ISSN 1503-299X

WORKING PAPER SERIES

No. 5/2020

When outside options bite:

Labor Demand in the Norwegian salmon farming industry and educational investments*

Ole Henning Nyhus†

Department of Economics
Norwegian University of Science and Technology

Department of Economics

Norwegian University of Science and Technology
N-7491 Trondheim, Norway
http://www.ntnu.edu/econ/working-papers

---

* Special thanks to Bjarne Strøm, Torberg Falch, and Lars-Erik Borge for guidance, discussions, and comments. I am also grateful for comments by participants at the IWAEE 2018 in Catanzaro, the Efficiency in Education workshop in Budapest 2017, and EALE 2019 in Uppsala, in addition to Colin Green and Lana Krehić for comments on an earlier draft. I also thank education administrators in my home region for this research idea through anecdotal evidence in local newspapers regarding low graduation rates. Financial support from the Norwegian Research Council under The Programme for Educational Research (UTDANNING 2020) is gratefully acknowledged.

† NTNU Social Research. E-mail: ole.nyhus@samforsk.no.

When outside options bite: Labor demand in the Norwegian salmon farming industry and educational investments[*]

Ole Henning Nyhus[†]

Abstract

This article presents empirical evidence on the effect of the opportunity cost of schooling on youths' educational investment in Norway. The findings suggest that increases in the demand for low-skilled labor originating from the Norwegian salmon farming industry's expansion harms upper secondary graduation rates. The salmon farming industry is an important workplace for low-skilled labor in Norway, and the stock of farming concessions issued by the central government increased by 25 percent in the period 1994-2006. Endogeneity concerns are handled using instruments for the industry's size based on geographical characteristics, such as the coastline of islands and variation in ocean temperature and international salmon prices. Using data on wages for low- and high-skilled workers, I find that salmon farming changes mainly affected low-skilled wages. This confirms that the growth in the industry has increased the demand for low-skilled labor. The findings from a structural model on demand for low-skilled labor, the relative wage gap between low- and high-skilled workers, and upper secondary school graduation support human capital theory.

Keywords: Return to education; opportunity cost of schooling; high school dropout; human capital; low-skilled labor demand

JEL Codes: I20, J24

---

[*] Special thanks to Bjarne Strøm, Torberg Falch, and Lars-Erik Borge for guidance, discussions, and comments. I am also grateful for comments by participants at the IWAEE 2018 in Catanzaro, the Efficiency in Education workshop in Budapest 2017, and EALE 2019 in Uppsala, in addition to Colin Green and Lana Krehić for comments on an earlier draft. I also thank education administrators in my home region for this research idea through anecdotal evidence in local newspapers regarding low graduation rates. Financial support from the Norwegian Research Council under The Programme for Educational Research (UTDANNING 2020) is gratefully acknowledged.

[†] NTNU Social Research. E-mail: ole.nyhus@samforsk.no.

1. Introduction

Seminal works by Becker (1964) and Ben-Porath (1967) formalized much of our understanding of human capital. The idea is that productive skills are a result of investments in human capital. The theory predicts that lower returns to education and higher opportunity costs, in terms of lost earnings during schooling, decrease enrollment in further education. Naturally, since most of our wealth is held in human capital, the understanding of labor markets and the economics of education has generated a huge body of research. This paper aims to quantify how labor market opportunities affect educational investments and returns to education by exploiting variation over time and across regions in the size of the salmon farming industry, a major workplace for low-skilled labor in Norway.

The paper is related to a literature that uses resource booms in North America to examine the relationship between labor market opportunities and educational investments. Black et al. (2005) exploit a boom and a bust in the coal industry and find that human capital investments are harmed (enhanced) by decreasing (increasing) returns to education. Similar results are also found in Kearney and Wilson (2018), Marchand and Weber (2020), and Cascio and Narayan (2020), whereas Feyrer et al. (2017) find substantial increases in regional employment due to fracking. A common feature of these more recent studies is that they utilize new technological breakthroughs in the North American oil and gas industry to study the impact of labor markets on educational outcomes.

Another related paper is Aparicio-Fenoll (2016), studying the educational outcomes following the Spanish housing boom. Although the study is fairly similar to Black et al. (2005), she, like my study, exploits wage data disaggregated by educational level and gender. She finds that the wage ratio between low- and high-skilled workers affect human capital accumulation among middle and late adolescent males. The findings are thus in line with, e.g., Abramitzky and Lavy (2014) and Lacuestaet al. (2020), and conclude that human capital accumulation is affected by changes in the anticipated returns to schooling.

My study is also related to Goldin and Katz (1997) and Atkin (2016). Goldin and Katz (1997) interpret an increase in the fraction of employment in the manufacturing industry, an industry containing jobs that do not require a high school diploma, as a reduction in schooling returns. Similarly, Atkin (2016) exploits variation in low-skilled opportunities in Mexico originating from major trade reforms between the US and Mexico. He concludes that factory openings in Mexico due to trade reforms had a negative impact on skill acquisition.

There are also a few Norwegian studies that utilize resource booms to study the impact of educational investments. Bütikofer et al. (2018) investigate whether the Norwegian oil boom starting in the 1970s affected cohorts entering the labor market. They find that geographic differences in intergenerational mobility are due to changes in the returns to education and that the resource boom broke the earnings link between grandfathers and grandsons. Reiling and Strøm (2015) use regional variation in oil industry exposure to instrument for regional unemployment. They show that poor labor market conditions when starting upper secondary education have a lasting effect on educational attainment. These studies also relate to Emery et al. (2012), who study human capital accumulation in Canada, exploiting regional variation in the OPEC oil shock impact during the 1970s. In addition, Bensnes and Strøm (2018) exploit exogenous variation in opening hours in retail in Norway and find that this demand shift for low-skilled workers permanently reduced educational attainment for affected high school students.

This paper adds to the labor and economics of education literature by studying how labor market opportunities in an important resource-based industry, salmon farming, affects educational investments among youths in Norway. By exploiting data from Norwegian administrative registers, with detailed information on education, labor market attachment, income, and socioeconomic characteristics, and utilizing arguably exogenous determinants of labor market opportunities in salmon farming, I am able to add to earlier studies based on reduced form estimates.

I utilize changes in the Norwegian salmon farming industry to capture changes in low-skilled labor demand. Since the early 1970s, salmon farming has grown to be a major industry in Norway. The government regulates the industry, and in my analysis period (1994-2006), the production capacity increased by 25 percent. The industry is the main employer of low-skilled labor in many regions and is located almost entirely along the Norwegian coastline, where the population density is relatively low. Thus, changes in the industry may have clear impacts on local labor markets and the incentives to invest in human capital.

However, identifying the causal effects of returns to education on human capital investment and the role of opportunity costs is always challenging due to endogeneity problems. One of the contributions in this study is to utilize arguably exogenous regional variation, such as variations in the coastline of islands and ocean temperatures, along with price variations on salmon, to identify causal effects of increased demand for low-skilled labor. The findings suggest that salmon farming growth decreases educational investments through a decline in upper secondary education graduation rates.

Standard human capital theory assumes that changes in educational investments are due to changes in the returns to education. By calculating wage differences, I relate the estimated relationship between educational investments and salmon farming's size to this theoretical insight by estimating a structural model (3SLS). The model estimates' suggest that exogenous increases in farmed salmon activity increase low-skilled wages and reduce the wage gap between low- and high-skilled workers. This leads to reduced upper secondary graduation. The results are thus consistent with core insights from standard human capital theory.

To my knowledge, this is also the first paper that exploits the Norwegian salmon farming industry to evaluate educational outcomes. Prior studies of this industry have often focused on environmental effects and the conflict with wild salmon interests, see Liu et al. (2011), Olaussen (2018), and Hersoug (2015). Another branch in this literature, represented by Asche et al. (2011), Asche et al. (2013), and Liu et al. (2016), evaluate the production of salmon and international demand. Färe et al. (2009), Aarset (1998), and Aarset and Jakobsen (2009) offer an understanding of the license fee system and governmental regulations of the sector.

The rest of the paper is organized as follows: Section 2 presents information about the institutional setting, while section 3 describes the data and empirical specification. The results are presented in section 4. Section 5 offers some concluding remarks.

2. Institutional setting

2.1. The salmon farming industry

FAO (2020) demonstrates that aquaculture has been the fastest-growing food production industry globally, with a yearly growth rate of 7.5 percent since 1970. Although the growth is expected to continue, the sector faces environmental challenges that must be tackled to obtain sustainable development in the coming decades. The same report also ranks Norway as the second major fish exporter next to China.

Historically, the introduction of salmon farming in Norway was based on a decentralization policy (Asche and Bjørndal, 2011). A few years after the first salmon farms were established, the central government decided in 1973 to regulate the industry by handing out concessions or licenses to operate. At that point, the concessions were free of charge and were meant to contribute to retraining and rural activity growth. Following a concession, the regulation requires that the salmon biomass does not exceed 780 metric tons.[1]

The market value for a salmon concession has varied substantially over time. At the start of this century, some operators bought production capacity in the private market, evaluating the price on a concession to 35 MNOK. In contrast, the price was about only 6.5 MNOK a short time after (Øyehaug, 2003).

The central government observed the increasing returns of owning a concession, and from 2002 it imposed fixed payments for new concessions. In 2013, the government started selling new concessions by holding closed auctions, which is the standard process for issuing new concessions today. The government sold approximately 19 concessions in 2018, which amounts to a total value of 2,900 MNOK and 14,949 tons in new capacity.

To obtain a salmon farming concession, one has to go through a two-step procedure. The first step is that the central government, represented by The Ministry of Trade, Industry and Fisheries, issues consecutive concessions. The farmers must apply or bid in an auction for the specific concessions. The Directorate of Fisheries determines which producers receive a concession. Second, the farmers have to apply one of the counties to operate in a specific location. Other relevant local authorities are then included in this process. With one concession, the farmers can choose to produce in multiple locations. However, no more than four different locations are allowed.

The sample period in this study is between 1994 and 2006, a period that coincides with vast expansion in salmon farming concessions issued by the government. Figure 1 illustrates the development of allowed biomass concession and salmon prices. Production capacity has increased by approximately 25 percent in this period. The expansion in new concessions has generated a large industry in Norway, exporting about 1.1 million tons of salmon to international markets in 2018. This amounts to an exported value of approximately 8.3 billion USD, or about 15 percent of the gross external trade in goods in Norway, excluding oil and gas.

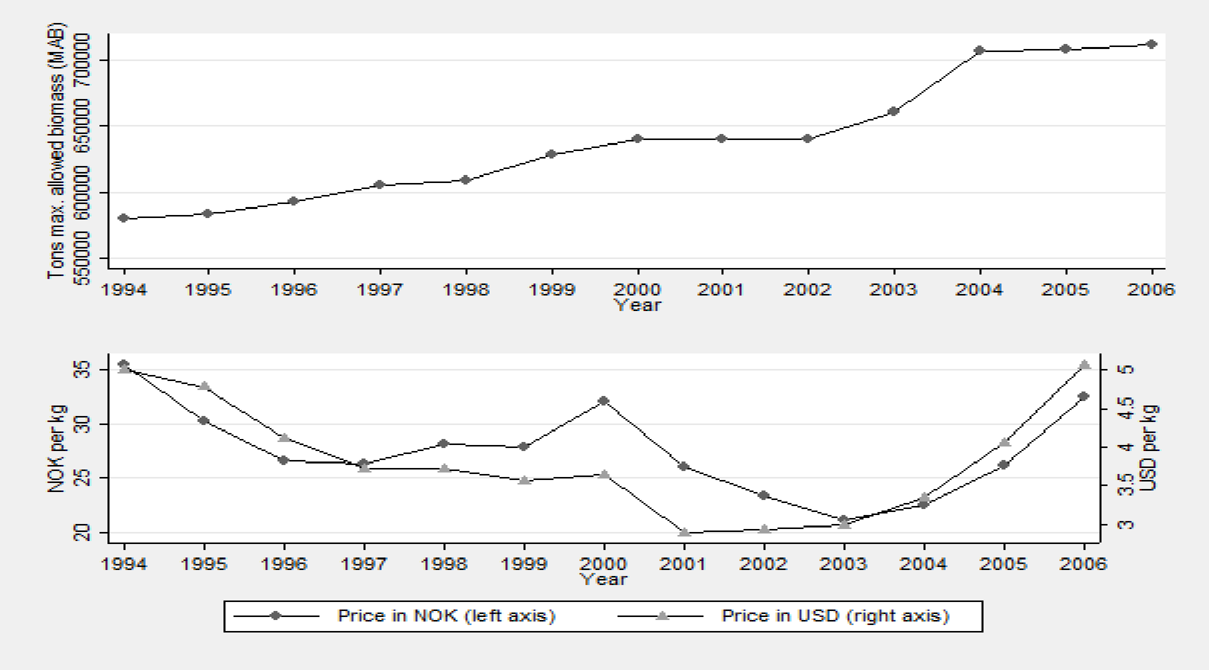
Using monthly price history for Norwegian farmed salmon from the International Monetary Fund, I calculate yearly averages. In general, the price of Norwegian salmon has been subject to fluctuation over the sample period. More precisely, from 1994 to the beginning of the 2000s,

---

[1] In practice, there are some variations in this amount in the northern parts of Norway.

the prices fell with increased production. However, from 2001 onwards, despite continuing production increases, the prices started to rise.

Figure 1: Development in the maximum allowed biomass and salmon prices.

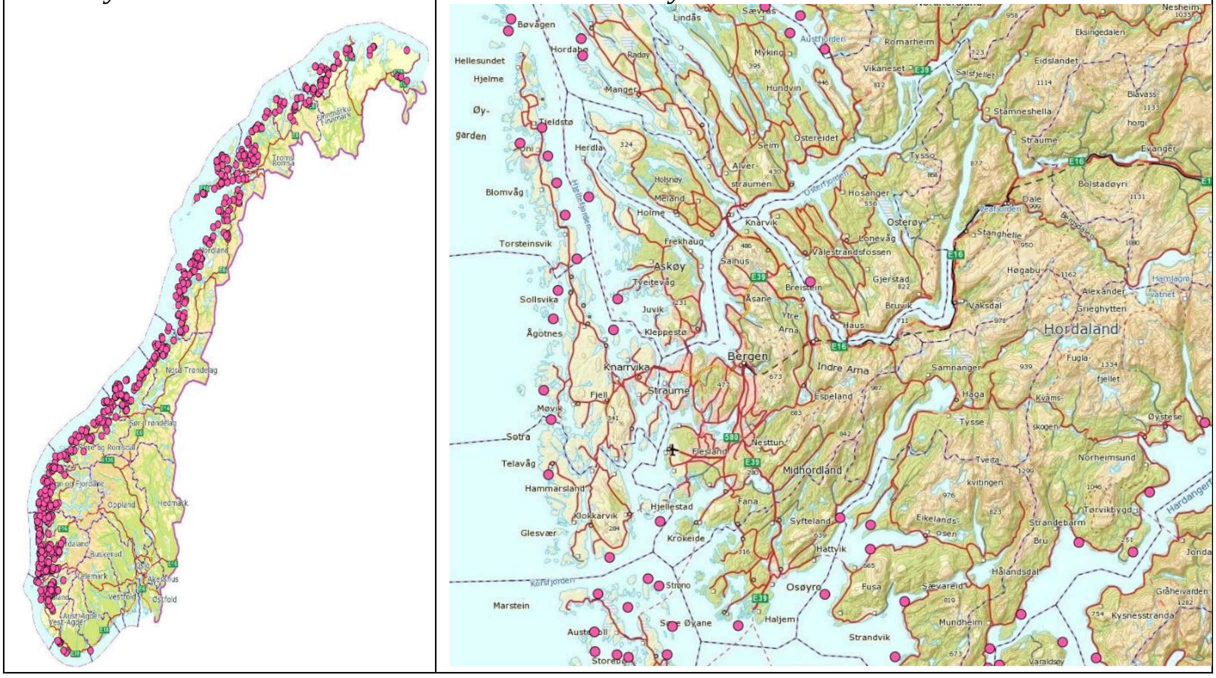


Over the years, Norwegian salmon farming has become a vital industry located almost entirely along the Norwegian coast. The locations of which today’s salmon farms are situated are shown in Figure 2. As observed in the left panel, there are hardly any salmon farmers along the south coast of Norway. This is due to ocean attributed, such as currents and temperature, making salmon farming unfavorable.

For example, Hevrøy (2013) documents that Atlantic salmon growth is higher when undergoing long (45 days) thermal exposure at 13℃ rather than 15, 17, and 19℃, while growth is highest during shorter exposure (15 days) at 17℃. Furthermore, Gutiérrez et al. (2019) and Mota et al. (2019) demonstrate the importance of other water characteristics, such as the concentration of nitrite and carbon dioxide, on the determinants of salmon growth, welfare, and salmon health. Aure (1984) underlines the importance of seven factors in a report advising on future concessions' geographical location. These key factors are *i*) temperature, *ii*) salt content, *iii*) currents, *iv*) mainland and ocean floor topography, *v*) the exposure from waves, wind, and ice, *vi*) the distance to other locations, and *vii*) pollution.

Olaussen (2018) presents a schematic overview of seven interdependencies and externalities in the aquaculture sector. These are sea lice, chemicals, shrimp and other crustaceans, wild salmon, fish welfare, escapement, and nutrition. The study also proposes some solutions to minimize the adverse consequences of salmon farming.

Figure 2: Salmon farming locations in Norway and near the city of Bergen in Hordaland



Salmon farming locations in Norway:

Salmon farming locations near the city of Bergen in Hordaland county:

The right panel in Figure 2 shows locations near Bergen city in Hordaland county. One can see that most of the farms are located on the outskirts of the coast bordering the North Atlantic Ocean, but always near an island. Other farms are located in the fjords. The main reason for placing the farms near islands is the need for shelter from wind and waves since harsh storms may destroy the production sites, leading to massive escapes of farmed salmons (Aure, 1984). Salmon escape hurts the producers directly through high costs and loss of income, but most importantly, it is perceived as being greatly damaging to the environment. The main reason for this is the need to protect the spawning grounds for wild salmon in Norwegian rivers.

2.2. The educational system

An overview of the Norwegian educational system is shown in Figure 3. Students are enrolled in school at age six and attend ten years in compulsory education. Compulsory education is comprehensive, and all students graduate at age 16. The municipalities are responsible for both primary and lower secondary education. In the period I study, there were about 440 municipalities in Norway. The compulsory education sector is the second-largest municipal sector measured in the use of resources after elderly care and constitutes roughly 25 percent of all municipal expenditures.

At age 16, about 95 percent of the students enroll directly in upper secondary education. The Norwegian counties are responsible for upper secondary education, which is mainly divided into two tracks: [2] The academic track that consists of three study programs aimed at preparing students for higher education, and the vocational track consisting of 10-12 study programs. About 45 percent of the students enroll in an academic track. Still, as shown in Figure 3, there is a possibility for students enrolling in vocational tracks to achieve a qualification to study in higher education. The vocational track's standard progress is to spend two years in school and then two years as an apprentice. A student completes upper secondary education with a diploma. This diploma is issued if all subjects are passed. Students completing the vocational track must also pass an apprentices' final examination at the apprenticeship's end. Since 1994, all students have a legal right to spend five years completing upper secondary education.

Figure 3: The educational system in Norway

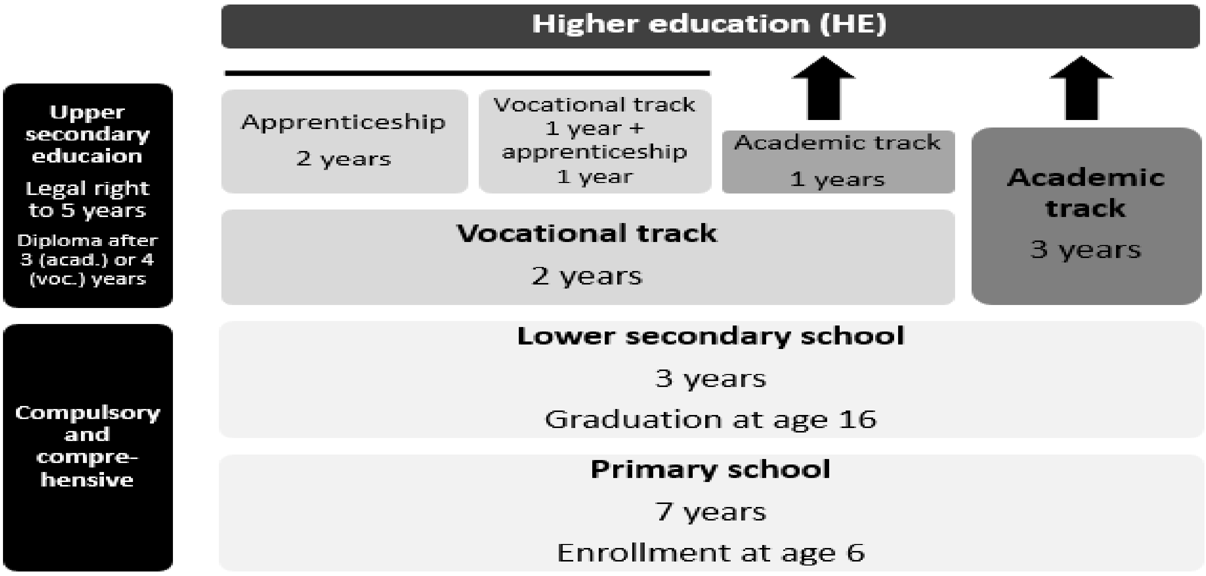


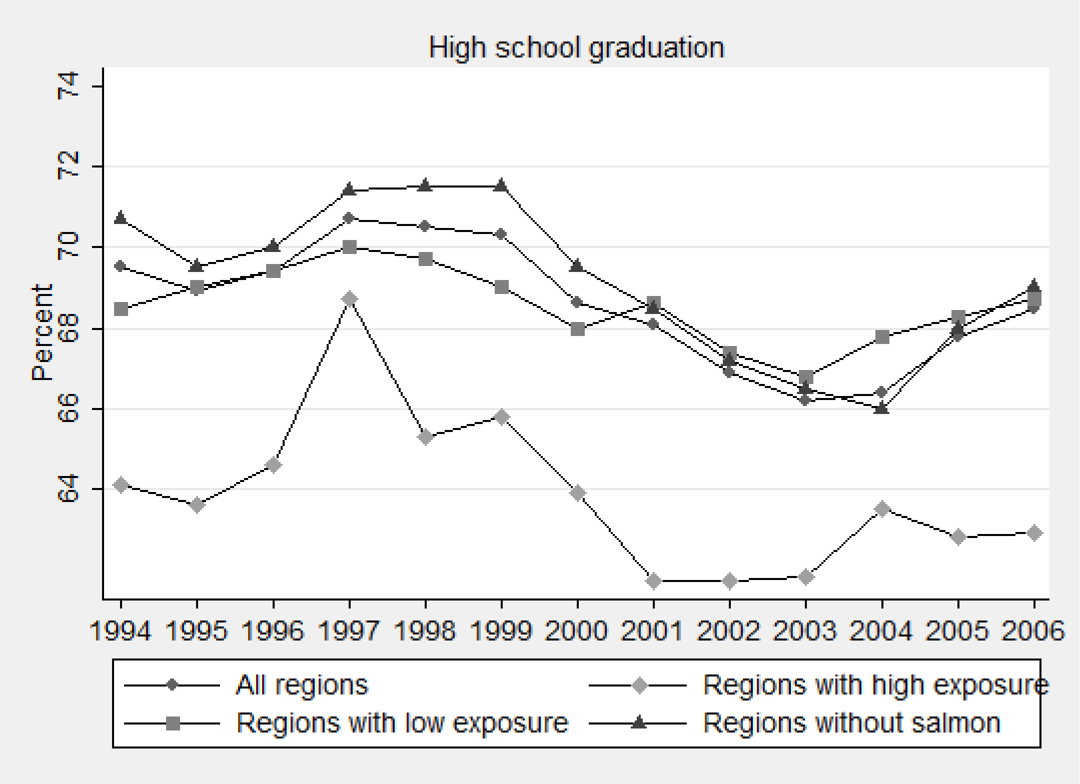
Figure 4 shows the development in upper secondary graduation rates over time. Within five years after completing compulsory education, about 70 percent of the cohorts graduate upper secondary education. The graduation rate varied from 71.1 percent for the 1997-cohort to 66.5 percent for the 2003-cohort.

---

[2] After recent local government reforms, there are now 11 counties. However, between 1994 and 2006, Norway was devided into 19 counties.

Moreover, I have chosen the labor market region level as the appropriate geographical unit to evaluate the salmon farming industry information in my analysis.[3] This is because it is likely that inhabitants in neighboring municipalities are equally affected by local changes in the salmon farming industry as those residing in an affected municipality. To see whether there is a relationship between local high school graduation and salmon production, I group individuals according to regions with high, low, and no salmon farming exposure.[4] As shown in the figure, the graduation rate in highly exposed regions differs from the other groups, where the graduation rate was as low as 61.7 percent in 2001 and 2002. Generally, the trends are quite parallel except for a spike in 1997 for individuals residing in areas with high exposure from the salmon farming industry.

Figure 4: Completion of upper secondary education for the 1994-2006 cohorts



---

[3] The 440 municipalities have been grouped into 89 different labor market regions based on commuting patterns by Statistics Norway.

[4] There is a total of 38 labor market regions that are registered with at least one salmon farming concession in this period. I have chosen to group the regions with salmon farmers located in the region, into two separate groups according to salmon farming exposure. In total, I assume that 14 regions are highly exposed, where the allowed biomass of salmon per capita for the lowest exposed region in this group is about the double (0.48) of the maximum in the other 24 regions (0.257). The number of individuals from my sample in each group is 47,853 (high exposure), 224.596 (low exposure), and 439.173 (no exposure).

3. Data, empirical strategy, and instruments

3.1. Data

The main data source for this paper is drawn from Norwegian administrative register data. Included datasets contain a large amount of information about individuals in Norway, e.g., family attachment, yearly data on the residing area, a complete educational history, including grades and diplomas, consecutive labor market attachment, and income information from the tax reports. Due to an upper secondary education reform implemented in 1994, I have restricted my analyses to students who finished compulsory education after that time. As the register data only has information on essential outcomes up to 2011, combined with the fact that students have a legal right to spend a maximum of five years in upper secondary education, the last cohort included is those finishing compulsory education in 2006. The full analytical sample consists of 711,622 individuals. The control variables on the individual level included in the analysis are gender, immigration status, and parental education. Descriptive statistics for included SES variables are presented in Appendix Table 1.

These register datasets are then merged with data on concessions (maximum allowed biomass of salmon, *MABs*) collected from *the Directorate of Fisheries*. Their dataset, *Akvakulturregisteret,* consists of information on when a concession is given, the maximum allowed biomass for each concession, precise location, ownership, purpose (commercial, research, education), and species (salmon, rainbow trout, trout, cod, bass, shell/mussel, etc.). The full dataset has information on about 5,000 potential salmon farming locations and more than 1,100 concessions.

Table 1 contains descriptive statistics on the outcome variable and the main variables of interest. Panel A presents descriptive statistics on high school graduation within five years after graduating from lower secondary education.[5] Since the variables of interest are mainly measured at the regional level, descriptive statistics for high school graduation rates are also presented at this level. The standard deviation for the high school graduation rate at the labor market region level is .063, and observations vary from 0.46 to 0.76.

Panel B in Table 1 presents descriptive statistics on salmon biomass and value. Measured at the individual level, the average biomass per capita in Norway is 0.091 tons, while the standard

---

[5] The individuals are assigned to a cohort according to the year they graduated from compulsory education at age 16.

deviation is 0.332. This amounts to about 2,800 NOK when multiplying the allowed biomass with an average salmon price.[6]

As shown earlier, many regions do not produce any farmed salmon, while the maximum value of biomass per capita is 5.181 tons, which amounts to more than 210,000 NOK per capita. Observed biomass only for regions with salmon farms, the average biomass per capita is 0.507 tons. Measured at the regional level, average biomass per capita is 0.228 tons for the whole country and 0.54 tons in regions with salmon farming.

Table 1: Descriptive statistics on the outcome variable and main variables of interest for the period 1994-2006.

	Mean	SD	Min	Max
Panel A: High school graduation within five years				
- at the individual level	0.687	0.464	0.000	1.000
- at the regional level	0.679	0.063	0.455	0.763
Panel B: Salmon biomass (MAB) and value				
Measured at the individual level:				
All observations:				
Biomass (1000 kg) per capita	0.091	0.332	0.000	5.181
Value (10000 NOK) per capita	0.2806	1.0432	0.000	21.2272
If biomass>0:				
Biomass (1000 kg) per capita	0.507	0.636	0.054	5.181
Value (10000 NOK) per capita	1.5698	2.0161	0.1783	21.2272
Measured at the regional level:				
All regions:				
Biomass (1000 kg) per capita	0.228	0.637	0.000	4.842
Value (10000 NOK) per capita	0.7053	1.9878	0.000	15.1981
If biomass>0:				
Biomass (1000 kg) per capita	0.540	0.896	0.007	4.842
Value (10000 NOK) per capita	1.6706	2.8016	0.0215	15.1981

After estimating the effect of salmon production on high school graduation rates in Section 4.1, I move on to analyzing relative wages for low - and high-skilled workers, respectively, in Section 4.2. I utilize two separate administrative register datasets on income and working hours to calculate hourly wage rates. Detailed individual data on pension-qualifying earnings are obtained from tax reports. The tax report data has then been merged with one of the labor registers, that has information on all working positions, including information on period and how many hours a person works each week. From these two data sources, I have calculated an

---

[6] This measurement of salmon biomass underestimates the real value of the MABs since there are both continuous salmon growth and harvest indefinitely. In relative terms, the discounted value of a MAB is constant as long as prices are held constant. For simplicy, I have therefor chosen to only multiply the maximum allowed biomass with the real yearly average price for salmon as a measure of the biomass value.

hourly wage rate for all individuals in Norway. The steps in this calculation are presented in the next paragraphs.

A full-time employee in Norway works typically 37.5 hours a week. In official statistics, working hours are often set to a maximum of 40 hours a week. Some individuals, however, are registered with weekly working hours that clearly exceeds this. This is mainly the case for individuals with more than one registered position. For these individuals, working hours per week have been set to 40.

I define the hourly wage rate as pensionable earnings divided by yearly working hours. I then calculate both a low-skilled and high-skilled wage rate for every region and year, defined as the average wage rate for individuals aged 26-30 without and with a high school graduation diploma, respectively.[7] The age group consisting of individuals aged 26-30 is chosen because students in higher education should graduate by the time they are about 25 years of age.

Table 2 presents descriptive statistics on calculated wages for low- and high-skilled workers. The first two columns show the estimated hourly wage rates, as described above. The hourly wages appear very high, which seems mainly to be caused by the denominator in the formula for the wage rate, i.e., the working hours. I exclude extreme observations by keeping only observations in the interval [p10, p90]. The adjusted wage rates are shown in the third and fourth columns. When excluding extreme observations, the calculated hourly wages seem accurate, except for the year 2003.

Table 2: Descriptive statistics on hourly wages at the regional level

Cohort	Low-skilled wage	High-skilled wage	Low-skilled wage [p10, p90]	High-skilled wage [p10, p90]
2003	390.11	392.88	182.75	194.83
2004	335.59	364.74	179.33	189.67
2005	379.01	345.93	182.94	193.05
2006	350.75	324.83	187.44	197.93

2003 is also the year this labor register was introduced. After closer inspection of the data, I conclude that working hours' registration is incomplete in the first year since there are systematic differences compared to registered working hours in 2004, 2005, and 2006. Because of this, I only include the period 2004-2006 when analyzing wages.

When analyzing the wage gap in Section 4.2, this is defined as:

$$(1) \qquad wage\ gap_{rt} = \ln lowskilled\_wage_{rt} - \ln highskilled\_wage_{rt},$$

---

[7] The individuals are allocated to their resident region at the time of lower secondary education graduation.

where *r* denotes labor market region and *t* denotes cohort/year. This means that the wage gap is measured as the percentage wage difference between low and high skilled wages. I have also calculated a similar wage gap for each gender. Table 3 presents descriptive statistics on the calculated wage gaps.

The wage gap is between 4 and about 6 percent when measured at the regional level. The gender-specific wage gaps are slightly higher than the average wage gap because there are systematic differences in the gender distribution by educational status between the regions. The variation in the wage gap measured by the standard deviation is about 2.5-3 percent for all individuals and males, and between 4-4.5 percent for females.

Table 3: Descriptive statistics on the calculated wage gap measured at the labor market regional level

Cohort	All individuals	Females	Males
2004	-0.0493 (0.0254)	-0.0652 (0.0397)	-0.0562 (0.0298)
2005	-0.0464 (0.0291)	-0.0591 (0.0413)	-0.0617 (0.0323)
2006	-0.0393 (0.0327)	-0.0578 (0.0545)	-0.0607 (0.0347)

Note: Standard deviations are presented in parentheses.

Compared to other countries, the calculated wage gap is small. Eg., descriptive statistics in Aparicio-Fenoll (2016) suggest that wages for uneducated workers are about 60 percent of the wages for educated workers in Spain. Although Norway has a flat wage structure, this gap also seems small compared to findings in Bhuller et al. (2017), implying that the internal rate of schooling is about 11 percent. However, they also point out that wages differ more within older age groups than those included in my calculation.

3.2. Empirical specification

To determine if changes in the labor market, through employment opportunities in the salmon farming industry, affect youths' educational choices, I regress educational outcomes on the salmon stocks or the stock value in the region. More precisely, I estimate different versions of the specification in Eq. (2).

$$(2) \qquad HS\_graduation_{itmr} = \alpha + \beta Salmon_{rt} + X'_{imrt}\theta + \delta_t + \gamma_{mr} + trend_r + u_{imrt}$$

$HE\_graduation_{itmr}$ is a dummy equal to 1 if individual *i* has completed upper secondary education within five years after finishing mandatory lower secondary education in year *t* in the municipality *m*, located in the labor market region *r*. $Salmon_{rt}$ is a measure of the importance of the salmon farming industry in the region. At the outset, I construct two variables to represent the industry's importance: The first is a quantity measure defined as the maximum allowed biomass measured in metric tons per capita in region *r* the year that the student completed mandatory lower secondary education. The second is the maximum allowed biomass multiplied with the real price of salmon in 10,000 NOK per capita. As shown in Figure 1, salmon prices have varied a lot over time. Hence, the latter value measure will be a more relevant measure of the industry's profitability and, therefore, of the fluctuations in regional labor demand due to changes in the salmon farming industry. These are the main reason for emphasizing the biomass value as my most preferred variable of interest.

X is a vector of control variables at the individual level. Included controls are gender, immigration status (first and second generation, respectively), and parental education. Parent-specific dummy variables include parental education for completion of upper secondary education, BSc, and MSc/Ph.D., respectively. The reference categories are hence mothers and fathers with only lower secondary education or unknown education. δ_t is fixed cohort/time effects, while γ_{mr} is municipality fixed effects. Controlling for municipal fixed effects rather than regional fixed effects is preferable since lower secondary education is a municipal responsibility. Thus, the specification accounts for time-invariant factors that affect both lower and upper secondary school quality. In some specifications, I also include linear labor market region trends. These trends will account for unobserved region-specific determinants of upper secondary school completion that evolves in a secular fashion. α and u are the constant and error term, respectively. All standard errors are clustered at the same level as salmon biomass is measured, i.e., the regional level.

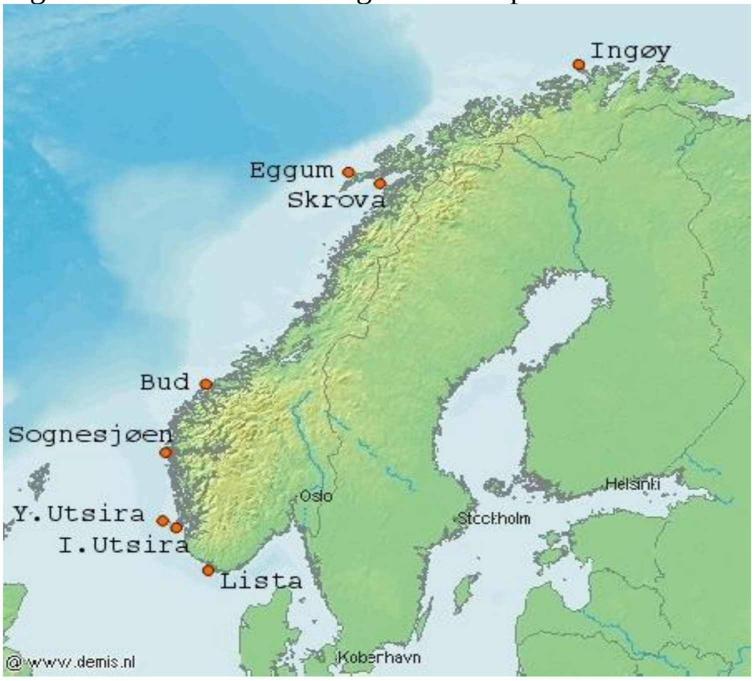
3.3. Threats to identification and an IV-approach

The specification in Eq. (2) accounts for a range of potential confounding determinants of school completion. One could also argue that changes in the salmon biomass value are perceived as exogenous when studying youths' educational choices since prices are cleared in international markets. It is also the central government that issues new concessions required to operate as a salmon farmer. However, it may still be the case that salmon farmers actively seek to locate the production to areas where the inhabitants' educational attainment is relatively low. One other concern is that returns to education increase due to reduced low-skilled wages from a higher supply of uneducated workers. To account for such endogeneity problems, I use an instrumental variable approach.

As pointed out in Section 2.1, ocean temperatures are a vital factor in salmon farming. First of all, high temperature increases the growth rates for salmon. This is especially influential during the winter when ocean temperatures along the Norwegian coast often reach low levels. However, high temperatures also increase the exposure to salmon lice, parasites, and disease. Hence, farmers need to implement preventive actions regarding salmon health and wellbeing. This will again provide higher activity in the service industry, a related industry that also employs a relatively high share of low educated workers.

I have collected information on ocean temperature from *the Institute of Marine Research*. One of their responsibilities is to govern eight monitoring stations along the coast of Norway. Figure 5 shows the location of each station. Ocean temperatures have been collected regularly at these stations since 1935. I have used this data source to calculate the average ocean temperature for each season (Dec-Feb, Mar-May, Jun-Aug, and Sep-Nov) every year in the period I study.

Figure 5: Stations measuring ocean temperatures

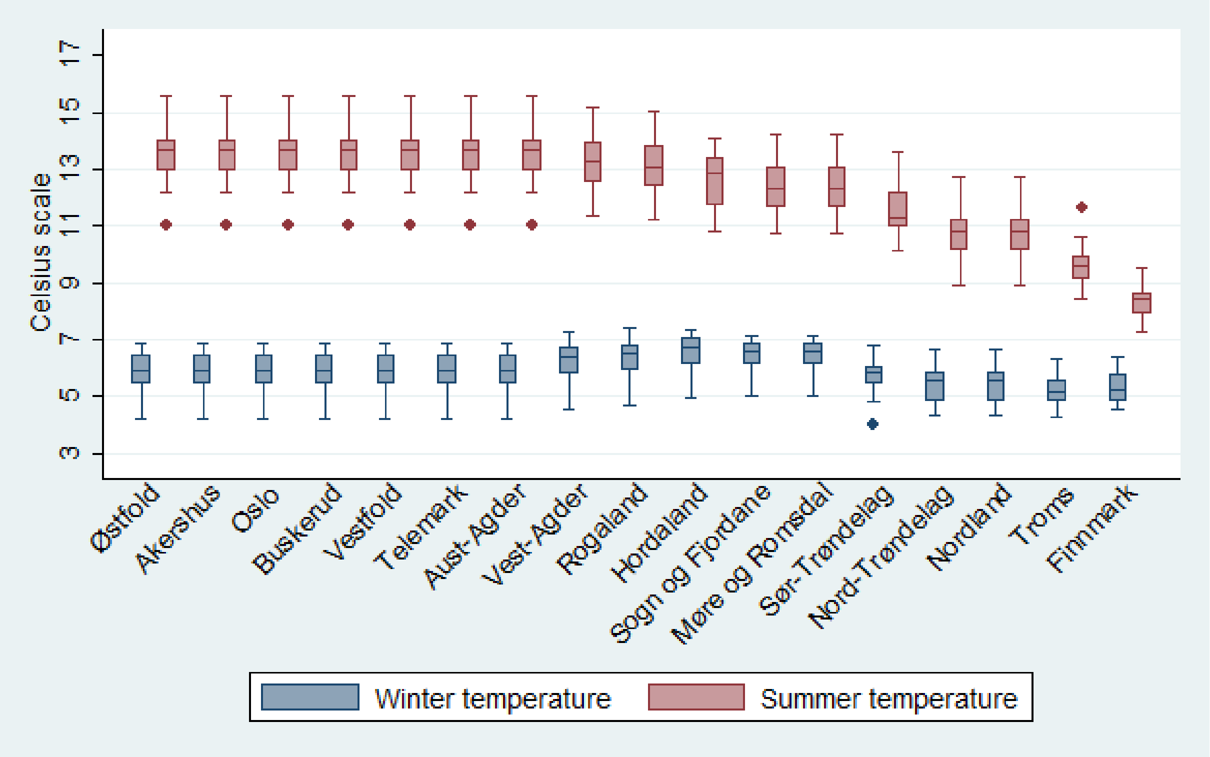


Source: http://www.imr.no

Moreover, I have calculated a seasonal ocean temperature for each county. For most counties, this is the mean temperature at the three nearest stations. However, seasonal variations in ocean temperatures are correlated. When analyzing this at the county level, the correlation between summer and winter ocean temperature is 0.55 in 1994-2006. Due to potential multicollinearity, it could be problematic to include more than one seasonal temperature measurement when instrumenting salmon farming activity changes. I have chosen to utilize winter temperatures in the analyses.

Figure 6 offers descriptive statistics on county variations in ocean temperatures. As noticed, there is no variation between the counties' furthest south (Østfold to Aust-Agder). This is a measurement error due to the absence of comparable monitoring stations, see Figure 5. However, it has no implications for the analyses since these counties do not have any salmon farms, and hence, do not contribute to the identification of salmon farming exposure. During the summer, the ocean temperatures are relatively low in northern counties (Troms and Finnmark), whereas there is less regional variation in winter temperatures. In most counties, the difference between the 25th and 75th percentile is about 1.5 degrees Celsius, while the difference is about 3 degrees for the lower and upper adjacent value. Following the discussion in Section 2.1, such variations will lead to large differences in salmon growth and activity over the period.

Figure 6: Descriptive statistics on ocean temperatures, 1994-2006



In addition to ocean temperatures, other regional characteristics are essential in deciding where salmon farms are located. As shown in Figure 2, many farms are found east of islands on the coast's outskirts bordering the North Atlantic Ocean. As discussed in Section 2.1, the main reason for this is the farms' access to fresh and clean water due to streams while having islands providing shelter from wind and waves. The importance of islands as shelter is also collected through talks with operating personnel at salmon farming locations. I have collected data on the length of island coastlines in every municipality from Statistics Norway. The measured coastline is then aggregated at the regional level and put into relative terms by dividing the total length by each region's population. The idea is that this element captures the probability of regional exposure from salmon farming.

Another element that might explain probable exposure is the industry's size prior to the period I study. Instruments based on this type of variation are commonly known as Bartik instruments (Bartik, 1991; Blancard and Katz, 1992). I operationalize this as a variable measuring the regional maximum allowed biomass in metric tons per capita in 1990.

Because prices directly affect profitability, I utilize the information presented in earlier paragraphs to construct valid instruments for the potentially endogenous variation in salmon farming importance, i.e., salmon biomass value in each region. The two instruments are specified in Eq. (3) and (4).

$$(3) \quad IV^{coastline} = Dsalmon_c * Coast\_Isl_r * WTemp_{ct} * Price\_usd_t$$

$$(4) \quad IV^{biomass1990} = Biomass\ per\ capita\ in\ 1990_r * WTemp_{ct} * Price\_usd_t$$

The instrument in Eq. (3) is a function of four components. First, $Dsalmon_c$ is a dummy variable that is equal to 1 for counties with salmon farms. $Coast\_Isl_r$ is the coastline length of islands per capita in region *r*, while $WTemp_{ct}$ is the ocean winter temperature in county *c* in year *t*. The last component, $Price\_usd_t$, is the (real) USD price per kg for Norwegian farmed salmon in year *t*. The instrument in Eq. (4) is quite similar to the one in Eq. (3), except that the first two components are replaced by the biomass of salmon per capita in 1990 in region *r*, four years prior to the period I study. The instrument is a multiplicative construction by choice since salmon prices only vary in time, coastlines vary between regions, while ocean temperatures vary both by time and region.

These two instruments are used one-by-one to tackle potential endogeneity problems related to the variable of interest in Eq. (2), $Salmon_{rt}$, salmon biomass value.

4. Results

This section shows how changes in the demand for low-skilled labor, through changes in the salmon farming industry, have affected educational investments among youths in Norway. Section 4.1 presents the results of changes in the salmon farming industry's importance on upper secondary graduation. The first part evaluates effects on youths' educational investments using OLS and fixed effects specification, whereas potential endogeneity issues are addressed in the second part. Here I use the IV-strategy presented in section 3.3. The last part of section 4.1

addresses effects in different periods following that prices decreases (increased) in the first (last) period and potential gender-specific effects. Section 4.2 addresses human capital theory mechanisms by estimating models that connect the salmon farming industry's impact on educational outcomes through the wage gap between high- and low-skilled workers.

4.1. Effects of changes in the salmon farming industry on high school graduation

OLS and fixed effects results

Table 4 presents OLS and fixed effects estimates of changes in the salmon farming industry, and hence changes in the demand for low-skilled labor on upper secondary education graduation.

Biomass volume

Column (1)-(3) investigates whether changes in the allowed maximum biomass of salmon in the ocean affect graduation rates. These changes can be interpreted as changes in the activity level since new concessions typically increase production and the farmed salmon stock. As pointed out in Section 3, the maximum allowed biomass of salmon in the ocean is measured at the labor market region level.

In all specifications, the point estimate of the volume of allowed biomass is negative. The specification in column (1), which only includes SES-variables on the individuals, indicates that an increase in allowed biomass by 1 ton per capita in a region decreases high school graduation with 1.76 percentage points. One concession is 780 metric tons. Considering that as many as ten regions consisted of less than 10,000 inhabitants in 2000, these findings indicate that such changes in the industry could have a considerable impact on many local societies. The effect is, however, not statistically significant.

The specification in column (2) includes municipality fixed effects. These variables explain all non-time varying characteristics of the local government, including the quality in lower and upper secondary education. In the FE-analysis, the estimated point estimate decreases to -0.104, indicating that a 10 percent increase in the mean allowed biomass (tons) per capita at the regional level (.228) decreases high school graduation with 0.23 percentage points. This effect doubles when evaluating this by the mean biomass (tons per capita) for regions with salmon producers (.54). In contrast to the specification in column (1), this effect is statistically significant at the 1 percent level.

Table 4: OLS and FE results with high school graduation as the dependent variable.

	(1)	(2)	(3)	(4)	(5)	(6)
Biomass (tons) per capita	-0.0176	-0.104***	-0.0565			
	(0.0112)	(0.0337)	(0.0461)			
Biomass value (10000) per capita				-0.00544	-0.0122	-0.00847
				(0.00356)	(0.00865)	(0.00575)
Female	0.0938***	0.0939***	0.0939***	0.0938***	0.0939***	0.0939***
	(0.00296)	(0.00296)	(0.00296)	(0.00296)	(0.00296)	(0.00296)
First-generation immigrant	-0.127***	-0.123***	-0.122***	-0.127***	-0.123***	-0.122***
	(0.00626)	(0.00534)	(0.00546)	(0.00626)	(0.00534)	(0.00546)
Second-generation immigrant	0.0275***	0.0367***	0.0343***	0.0276***	0.0369***	0.0343***
	(0.00597)	(0.00560)	(0.00558)	(0.00598)	(0.00560)	(0.00557)
Father's edu. = high school	0.137***	0.132***	0.132***	0.137***	0.132***	0.132***
	(0.00196)	(0.00204)	(0.00204)	(0.00196)	(0.00204)	(0.00204)
Father's edu. = BSc	0.208***	0.207***	0.207***	0.208***	0.207***	0.207***
	(0.00289)	(0.00263)	(0.00263)	(0.00289)	(0.00263)	(0.00263)
Father's edu. = MSc or Ph.D.	0.232***	0.231***	0.231***	0.232***	0.231***	0.231***
	(0.00380)	(0.00323)	(0.00322)	(0.00380)	(0.00323)	(0.00322)
Mother's edu. = high school	0.134***	0.132***	0.132***	0.134***	0.132***	0.132***
	(0.00242)	(0.00244)	(0.00244)	(0.00241)	(0.00245)	(0.00244)
Mother's edu. = BSc	0.202***	0.203***	0.203***	0.202***	0.203***	0.203***
	(0.00238)	(0.00215)	(0.00215)	(0.00237)	(0.00215)	(0.00215)
Mother's edu. = MSc or Ph.D.	0.221***	0.225***	0.224***	0.221***	0.225***	0.224***
	(0.00362)	(0.00358)	(0.00361)	(0.00362)	(0.00357)	(0.00361)
Municipal FE	No	Yes	Yes	No	Yes	Yes
Regional linear trends	No	No	Yes	No	No	Yes
Observations	711,622	711,621	711,621	711,622	711,621	711,621

Included individuals are students who completed lower secondary education in the period 1994-2006. A constant term and cohort fixed effects are also included (not reported). Standard errors in parentheses are clustered at the labor market region level. ***, **, and * denotes significance at the 1, 5, and 10 % level, respectively.

To further check the robustness of these associations, linear regional trends are included in column (3). There are several reasons why linear trends are appropriate to include in the model. One potential mechanism is that smooth changes in the preference for educational investments among youths in the local labor market regions is potentially an omitted variable. Including regional linear trends should absorb the influence of such changes. However, a possible concern is that the inclusion of local labor market trends leaves too little variation to precisely identify the effects of salmon farming activity changes. As expected, the linear trends are correlated with the measure of activity in the salmon farming industry, resulting in a reduction in the point estimate to -0.057. The inclusion of linear trends also made the point estimate imprecise in regards to statistical significance. Still, the main take-away from this is that it does not change the qualitative result about how salmon farming activity changes affect educational choices.

As we can see in all models, the share of females that graduates upper secondary education within five years after compulsory schooling is about nine percentage points higher than it is for males. The choice of study track might explain some of the differences in graduation across gender. This is because males’ share is relatively high in vocational high school tracks, where the general dropout rate is higher than academic tracks. However, it is not valid to control for study track since this is an endogenous decision.

There are also differences in graduation rates across immigration status. Individuals categorized as first-generation immigrants have a graduation rate that is about twelve percentage points lower than non-immigrants. However, second-generation immigrants tend to be more successful in regards to high school graduation than non-immigrants. The analyses indicate that the difference is around three percentage points. I also find that parental education is associated with high school graduation. The reference group in the analyses are individuals where both parents have only graduated from compulsory education or where educational attainment is unknown. The point estimates between mothers’ and fathers’ education do not differ for each categorization, while higher educated parents are associated with higher graduation rates.

Biomass value

As argued in Section 3.2, the biomass's value is a better measure of the activity level and importance of the salmon farming industry due to the direct effect prices have on profitability. The analyses in columns (4)-(6) in Table 4 are similar to those in (1)-(3), except for the primary variable of interest. In these models, I study how changes in the allowed biomass’s value are associated with high school graduation. For simplicity, the value is defined as the maximum allowed biomass multiplied by the real average yearly price of salmon, measured in 10,000 NOK. This underestimates the value compared to a definition taking the present value of a concession with an infinite duration. However, this has no implications for the inference in relative terms since the salmon price, and the allowed biomass are the only two important factors.

As presented in columns (4)-(6) in Table 4, I find a negative association of the biomass value on high school graduation in all models. However, the estimated point estimates are not statistically significant.

IV-results

Section 3.3 raises questions of whether changes in the salmon biomass value are endogenous. To tackle such issues, I utilize an IV approach. Table 5 presents the results of the IV-estimations. Columns (1) and (3) correspond to column (5) in Table 4, while columns (2) and (4), which includes regional linear trends, correspond to column (6) in Table 4.

Both instruments appear to fulfill the relevance condition, with estimated F-stats in the first stage around 25-28 and 107-118, respectively. Moreover, the point estimate in the first stage has positive values estimated to 0.545, 0.505, 0.164, and 0.150, respectively. This is important because the argument for both instruments is that one should expect a positive correlation. Since the instruments are based on exogenous variations as they appear for the regions, see the discussion in Section 3.3, I would argue that they also uphold exclusion restrictions.

In contrast to the FE-estimations in Table 4, IV-estimation produces statistically significant estimates in all specifications. It is, however, reassuring to see that the IV-strategy produces results that point in the same directions as the FE-models. The salmon biomass value's estimated effect is -0.0166 in columns (1), indicating that the high school graduation rate will fall by 0.33 percentage points when the salmon biomass value increases by ten percent of a standard deviation. The inclusion of regional linear trends in column (2) produces the same effect size as the model without trends.

Table 5. IV-results with high school graduation as the dependent variable, years 1994-2006.

Instrument	(1) $IV^{coastline}$	(2) $IV^{coastline}$	(3) $IV^{biomass1990}$	(4) $IV^{biomass1990}$
Biomass value (10000) per capita	-0.0166* (0.00857)	-0.0164** (0.00772)	-0.0125** (0.00504)	-0.0116*** (0.00401)
F-stat first stage (Kleibergen-Paap)	25,48	28,27	106.82	118.30
SES included	Yes	Yes	Yes	Yes
Municipal FE	Yes	Yes	Yes	Yes
Regional linear trends	No	Yes	No	Yes
Observations	711,621	711,621	711,621	711,621

A constant term and cohort fixed effects are also included (not reported). Standard errors in parentheses are clustered at the labor market region level. ***, **, and * denotes significance at the 1, 5, and 10 % level, respectively.

In columns (3) and (4), the instrument is based on a different element of expected regional exposure from changes in salmon farmers' production, which is the industry's activity some years prior to the analysis period. The point estimate is about -0.012, precisely the same as estimated in the FE-model without linear trends (column (5) in Tabel 4). This suggests that the graduation rate decreases by 0.24 percentage points when salmon biomass value increases by ten percent of a standard deviation (measured at the regional level). Considering the vast inflow of foreign workers into this industry due to the EEA agreement, I would also argue that my findings are downward biased as this will likely dampen the demand for domestic labor.

Robustness checks

Different periods

Table 4 documented that the salmon value's effect was statistically insignificant with FE-estimation. As shown in Figure 1, there might be a valid explanation for this. In the first years of the period, the salmon price declined, while there was a significant increase in the latter years. However, there was relatively stable growth in the number of concessions throughout the whole period, except for 2003 and 2004, which saw a substantial increase in new concessions.

There is a possibility that the reduction in prices in the first half of the period average out the effect of price increases observed in the second part of the period. To further examine this, the analysis period is split into two separate periods; *i*) the period with declining prices (1994-2000) and *ii*) the period with price growth (2001-2006).

The FE-estimations from these analyses are presented in Table 6. Columns (1) and (3) correspond to column (5) in Table 4, and columns (2) and (4) correspond to column (6) in Table 4. The difference in the specification is that columns (2) and (4) include regional linear trends.

Table 6. Analyzing the effects of biomass value separately for periods with a decline (1994-2000) and growth (2001-2006), respectively, in the international salmon price.

Period	(1) 1994-2000	(2) 1994-2000	(3) 2001-2006	(4) 2001-2006
Biomass value (10000)	-0.0151	-0.00544	-0.0110**	-0.0191***
per capita	(0.0134)	(0.0119)	(0.00495)	(0.00547)
SES included	Yes	Yes	Yes	Yes
Municipal FE	Yes	Yes	Yes	Yes
Regional trends	No	Yes	No	Yes
Observations	362,227	362,227	349,394	349,394

Included individuals are students who completed lower secondary education. A constant term and cohort fixed effects are also included (not reported). Standard errors in parentheses are clustered at the labor market region level. ***, **, and * denotes significance at the 1, 5, and 10 % level, respectively.

Although the effect is negative in columns (1) and (2), I do not find a statistically significant association between the value of salmon in the labor market region and high school graduation in the first period. However, when studying the period with increasing prices (2001-2006), the negative association is quite precisely estimated. Evaluated by an increase in the biomass value of ten percent of a standard deviation (1.9878*10%), the association in column (3) corresponds to a 0.22 percentage point lower graduation rate. The point estimate is even slightly higher when I include regional linear trends in column (4).

In Table 7, the two periods are evaluated by applying the IV-strategy. Similar to the findings in Table 6, the IV-estimates do not show that there is a statistically significant effect of changes in the salmon biomass value on high school graduation in the period where prices dropped. However, the point estimates utilizing the IV-strategy are fairly in line with the latter period's FE-estimations in columns (3) and (4) in Table 6. The point estimate of -0.0193 suggests that the high school graduation rate will fall by almost 0.4 percentage points when the salmon biomass value increases by ten percent of a standard deviation.

As a further robustness check, I have also estimated the models in columns (3) and (4) in Table 7 without municipal FE (not reported). The estimated effects decrease somewhat (-0.0135 and -0.00156, respectively). The effect corresponding to column (4) is thus no longer statistically significant, whereas the effect corresponding to column (3) is significant at the 5 percent level. Also, the estimated F-stats are relatively unaffected by estimating the models without municipal fixed effects.

Table 7. IV-results with high school graduation as the dependent variable when analyzing different periods.

Period	(1) 1994-00	(2) 1994-00	(3) 2001-06	(4) 2001-06
Instrument	$IV^{coastline}$	$IV^{biomass1990}$	$IV^{coastline}$	$IV^{biomass1990}$
Biomass value (10000) per capita	-0.0282 (0.0250)	-0.0161 (0.0162)	-0.0193** (0.00966)	-0.0129** (0.00612)
F-stat first stage (Kleibergen-Paap)	10.74	14.64	26.79	191.47
SES included	Yes	Yes	Yes	Yes
Municipal FE	Yes	Yes	Yes	Yes
Regional linear trends	No	No	No	No
Observations	362,227	362,227	349,394	349,394

A constant term and cohort fixed effects are also included (not reported). Standard errors in parentheses are clustered at the labor market region level. ***, **, and * denotes significance at the 1, 5, and 10 % level, respectively.

Gender differences

Earlier studies have often relied on exogenous changes that primarily affect males to establish causal evidence of the returns to education. Examples of such studies are Aparicio-Fenoll (2016), utilizing that a housing boom in Spain affected males through a growth in the construction industry, and Cascio and Narayan (2020), identifying opportunity costs through the development of the fracking technology in the US oil and gas industry.

Although there are more males than females employed in the salmon farming industry, the share of females is non-trivial. Norwegian labor statistics show that almost 15 percent in the fishing and aquaculture sector are females. This sector does not include processing in factories, where the share of females generally amounts to almost 40 percent.[8] Gender differences regarding changes in the return to schooling from changes in the aquaculture sector are therefore evaluated in Table 8.

Table 8. Heterogenous effects by gender - FE and IV-results for high school graduation as the dependent variable, period 2001-2006.

	(1)	(2)	(3)	(4)	(5)	(6)
		Females			Males	
Instrument		$IV^{coastline}$	$IV^{biomass1990}$		$IV^{coastline}$	$IV^{biomass1990}$
Biomass value (10000) per capita	-0.0125 (0.00784)	-0.032** (0.0150)	-0.025*** (0.00906)	-0.00946 (0.00756)	-0.00748 (0.00768)	-9.78e-04 (0.00603)
F-stat first stage (Kleibergen-Paap)		27.50	195.45		26.10	186.88
Method	FE	IV	IV	FE	IV	IV
SES included	Yes	Yes	Yes	Yes	Yes	Yes
Municipal FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	169,979	169,979	169,979	179,415	179,415	179,415

A constant term and cohort fixed effects are also included (not reported). Standard errors in parentheses are clustered at the labor market region level. ***, **, and * denotes significance at the 1, 5, and 10 % level, respectively.

The first three columns in Table 8 show estimates where only females are included in the sample. The corresponding analyses for males are shown in columns (4) to (6). These analyses include only the cohorts finishing compulsory schooling in 2001-2006, which is coinciding with increasing prices. The first model presents the FE-estimate, whereas the consecutive columns present IV-estimates utilizing the two different instrumental variables presented above. The FE-estimates are negative, although not statistically significant, both for males and females. Using the IV-strategy, I find a statistically negative effect for females and that the point estimates increase somewhat compared to the FE-estimation. For males, the estimated effect does not depend on the choice of estimation method. Here, the estimates are closer to zero compared to the findings for females. These findings suggest that females responded more to these changes than males. However, it is not possible to conclude that the difference between, e.g., the effect in column (2) and (5) are statistically significant.

---

[8] See https://www.ssb.no/en/statbank/table/08536/ for official statistics.

As a robustness check, I have also performed similar analyses as those presented in Table 8 on the whole period 1994-2006. This produces very similar findings, except that the FE-estimate for females is statistically significant at the 10 percent level and that the IV-estimates for males are somewhat reduced.

4.2. Analyses of the wage gap between low- and high-skilled workers

The results so far suggest that the farmed salmon industry's size negatively affects high school graduation rates. This section considers to what extent this finding is consistent with the prediction of standard human capital theory. The central understanding is that educational decisions are to be affected by expected returns to education, usually measured by earnings or income over the life cycle. However, information about the counterfactual life cycle income is very challenging to estimate. Section 3.1 describes how I have calculated a yearly low- and high-skilled wage, respectively, in every labor market region using Norwegian administrative register data on labor market attachment, income, and educational status for the period 2004-2006.

This section investigates how educational investment is affected by changes in the wage gap between low- and high-skilled workers. Using the calculated wage gap to study educational investment decisions directly in an OLS or FE strategy is challenging due to endogeneity issues. I solve this problem by instrumenting the calculated regional wage gap between low- and high-skilled workers with regional changes in the salmon biomass value.

Moreover, since it is also unclear if changes in salmon value are exogenous, I perform a 3SLS analysis where changes in low-skilled labor demand, i.e., the effect of changes in salmon biomass value, are instrumented. This arguably exogenous variation is then used as an instrument for the wage gap in the second step. Hence, the critical question is that the regional demand for low-skilled labor increases when new salmon concessions are allocated to specific regions, and when prices rise. This analysis is executed within the following system of equations:

$$(5) \quad HS\ graduation_{itmr} = \alpha_1 + \beta_1 \widehat{Wage\ gap}_{\imath mrt} + X'_{imrt}\theta_1 + \delta_t + \gamma_{mr} + u_{imrt}$$

$$(6) \quad Wage\ gap_{itmr} = \alpha_2 + \beta_2 \widehat{B\imath omass\ value}_{\imath mrt} + X'_{imrt}\theta_2 + \delta_t + \gamma_{mr} + v_{imrt}$$

$$(7) \quad Biomass\ value_{itmr} = \alpha_3 + \beta_3 INSTRUMENT_{rt} + X'_{imrt}\theta_3 + \delta_t + \gamma_{mr} + e_{imrt}$$

The procedure is related to the strategy utilized by Becker and Woessman (2009), studying the importance of literacy on economic prosperity. The first step, see Eq. (7), predicts the value of salmon biomass by the instruments presented in Section 3.3. The variation in biomass value due to changes in, e.g., ocean temperatures and international salmon prices, is then used in the second stage, see Eq. (6), to predict the wage gap between low- and high-skilled workers. Finally, in the third stage, this variation in the wage gap is used to predict high school graduation. In practice, this three-step least squares is performed as two separate 2SLS-analyses. This is because available 3SLS estimation packages do not allow for clustering at the regional level, which is essential due to autocorrelations in the error term. For this reason, I save the predicted biomass value from the first step, and utilizes these values in a separate 2SLS analysis on Eq. (6) and (5), respectively.

The analyses of how the wage gap affects high school graduation are presented in Table 9. The first two columns show 2SLS estimations. The reported F-stat of 25.4 suggests that the salmon biomass value is a relevant instrument. The estimated effect on high school graduation is -1.019, which suggests that a 0.3 percentage point decrease in the wage gap, which is about ten percent of a standard deviation measured at the regional level, decreases the high school graduation rate by about 0.3 percentage points. This result is broadly in line with Aparicio-Fenoll (2016), who found that a 10 percent decrease in the ratio of wages between uneducated and educated individuals lead to a 0.2 percent decrease in grade completion among 16-18-years-old in Spain. When linear labor market regional trends are included, see column (2), the F-stat indicates that the salmon biomass value is not valid as an instrument. However, the analysis produces almost an identical effect size.

It must also be mentioned that the value of the salmon biomass mainly affects the calculated low-skilled wage rather than the high-skilled wage. A model with the logarithm of low- and high-skilled wages, respectively, as the dependent variable suggest that the effect from the biomass value on low-skilled wages is about 28 times the effect on high-skilled wages.[9] The fact that only low-skilled wages are affected by changes in the salmon farming industry strengthens my claim that it is primarily the demand for low-skilled labor that increases with increasing salmon biomass value.

Columns (3) to (8) presents the 3SLS estimations. When I include the instrument that utilizes the coastline of islands as a proxy on salmon farming exposure, the F-stat in the first stage is 27. In contrast, the exogenous salmon biomass variable only produces an F-stat equal to 5.8 in the second stage. This indicates that the exogenous salmon biomass value's relevance is a bit

---

[9] The point estimate of the salmon biomass value on low-skilled wages as the dependent variable is 0.0011144 with a p-value of 0.004, using a similar model as in column (1) in Table 9. In contrast, the p-value for a similar analysis with high-skilled wages as the variable of interest is 0.864.

weak. However, the estimated effect of the wage gap on high school graduation (-1.461) increases by more than 40 percent compared to the 2SLS estimate in column (1). This effect is statistically significant at the 5 percent level.

Table 9. IV-results for wage gap (ln low-skilled wage – ln high-skilled wage), 2004-2006.

Dep. Variable	(1) 2SLS	(2) 2SLS	(3) 1st step Biomass value	(4) 2nd step Wage gap	(5) 3rd step High school graduation	(6) 1st step Biomass value	(7) 2nd step Wage gap	(8) 3rd step High school graduation
Wage gap	-1.019***	-0.983			-1.461**			-1.116***
	(0.343)	(2.942)			(0.700)			(0.256)
Biomass Value				0.020***			0.022***	
				(0.0062)			(0.0033)	
$IV^{coastline}$			5.112***					
			(0.986)					
$IV^{biomass1990}$						1.775***		
						(0.107)		
F-stat	25.381	1.148	26.91	5.81		274.59	54.08	
SES included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipal FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional trends	No	Yes	No	No	No	No	No	No
Observations	185,664	185,664	185,664	185,664	185,664	185,664	185,664	185,664

A constant term and cohort fixed effects are also included (not reported). Standard errors in parentheses are clustered at the labor market region level. ***, **, and * denotes significance at the 1, 5, and 10 % level, respectively.

When using the instrument that utilizes prior biomass to measure expected exposure of changes in salmon biomass value, the F-stat in the second stage is 54, while the estimated effect on high school graduation is equal to the 2SLS estimate in column (1) and statistically significant.

Heterogenous effects from changes in the wage gap between low- and high-skilled workers for each gender are examined in Table 10. The sample in columns (1) to (4) only consists of females, whereas only males are included in the four last columns. Column (1) and (4) present the 2SLS estimates for females and males, respectively. Although the point estimates are quite similar, the estimated effect is only statistically significant for females. The structural models confirm this finding. I find that only the impact of changes in the female' wage gap between low- and high-skilled workers have a statistically significant effect on the probability of graduating from high school. The effect is almost 75 percent higher for females compared to what I found for the genders pooled in Table 9. The negative effect for males is relatively low and not statistically significant.

Table 10. Heterogenous effects by gender - IV-results for wage gap (ln low-skilled wage – ln high-skilled wage), 2004-2006.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Females				Males			
	2SLS	1st step	2nd step	3rd step	2SLS	1st step	2nd step	3rd step
Dep. variable		Biomass value	Wage gap	High school graduation		Biomass value	Wage gap	High school graduation
Wage gap	-1.143*			-1.953***	-0.895			-0.289
	(0.592)			(0.428)	(0.555)			(0.318)
Biomass value			0.021***				0.023***	
			(0.00328)				(0.00343)	
$IV^{biomass1990}$		1.807***				1.743***		
		(0.108)				(0.107)		
F-stat	24.13	280.31	49.61		26.14	264.65	59.68	
SES included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Municipal FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	90,271	90,271	90,271	90,271	95,393	95,393	95,393	95,393

A constant term and cohort fixed effects are also included (not reported). Standard errors in parentheses are clustered at the labor market region level. ***, **, and * denotes significance at the 1, 5, and 10 % level, respectively.

5. Conclusions

This paper utilizes variation in the Norwegian salmon farming industry to investigate if increased demand for low-skilled labor supply affects educational choice and investment among youths in Norway.

Evaluating regional changes in farmed salmon and its value, I find that industry growth decreases educational attainment by decreasing graduation rates in upper secondary education. The salmon stock value is instrumented with fixed and time-varying exogenous attributes like the length of island coastlines and ocean temperatures to deal with endogeneity issues. Similarly to Atkin (2016), I argue that this industry has a relatively high demand for low-skilled labor. By evaluating regional low- and high-skilled wages from changes in the salmon stock value, this hypothesis is somewhat confirmed since only low-skilled wages seem to be affected.

An important question is if the channel for educational investment changes is due to changes in the returns to education. I address this question by developing a structural model (3SLS) analyzing whether the wage gap between low- and high-skilled workers affects high school graduation. My findings suggest that the relative wage for low- versus high-skilled workers matters. This finding is in line with human capital theory. Although I cannot conclude that there are gender differences in response to changes in the returns to education, my findings suggest that females respond more distinctly than males. Considering the vast inflow of foreign workers into this industry due to the EEA agreement, I would also argue that my findings are downward biased as this will likely dampen the demand for domestic labor.

My findings have important policy implications. If youth responses to changes in the returns to education are based on an informed decision, i.e., if the changes in returns are permanent, human capital theory suggests that these are rational choices. On the other hand, if changes in schooling returns are temporary, reduced educational investments will have adverse long-term consequences through lower life cycle incomes. This impacts individuals directly but also society through lower productivity and taxes. Such effects can be reduced by strengthening higher education policies.

References

Aarset, B. (1998). Norwegian salmon-farming industry in transition: dislocation of decision control. *Ocean & Coastal Management, 38*, pp. 187-206.

Aarset, B., & Jakobsen, S.-E. (2009). Political regulation and radical institutional change: The case of aquaculture in Norway. *Marine Policy, 33*, pp. 280-287.

Abramitzky, R., & Lavy, V. (2014). How Responsive Is Investment in Schooling to Changes in Redistributive Policies and in Returns? *Econometrica, 82*(4), pp. 1241-1272.

Aparicio-Fenoll, A. (2016). Returns to Education and Educational Outcomes: The Case of the Spanish Housing Boom. *Journal of Human Capital, 10*(2), pp. 235-265.

Asche, F., & Bjørndal, T. (2011). *The Economics of Salmon Aquaculture.* Chichester: Wiley-Blackwell. doi:10.1002/9781119993384

Asche, F., Dahl, R. E., Gordon, D. V., Trollvik, T., & Aandahl, P. (2011). Demand Growth for Atlantic Salmon: The EU and French Markets. *Marine Resource Economics, 26*, pp. 255-265.

Asche, F., Roll, K. H., Sandvold, H. N., Sørvig, A., & Zhang, D. (2013). Salmon Aquaculture: Larger Companies and Increased Production. *Aquaculture Economics & Management, 17*, pp. 322-339.

Atkin, D. (2016). Endogenous Skill Acquisition and Export Manufacturing in Mexico. *American Economic Review, 106*(8), pp. 2046-85. doi:10.1257/aer.20120901

Aure, J. (1984). *Akvakultur i Sør-Trøndelag: Kartlegging av høvelige lokaliteter for fiskeoppdrett.* Bergen: Fiskeridirektoratets Havforskningsinstitutt. Retrieved from https://imr.brage.unit.no/imr-xmlui/bitstream/handle/11250/114302/fhb_1984_04.pdf

Bartik, T. (1991). *Who Benefits from State and Local Economic Development Policies?* W.E. Upjohn Institute.

Becker, G. (1964). *Human capital: a theoretical and empirical analysis, with special reference to education.* New York: Columbia Univ. Press.

Becker, S. O., & Woessmann, L. (2009). Was Weber Wrong? A Human Capital Theory of Protestant Economic History. *The Quarterly Journal of Economics, 124*(2), pp. 531-596.

Ben-Porath, Y. (1967). The Production of Human Capital and the Life Cycle of Earnings. *Journal of Political Economy, 75*(4), pp. 352-365.

Bensnes, S. S., & Strøm, B. (2019). Earning or Learning? How Extending Closing Time in the Retail Sector Affects Youth Employment and Education. *Oxford Bulletin of Economics and Statistics, 81*(2), pp. 299-327. doi:10.1111/obes.12262

Bhuller, M., Mogstad, M., & Salvanes, K. G. (2017). Life-cycle earnings, education premiums, and internal rates of return. *Journal of Labor Economics, 35*(4), pp. 993-1030.

Black, D. A., McKinnish, T. G., & Sanders, S. G. (2005). Thight Labor Market and the Demand for Education: Evidence from the Coal Boom and Bust. *ILR Review, 59*(1), pp. 3-16.

Blanchard, O. J., & Katz, L. F. (1992). Regional Evolutions. *Brookings Papers on Economic Activity, 23*(1), pp. 1-76.

Bütikofer, A., Dalla-Zuanna, A., & Salvanes, K. G. (2018). Breaking the Links: Natural Resource Booms and Intergenerational Mobility. *NHH Dept. of Economics Discussion Paper No. 19/2018*. doi:dx.doi.org/10.2139/ssrn.3246895

Cascio, E. U., & Narayan, A. (2020). Who Needs a Fracking Education? The Educational Response to Low-Skill Biased Technological Change. *ILR Review*. doi:doi.org/10.1177/0019793920947422

Emery, J. C., Ferrer, A., & Green, D. (2012). Long-Term Consequences of Natural Resource Booms for Human Capital Accumulation. *ILR Review, 65*(3), pp. 708-734.

FAO. (2020). *The State of World Fisheries and Aquaculture 2020. Sustainability in action.* Rome. doi:doi.org/10.4060/ca9229en

Feyrer, J., Mansur, E. T., & Sacerdote, B. (2017). Geographic Dispersion of Economic Shocks: Evidence from the Fracking Revolution. *American Economic Review, 107*(4), pp. 1313-1334.

Färe, R., Grosskopf, S., Roland, B.-E., & Weber, W. L. (2009). License fees: The case of Norwegian salmon farming. *Aquaculture Economics & Management*, *13*, pp. 1-21.

Goldin, C., & Katz, L. F. (1997). Why the United States Led in Education: Lessons from Secondary School Expansion, 1910 to 1940. *NBER Working Paper No. w.6144*.

Gutiérrez, X. A., Kolarevic, J., Takle, H., Baeverfjord, G., Ytteborg, E., & Terjesen, B. F. (2019). Effects of chronic sub-lethal nitrite exposure at high water chloride concentration on Atlantic salmon (Salmo salar, Linnaeus 1758) parr. *Aquaculture Research, 50*(9), pp. 2687-2697.

Hersoug, B. (2015). The greening of Norwegian salmon production. *Maritime Studies, 14:16*.

Hevrøy, E. M., Hunskår, C., de Gelder, S., Shimizu, M., Waagbø, R., Breck, O., . . . Hansen, T. (2013). GH–IGF system regulation of attenuated muscle growth. *Journal of Comparative Physiology B, 183*, pp. 243-259.

Kearney, M. S., & Wilson, R. (2018). Male Earnings, Marriageable Men, and Nonmarital Fertility: Evidence from the Fracking Boom. *The Review of Economics and Statistics, 100*(4), pp. 678-690. doi:10.1162/rest_a_00739

Lacuesta, A., Puente, S., & Villanueva, E. (2020). The schooling response to a sustained increase in low-skill wages: evidence from Spain 1989–2009. *SERIEs*. doi:doi.org/10.1007/s13209-020-00218-0

Liu, P., Lien, K., & Asche, F. (2016). The impact of media coverage and demographics on the demand for Norwegian salmon. *Aquaculture Economics & Management, 20*(4), pp. 342-356.

Liu, Y., Olaussen, J. O., & Skonhoft, A. (2011). Wild and farmed salmon in Norway - A review. *Marine Policy, 35*, pp. 413-418.

Marchand, J., & Weber, J. G. (2020). How Local Economic Conditions Affect School Finances, Teacher Quality, and Student Achievement: Evidence from the Texas Shale Boom. *Journal of Policy Analysis and Management, 39*(1), pp. 36-63.

Mota, V. C., Nilsen, T. O., Gerwins, J., Gallo, M., Ytteborg, E., Baeverfjord, G., . . . Terjesen, B. F. (2019). The effects of carbon dioxide on growth performance, welfare, and health of Atlantic salmon post-smolt (Salmo salar) in recirculating aquaculture systems. *Aquaculture, 498*, pp. 578-586.

Olaussen, J. O. (2018). Environmental problems and regulation in the aquaculture industry. Insights from Norway. *Marine Policy, 98*, pp. 158-163.

Reiling, R. B., & Strøm, B. (2015). Upper Secondary School Completion and the Business Cycle. *The Scandinavian Journal of Economics, 117*(1), pp. 195-219. doi:10.1111/sjoe.12088

Øyehaug, O. (2003). Krakk for konsesjoner. Bergens Tidende. Retrieved from https://www.bt.no/nyheter/okonomi/i/zOREw/Krakk-for-konsesjoner

Appendix

Appendix Table 1. Descriptive statistics on individual SES variables

	Mean	Standard deviation
Female	0.487	0.500
First generation immigrant	0.047	0.213
Second generation immigrant	0.017	0.131
Father's edu. = high school	0.480	0.500
Father's edu. = BSc	0.171	0.376
Father's edu. = MSc or PhD	0.089	0.284
Mother's edu. = high school	0.419	0.493
Mother's edu. = BSc	0.238	0.426
Mother's edu. = MSc or PhD	0.030	0.170