnings penalty for electrical engineers compared to chemical engineers in 1986 but only in the first year after graduation. The estimated coefficients suggest significant earnings penalties of 31 percent in 1986 relative to chemical engineers. Note that our test for parallel trends prior to the supply shock (using a joint F-statistic of pretreatment years) is safely accepted. Thus, we do not find any sign of our results being biased because of any pretreatment differences in the trajectories of earnings of electrical engineers, compared to chemical engineers.

Table 2. *Marginal effects of graduation year on logged earnings for electrical engineers relative to chemical engineers. Separate graduation year cohorts in the period from 1981-1988*

	Graduation year						
	1981	1982	1983	1984	1985	1986	1987
1981 × Electrical engineer	0.23						
	(0.20)						
1982 × Electrical engineer	0.17	0.05					
	(0.11)	(0.16)					
1983 × Electrical engineer	0.12	0.01	-0.13				
	(0.13)	(0.06)	(0.13)				
1984 × Electrical engineer	0.10	0.06	-0.00	-0.14			
	(0.08)	(0.06)	(0.06)	(0.12)			
1985 × Electrical engineer	-0.03	0.03	0.08	-0.02	-0.13		
	(0.05)	(0.04)	(0.08)	(0.04)	(0.17)		
1986 × Electrical engineer	0.04	-0.03	0.05	0.00	-0.01	-0.31**	
	(0.05)	(0.05)	(0.06)	(0.04)	(0.06)	(0.09)	
1987 × Electrical engineer	0.07*	-0.01	0.05	0.05	-0.01	-0.01	-0.17
	(0.03)	(0.03)	(0.05)	(0.05)	(0.04)	(0.04)	(0.15)
Main effects of time dummies	YES	YES	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES	YES
Joint F-statistic of pretreatment years	1.19	0.33	0.57				
(before 1985)	(0.31)	(0.81)	(0.57)				
Observations	1611	1381	1316	1056	1008	902	686

Note: The models include main effects of the year dummies, and labor market experience is controlled. Standard errors clustered at the individual level are displayed in parentheses. The value in parenthesis under the joint F-statistic of pretreatment years (before 1985) is the p-value of the F-statistic. * and ** indicate statistical significance at the 5% and 1% levels, respectively. The year 1988 is the baseline year.

Table 3 presents the employment rates of electrical engineers, compared to chemical engineers. From table 3, we do not find any employment penalty for electrical engineers compared to chemical engineers. Hence, the exogenous increase in the supply of electrical engineers did not seem to affect the employment of electrical engineers. One possible interpretation of this result is that the young people who graduated as electrical engineers during the time of the increase in the supply were productive and found lower-paying jobs, possibly outside their core profession. In summary, the exogenous increase in the supply of electrical engineers seemed to influence only annual earnings and not employment. A result that is concordant with our theory section, which states that, in a competitive labor market, an exogenous increase in the supply of one type of engineers will lead to a decrease in the wage rate for this type of engineer and that employment rates will not be much affected.

Table 3. *Marginal effects of graduation year on employment rates for electrical engineers relative to chemical engineers. Separate graduation year cohorts in the period from 1981-1988*

	Graduation year						
	1981	1982	1983	1984	1985	1986	1987
1981 × Electrical engineer	-0.01						
	(0.06)						
1982 × Electrical engineer	0.07	0.10*					
	(0.12)	(0.05)					
1983 × Electrical engineer	0.04	0.02	-0.04				
	(0.05)	(0.05)	(0.05)				
1984 × Electrical engineer	-0.02	0.07	0.01	0.03			
	(0.07)	(0.06)	(0.08)	(0.04)			
1985 × Electrical engineer	0.00	0.03	-0.03	0.03	0.07		
	(0.09)	(0.03)	(0.03)	(0.02)	(0.06)		
1986 × Electrical engineer	0.01	0.01	0.01	0.01	0.10	0.03	
	(0.10)	(0.02)	(0.06)	(0.02)	(0.06)	(0.03)	
1987 × Electrical engineer	-0.04	-0.00	-0.02	0.01	-0.04	0.05	0.03
	(0.04)	(0.01)	(0.02)	(0.03)	(0.08)	(0.04)	(0.08)
Main effects of time dummies	YES	YES	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES	YES
Joint F-statistic of pretreatment years (before 1985)	0.73	1.82	0.61				
	(0.57)	(0.14)	(0.55)				
Observations	1651	1410	1343	1080	1030	933	744

Note: The models include main effects of the year dummies, and labor market experience is controlled. Standard errors clustered at the individual level are displayed in parentheses. The value in parenthesis under the joint F-statistic of pretreatment years (before 1985) is the p-value of the F-statistic. * and ** indicate statistical significance at the 5% and 1% levels, respectively. The year 1988 is the baseline year.

5.2. Were Returns to an Electrical Engineering Degree from DTU also Affected?

One possible explanation for our results is that returns to receiving an electrical engineering degree from the newly opened AAU were lower than those for electrical engineers from DTU. Although the individual fixed effects estimation eliminates baseline differences in the quality of students, another source of bias is differences in the quality of education across universities (see, e.g., Lindahl and Regnér 2005) or that graduation from an established and selective college, such as DTU, has a strong signaling effect. Finally, despite the small size of Denmark, it contains local labor markets, indicating that the increase in electrical engineers from AAU might have mainly affected the labor market in proximity to AAU and, to a lesser extent, the labor market in proximity to DTU. In either of these cases, we expect that only electrical engineers from AAU would be affected. To investigate these potential sources of bias, we re-estimate the fixed effects, excluding electrical engineers from AAU. In the online Appendix, table A1, we show the earnings rates for electrical engineers from DTU only.

We find that electrical engineers from DTU only experienced an earnings penalty of approximately 20 percent compared to all electrical engineers. Thus, the earnings penalty in 1986 for electrical engineers from AAU must be larger than the average 31 percent reported in table 2.

We also investigate whether the employment effects from the exogenous increase in the supply of electrical engineers vary across engineers from DTU and AAU. Table A2 presents the employment rates for electrical engineers from DTU only, compared to chemical engineers.

We find that there are no significant employment effects for electrical engineers from DTU, confirming that the effect of the exogenous increase in the supply of electrical engineers affected earnings rates and not employment rates.

5.3. Is the Supply Effect for Electrical Engineers Socially Heterogeneous?

We ask whether some candidates are exempted from the effects of the sudden increase in the supply of engineers, which could be the case if social networks play a role. In particular, we expect social ties of parents to matter to job searches and the job quality of new entrants to the labor market; see, e.g., Ioannides and Loury (2004). Additionally, students with more affluent and better educated parents might be better able to afford to begin with a lower-paying job or even wait for the right job. In other words, we are testing for social heterogeneous effects. To do so, we ran separate models for engineers with and without parents with a college education, with the results for earnings shown in table 4 and employment in table 5.

Table 4 reveals that there are heterogeneous effects in the sense that the largest earnings penalty is seen for students with parents without a college education, whereas students with parents with a college education have smaller earnings penalties in both 1985 and 1986.[11]

From table 5, we find no effects from the exogenous increase in the supply of electrical engineers on employment rates. Thus, the heterogeneous effects only appear in the earnings rates. However, somewhat surprisingly, we find a significant, positive employment effect for the 1985 cohort. We have no particular rationale for this finding. We believe that this might be an artifact arising from multiple testing; that is, we test multiple times for supply effects (each entry in all our tables is a test), and hence, we will eventually encounter an anomaly.

[11] We note, however, that the difference across parental education in table 4 is not significant. However, the results, together with further results below on social heterogeneous effects, show consistently larger negative effects for students with parents without a college education, compared to students with parents with a college education. In total, we make eight comparisons around the supply peaks, and all of them show larger negative effects for students with parents without a college education compared to students with parents who have a college education.

Table 4. *Marginal effects of graduation year on logged earnings for electrical engineers relative to chemical engineers. Separate graduation year cohorts in the period from 1981-1988. Individuals of parents with and without a college education*

	Parents without college Graduation year							Parents with college Graduation year						
	1981	1982	1983	1984	1985	1986	1987	1981	1982	1983	1984	1985	1986	1987
1981 × Electrical engineer	0.32							0.17						
	(0.36)							(0.22)						
1982 × Electrical engineer	0.06	0.13						0.39	-0.04					
	(0.11)	(0.16)						(0.30)	(0.29)					
1983 × Electrical engineer	-0.06	-0.06	-0.15					0.42	0.03	-0.21				
	(0.08)	(0.08)	(0.20)					(0.38)	(0.10)	(0.22)				
1984 × Electrical engineer	0.09	0.02	0.05	-0.20				-0.08	0.03	-0.07	-0.05			
	(0.13)	(0.05)	(0.07)	(0.16)				(0.12)	(0.11)	(0.13)	(0.18)			
1985 × Electrical engineer	-0.01	0.06	0.03	-0.07	0.05			-0.17	-0.05	0.09	0.03	-0.42*		
	(0.05)	(0.05)	(0.06)	(0.08)	(0.31)			(0.11)	(0.05)	(0.16)	(0.05)	(0.19)		
1986 × Electrical engineer	0.07	-0.09	0.04	0.01	-0.00	-0.48**		-0.07	-0.00	0.05	0.02	-0.05	-0.28*	
	(0.09)	(0.10)	(0.05)	(0.08)	(0.06)	(0.12)		(0.10)	(0.07)	(0.15)	(0.04)	(0.14)	(0.12)	
1987 × Electrical engineer	0.01	0.03	0.08*	0.13	-0.02	-0.07	-0.13	0.06	-0.05	0.05	0.03	0.03	-0.04	-0.22
	(0.05)	(0.04)	(0.03)	(0.08)	(0.06)	(0.04)	(0.25)	(0.03)	(0.05)	(0.12)	(0.04)	(0.08)	(0.04)	(0.18)
Main effects of time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Joint F-statistic of pretreatment years	1.11	1.02	1.14					1.00	0.06	049				
(before 1985)	(0.36)	(0.39)	(0.32)					(0.41)	(0.98)	(0.61)				
Observations	687	624	630	424	519	430	377	561	560	516	497	386	411	282

Note: The models include main effects of the year dummies, and labor market experience is controlled. Standard errors clustered at the individual level are displayed in parentheses. The value in parenthesis under the joint F-statistic of pretreatment years (before 1985) is the p-value of the F-statistic. * and ** indicate statistical significance at the 5% and 1% levels, respectively. The year 1988 is the baseline year.

Table 5. *Marginal effects of graduation year on logged employment rates for electrical engineers relative to chemical engineers. Separate graduation year cohorts in the period from 1981-1988. Individuals of parents with and without a college education*

	Parents without college Graduation year							Parents with college Graduation year						
	1981	1982	1983	1984	1985	1986	1987	1981	1982	1983	1984	1985	1986	1987
1981 × Electrical engineer	0.02							-0.16						
	(0.03)							(0.17)						
1982 × Electrical engineer	-0.10	0.06						0.12	0.13*					
	(0.09)	(0.06)						(0.23)	(0.06)					
1983 × Electrical engineer	-0.03	-0.05	-0.04					-0.05	0.08	-0.02				
	(0.04)	(0.08)	(0.04)					(0.10)	(0.08)	(0.09)				
1984 × Electrical engineer	-0.04	0.00	-0.03	0.00				-0.18	0.11	0.08	0.09*			
	(0.04)	(0.02)	(0.06)	(0.04)				(0.19)	(0.12)	(0.16)	(0.04)			
1985 × Electrical engineer	-0.01	0.05	0.00	0.04	-0.06			-0.20	-0.00	-0.09	0.06*	0.29*		
	(0.02)	(0.04)	(0.01)	(0.03)	(0.10)			(0.19)	(0.03)	(0.07)	(0.03)	(0.13)		
1986 × Electrical engineer	-0.03	0.02	0.01	0.05	-0.00	0.06		-0.19	0.01	-0.09	0.01	0.30	0.01	
	(0.02)	(0.02)	(0.01)	(0.03)	(0.05)	(0.07)		(0.19)	(0.02)	(0.06)	(0.02)	(0.16)	(0.02)	
1987 × Electrical engineer	-0.03	0.02	0.02	0.08	-0.20	0.09	0.06	-0.11	-0.03	-0.06	0.01	0.18	-0.03	-0.04
	(0.02)	(0.01)	(0.01)	(0.04)	(0.13)	(0.09)	(0.07)	(0.09)	(0.03)	(0.04)	(0.01)	(0.11)	(0.03)	(0.12)
Main effects of time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Joint F-statistic of pretreatment years (before 1985)	2.29	1.16	0.64					1.22	1.58	0.24				
	(0.07)	(0.33)	(0.53)					(0.31)	(0.20)	(0.79)				
Observations	695	639	639	435	530	443	402	573	571	523	506	392	426	309

Note: The models include main effects of the year dummies, and labor market experience is controlled. Standard errors clustered at the individual level are displayed in parentheses. The value in parenthesis under the joint F-statistic of pretreatment years (before 1985) is the p-value of the F-statistic. * and ** indicate statistical significance at the 5% and 1% levels, respectively. The year 1988 is the baseline year.

5.4. Results for construction engineers versus chemical engineers

Table 6 presents the results of the fixed effects estimations of the returns to a construction engineering degree specific to the year of observation and year of graduation.

Table 6. *Marginal effects of graduation year on logged earnings for construction engineers relative to chemical engineers. Separate graduation year cohorts in the period from 1981-1988*

	Graduation year						
	1981	1982	1983	1984	1985	1986	1987
1981 × Construct. engineers	0.19						
	(0.22)						
1982 × Construct. engineers	0.22	-0.33					
	(0.12)	(0.18)					
1983 × Construct. engineers	0.13	-0.07	-0.48**				
	(0.13)	(0.07)	(0.14)				
1984 × Construct. engineers	0.10	-0.03	-0.06	-0.46**			
	(0.09)	(0.07)	(0.05)	(0.12)			
1985 × Construct. engineers	-0.02	0.01	0.03	-0.06	-0.16		
	(0.06)	(0.03)	(0.06)	(0.05)	(0.18)		
1986 × Construct. engineers	0.01	0.04	-0.04	-0.02	-0.06	-0.33**	
	(0.06)	(0.04)	(0.05)	(0.04)	(0.06)	(0.11)	
1987 × Construct. engineers	0.04	0.01	-0.07	0.01	-0.02	-0.02	-0.03
	(0.04)	(0.03)	(0.04)	(0.05)	(0.05)	(0.05)	(0.16)
Main effects of time dummies	YES	YES	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES	YES
Observations	1201	1292	1046	1082	583	591	322

Note: The models include main effects of the year dummies, and labor market experience is controlled. Standard errors clustered at the individual level are displayed in parentheses. * and ** indicate statistical significance at the 5% and 1% levels, respectively. The year 1988 is the baseline year.

Table 6 provides clear evidence of a marked earnings penalty for construction engineers compared to chemical engineers in 1983, 1984, and 1986 but only in the first year after graduation, similar to what we found for electrical engineers compared to chemical engineers. The estimated coefficients suggest significant earnings penalties in the range of approximately 48 percent in 1983, 46 percent in 1984, and 33 percent in 1986 relative to chemical engineers. These results suggest that the increased supply of construction engineers already began to affect returns to a construction engineering degree in 1983, with similar earnings penalties in 1984 as the supply of new candidates from AAU peaked, and it lost its importance thereafter as the supply of construction engineers declined in both absolute and relative terms. The reason for the earnings penalty in 1986, after the supply peaked, was likely a minor slowdown in the construction industry in 1986 following a fiscal intervention by the government to slow the growth of the Danish housing market; see Kananen (2014). (We return to the importance of differential demand by type of engineer at the end of this section. There, we show that it is unlikely that our earnings effect coincides with differential demand such that the large earnings penalties that we find are all associated with demand shifts. We also note that the earnings effect seems transitory. We return to this issue in the discussion below).

Table 7. *Marginal effects of graduation year on logged employment rate for construction engineers relative to chemical engineers. Separate graduation year cohorts in the period from 1981-1988*

	Graduation year						
	1981	1982	1983	1984	1985	1986	1987
1981 × Construct. engineers	-0.04						
	(0.07)						
1982 × Construct. engineers	0.15	0.06					
	(0.12)	(0.05)					
1983 × Construct. engineers	0.02	-0.07	-0.05				
	(0.06)	(0.07)	(0.06)				
1984 × Construct. engineers	-0.03	-0.00	0.01	-0.07*			
	(0.07)	(0.07)	(0.08)	(0.03)			
1985 × Construct engineers	0.01	0.02	-0.00	-0.04	-0.01		
	(0.09)	(0.03)	(0.05)	(0.02)	(0.05)		
1986 × Construct. engineers	0.01	0.04	0.04	-0.02	0.05	0.03	
	(0.10)	(0.02)	(0.07)	(0.01)	(0.05)	(0.03)	
1987 × Construct. engineers	-0.02	0.00	0.00	-0.00	-0.05	0.03	-0.02
	(0.04)	(0.02)	(0.03)	(0.02)	(0.07)	(0.04)	(0.08)
Main effects of time dummies	YES	YES	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES	YES
Observations	1233	1333	1087	1097	596	603	349

Note: The control variables include labor market experience. Standard errors clustered at the individual level are displayed in parentheses. * and ** indicate statistical significance at the 5% and 1% levels, respectively. The year 1988 is the baseline year.

Table 7 provides evidence of a relative decrease in the employment rates of construction engineers compared to other types of engineers in the first year after graduation and only in 1984. The estimated coefficient suggests a significant decrease of approximately 7 percent. When viewed in conjunction with the results described above, it suggests that the increase in the supply of construction engineers mainly affected the relative earnings of construction engineers and, to a lesser extent, their employment rates.

5.5. Were Returns to a Construction Engineering Degree from DTU also Affected?

Regarding electrical engineers, we investigate whether the earnings penalty for construction engineers is applicable only for engineers from DTU. Table A3 presents the results of the fixed effects estimation of the relative effects on earnings using only the sample of engineers from DTU (see also the corresponding analysis for electrical engineers in table A1). The point estimates suggest that construction engineers graduating from DTU also experienced an earnings penalty, but these estimates are almost all not significant, in part because the magnitude of the coefficient is smaller and in part because of the smaller sample size. However, the results shown in table A3 suggest that construction engineers graduating from DTU in 1983 experienced a significant earnings penalty in 1984—approximately 15 percent.

Table A4 presents the results of the fixed effects estimation of the relative effects on employment rates using only the sample of engineers from DTU. These results suggest that the employment rates of construction engineers from DTU were not significantly negatively affected by the supply shock from AAU.

5.6. Is the Supply Effect for Construction Engineers Socially Heterogeneous?

Again, we ask whether some candidates are exempt from the sudden increase in the supply of engineers. To do so, we run separate models for engineers with and those without parents with a college education, and the results for earnings are shown in table 8 and those for employment in table 9. This analysis suggests that the earnings penalty of construction engineers in 1982, 1983 and 1984 was markedly larger for construction engineers who had parents without a college education. In fact, the results are not significant for construction engineers who had parents with a college education, although there seems to have been a delayed effect for this group in 1985.

Table 8. *Marginal effects of graduation year on logged earnings for construction engineers relative to chemical engineers. Separate graduation year cohorts in the period from 1981-1988. Individuals with parents with and without a college education*

	Parents without college Graduation year							Parents with college Graduation year						
	1981	1982	1983	1984	1985	1986	1987	1981	1982	1983	1984	1985	1986	1987
1981 × Construction engineers	0.30							0.54*						
	(0.36)							(0.23)						
1982 × Construction engineers	0.17	-0.50*						0.41	-0.02					
	(0.14)	(0.20)						(0.31)	(0.29)					
1983 × Construction engineers	0.04	-0.07	-0.60*					0.40	-0.08	-0.39*				
	(0.11)	(0.09)	(0.23)					(0.38)	(0.12)	(0.18)				
1984 × Construction engineers	0.19	-0.09	0.02	-0.62**				-0.14	-0.01	-0.16	-0.26			
	(0.15)	(0.07)	(0.07)	(0.16)				(0.16)	(0.12)	(0.09)	(0.18)			
1985 × Construction engineers	0.10	0.02	0.04	-0.12*	0.10			-0.24	-0.03	-0.04	0.01	-0.47*		
	(0.10)	(0.05)	(0.06)	(0.06)	(0.30)			(0.13)	(0.05)	(0.10)	(0.05)	(0.22)		
1986 × Construction engineers	0.15	-0.02	-0.01	-0.04	-0.06	-0.62**		-0.16	0.06	-0.11	0.03	-0.07	-0.14	
	(0.11)	(0.06)	(0.05)	(0.06)	(0.07)	(0.16)		(0.11)	(0.05)	(0.09)	(0.04)	(0.14)	(0.13)	
1987 × Construction engineers	0.09	0.01	-0.03	0.08	0.02	-0.06	-0.11	-0.03	-0.03	-0.10	0.01	-0.01	-0.07	0.10
	(0.08)	(0.05)	(0.04)	(0.08)	(0.07)	(0.05)	(0.26)	(0.07)	(0.03)	(0.07)	(0.04)	(0.09)	(0.08)	(0.21)
Main effects of time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	533	697	483	608	295	273	149	334	456	484	376	250	289	159

Note: The control variables include labor market experience. Standard errors clustered at the individual level are displayed in parenthesis. * and ** indicate statistical significance at the 5% and 1% levels, respectively. The year 1988 is the baseline year.

The results for employment rates are shown in table 9. Here, we only find negative employment effects for students with parents with no college education for the cohort graduating in 1984.

In summary, we find that the opening of the construction engineering program from AAU implied short-term earnings penalties, especially for engineers from AAU and engineers with parents without a college education. This finding suggests that new engineers who enter the labor market in a period of expansion suffer from a labor market penalty that is dependent on their social network. Finally, we note that this result accords with the theoretical model for a wage-clearing labor market—a model that would lead us to expect larger effects on wages and transitory effects on employment.

Table 9. *Marginal effects of graduation year on logged employment rates for construction engineers relative to chemical engineers. Separate graduation year cohorts in the period from 1981-1988. Individuals who have parents with a college education*

	Parents without college							Parents with college						
	Graduation year							Graduation year						
	1981	1982	1983	1984	1985	1986	1987	1981	1982	1983	1984	1985	1986	1987
1981 × Construction engineers	0.03							-0.22						
	(0.08)							(0.20)						
1982 × Construction engineers	-0.04	0.01						0.10	0.04					
	(0.13)	(0.07)						(0.25)	(0.07)					
1983 × Construction engineers	0.00	-0.06	-0.08					-0.09	-0.00	-0.07				
	(0.08)	(0.09)	(0.04)					(0.13)	(0.11)	(0.09)				
1984 × Construction engineers	0.01	-0.09	-0.03	-0.09**				-0.20	0.08	0.02	-0.02			
	(0.07)	(0.06)	(0.07)	(0.02)				(0.22)	(0.13)	(0.16)	(0.05)			
1985 × Construction engineers	0.04	0.02	0.01	-0.05*	-0.00			-0.21	0.01	-0.09	0.00	-0.01		
	(0.06)	(0.05)	(0.04)	(0.02)	(0.07)			(0.21)	(0.03)	(0.06)	(0.03)	(0.05)		
1986 × Construction engineers	0.02	0.05	0.05	-0.00	0.01	0.04		-0.21	0.02	-0.09	-0.00	0.10	0.03	
	(0.06)	(0.03)	(0.05)	(0.01)	(0.04)	(0.07)		(0.21)	(0.02)	(0.06)	(0.01)	(0.11)	(0.03)	
1987 × Construction engineers	0.01	0.01	0.05	0.04	-0.12	0.07	0.02	-0.11	-0.01	-0.05	0.00	0.04	-0.03	-0.07
	(0.04)	(0.03)	(0.04)	(0.03)	(0.11)	(0.09)	(0.06)	(0.10)	(0.01)	(0.04)	(0.00)	(0.07)	(0.03)	(0.13)
Main effects of time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Individual fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	548	721	504	615	302	280	156	341	465	498	383	255	294	176

Note: The control variables include labor market experience. Standard errors clustered at the individual level are displayed in parenthesis. * and ** indicate statistical significance at the 5% and 1% levels, respectively. The year 1988 is the baseline year.

5.7. Summary of Results

In summary, we find significant earnings effects for both construction and electrical engineers around the time of a large increase in the supply of both type of engineers. In addition, we find only modest employment rate effects. Thus, it seems that the empirical evidence supports a wage-clearing labor market model in which electrical and construction engineers are not perfect substitutes for the comparison group, chemical engineers. We further note that the earnings effects are short lived and concentrated around the first-year graduating cohorts only. These observations are addressed in the discussion section.

Our findings suggest that the 50 to 100 percent increase in the supply of engineers led to a transient earnings effect for newly graduated engineers of approximately 30 to 40 percent. Although our specification is not straightforwardly comparable to the specifications used in other studies, our findings are in line with Angrist (1996), who found large (1-4 percent) wage elasticities for the supply of Palestinian labor in the Israeli labor market, but our findings are somewhat larger than those of Card and Lemieux (2001), who found smaller but more persistent elasticities. Angrist (1995) found that wage rates were halved from when Palestinian youth chose to enroll in college in increasing numbers compared to when they entered the labor market. In summary, our large, negative effects on earnings for new graduates seem to be in line with the previous literature.

5.8. *Are supply effects masked effects from changes in demand?*

In this subsection, we investigate whether our earnings effects are more likely to be driven by differential demand such that the relative wage penalty for newly graduated construction and electrical engineers coincides with relatively lower demand for these types of engineers, compared to chemical engineers. First, we show the relative size (measures of the relative value of production) of the construction industry and the electrical industry compared to the chemical industry.

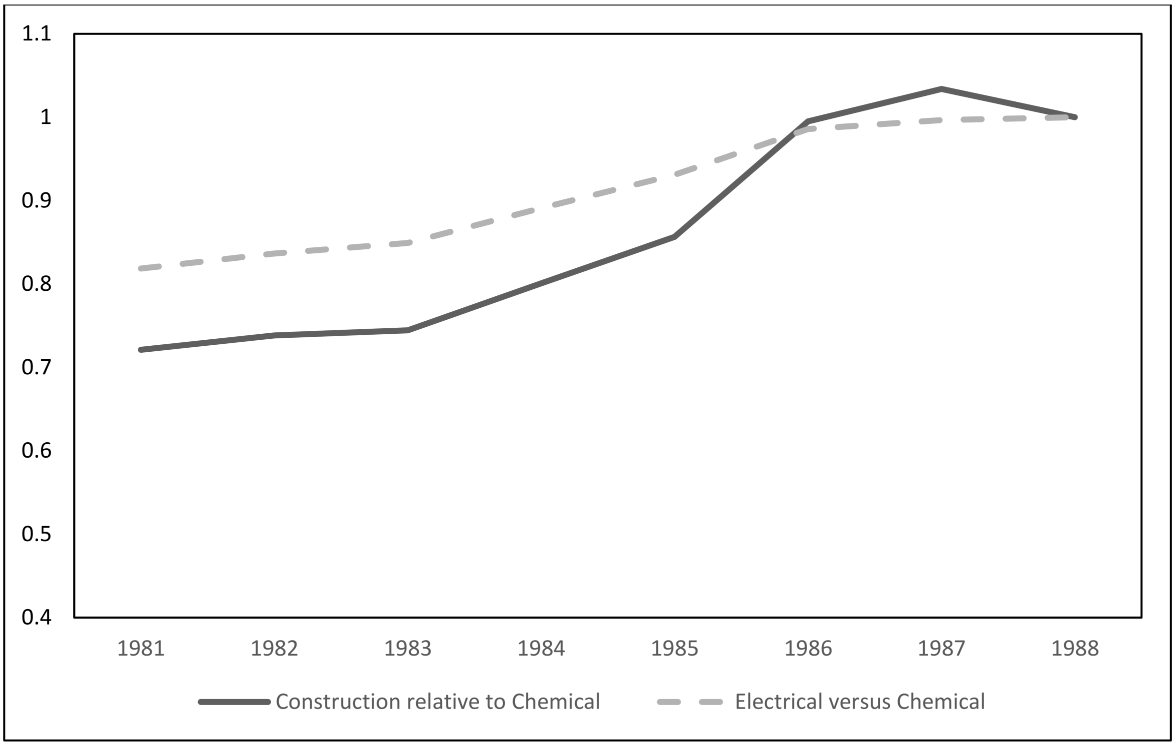

Fig. 2. The relative value of production in the construction and electrical industries relative to the value of production in the chemical industry.
Note: Data are production values taken from online registers from Statistics Denmark (relative to 2000 prices). The electrical sector covers electrical production, telecommunications, IT services, and the power supply industry. Construction is only the construction industry, whereas the chemical sector covers the chemical, plastics, and glass industries. Industry size is indexed to 100 in 1988 for each sector.

Fig. 2 reveals a monotonic increase in the relative size of the electrical industry compared to the chemical industry, and we find the same for the construction industry compared to the chemical industry until approximately 1986, when the relative size of the construction industry leveled off compared to the chemical industry. Hence, for construction engineers, we find no reason to believe that relatively shrinking demand caused the observed earnings effects in the early 1980s; similarly for the electrical engineers, we find little reason to believe that the observed earnings effect in 1986 was due to demand-side effects. Finally, we observe that the negative earnings effect for construction engineers observed in 1986 could be due to the relative leveling off of the construction industry relative to the chemical industry, as previously mentioned.

VI. Conclusion and discussion

The primary contribution of this paper is that it provides evidence that an exogenous shock to the supply of new graduates in a specific program will affect the returns to the particular college degree, implying a decrease in the wage rate for graduates from the specific program, at least in the short run. There were no indications of violations of the parallel trend assumption, indicating that earnings and employment patterns for electrical and chemical engineers developed similarly prior to the expansion of the supply of electrical engineers.

We argue that a plausible explanation for this finding is that, if sufficiently large numbers of new engineers enter the labor market, thus providing a saturation effect even when in high demand, the supply of suitable candidates strongly increases; consequently, competition for jobs increases. This outcome likely results in a lower price of labor within this skill group and, consequently, lower wages. It appears that this effect is very much an entry-level effect. Once engineers gain a foothold in the labor market and gain labor market experience, the wage penalty seems to disappear. This effect might occur because once some relevant labor market experience is gained, the return to (small) increments in labor market experience becomes indistinguishable from our data.

We also find clear socially heterogeneous effects, implying that the earnings penalty is largest for graduates with parents without a college education compared to graduates with parents with a college education, suggesting that future research might investigate the possible effects of social networks on earnings and employment.

A more general interpretation of our findings is that individual-level estimates of the returns to a particular college degree should be extrapolated with caution because interference between individuals in the labor market can cause returns to decrease when many individuals earn the same degree. Here, we follow Angrist (1995, p. 1084), who used a rapidly expanding education system in the West Bank and Gaza Strip in the period from 1981 to 1991 to argue "…*that contemporaneous schooling coefficients can be a poor indicator of the ultimate economic value of additional schooling when large numbers of new graduates enter the labor market.*" We extend this finding by showing that the returns to a particular college degree can also decrease as an increasing supply of candidates within that particular skill group enters the labor market. In this sense, we find a general equilibrium effect. Policymakers should be aware of this adverse effect of expanding certain fields of study; otherwise, they risk making misguided decisions based on individual-level estimates of returns, which are likely to change as a consequence of increasing student intake.

It should be noted that this study focuses on engineers, who are generally in high demand. In other fields of study, the decreasing returns might be even larger or their effects more prolonged. In relation to this argument, we find only transitory effects of the increase in the supply of construction and electrical engineers, which could be because the size of an industry is endogenous to the supply. A large increase in the supply of a skilled group in demand can induce employers to allocate more employment to areas with an abundance of supply, leading to short-lived supply effects.

Declaration of interest

Declarations of interest: none

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