Losing in a Boom: Long-term Consequences of a Local Economic Shock for Female Labour Market Outcomes

BY Patrick Bennett, Chiara Ravetti and Po Yin Wong

DISCUSSION PAPER

Institutt for samfunnsøkonomi
Department of Economics

SAM 03/2020

ISSN: 0804-6824
February 2020

Losing in a Boom: Long-term Consequences of a Local Economic Shock for Female Labour Market Outcomes*

Patrick Bennett† Chiara Ravetti‡ Po Yin Wong§

February 2020

Abstract

This paper examines the long-term labour market consequences of a positive economic shock, the first discovery of oil and gas in Norway. Existing studies focus on the short-term and men, while less is known about women and the persistence of such shocks. Oil discovery increased male earnings (by 7%), while female earnings declined (by 10%). These shifts persist for two decades. Labour force participation and occupational change account for the earnings divergence. Within married couples, wives' earnings declined, but household earnings increased. However, women's income loss in oil regions is transitory: younger cohorts catch up to women in non-oil regions.

*The views expressed in this paper are those of the authors and do not necessarily reflect those of the Hong Kong Monetary Authority. The authors wish to thank Aline Bütikofer, Katrine Løken, Kjell Salvanes, Rick Van der Ploeg, Michael Ross, Gerhard Toews, seminar and workshop participants from HEC Montréal, the Norwegian School of Economics, the Centre for International Environmental Studies, NAERE, OxCarre, CEA 2019, ESPE 2019, EALE 2019, SIEPI 2020 and IAERE 2020 for their helpful comments and suggestions. This work was partially supported by the Research Council of Norway through its Centres of Excellence Scheme, FAIR project No. 262675. The authors acknowledge financial support from the Norwegian School of Economics, FAIR, the Research Council of Norway, Polytechnic of Turin, Oxford Centre for the Analysis of Resource-Rich Economies (OxCarre), and the Hong Kong Monetary Authority. The paper was previously circulated under the title "Women and Resource Windfalls: The Norwegian Oil Boom".

†Department of Economics and FAIR-CELE, Norwegian School of Economics (NHH)

‡Polytechnic of Turin

§Research Department, Hong Kong Monetary Authority

1 Introduction

Over the past few decades, the gender wage gap in industrialized countries has been narrowing and female labour force participation has been steadily increasing. However, this overall trend varies significantly across time and geography (Goldin, 2006; Olivetti and Petrongolo, 2016). Understanding the different labour market outcomes experienced by men and women in the short and long run has important implications for gender equality, yet it is empirically challenging to study this question. Ideally, it requires a sizeable and plausibly exogenous change in economic conditions as well as detailed longitudinal data on labour market outcomes over a long time horizon.

In this paper, we exploit a substantial and persistent sectoral shock, Norway's first discovery of oil and gas deposits in 1969. Given the unexpected nature of the shock, we leverage the spatial variation of its impact within Norway to identify the differences in labour market outcomes for various groups of workers. An important distinguishing feature of our work is the detailed individual- and household-level panel data from the Norwegian Registry and Census that allows us to follow Norwegian residents before and after the local shock over their life cycle. We compare 'treated' individuals who, prior to the discovery of oil, were residing in a local labour market that later experienced high exposure to oil, with a control group of people who were living in a low-exposure labour market. We hypothesize that the effects of the economic boom depend on the substitutability of men and women in the labour markets and on the reallocation of joint labour supply within households. Moreover, in the long run, these outcomes might differ depending on each individual's flexibility to modify lifetime decisions such as full versus part-time employment, education, household formation, fertility, and occupational choices.

The recent literature on fracking in the US has leveraged an analogous economic boom to explore short to medium-run changes in the labour market, finding an overall positive impact

on wages and other labour market outcomes (Allcott and Keniston, 2018; Bartik et al., 2019) as well as significant, but not necessarily positive, social changes such as increases in fertility (Kearney and Wilson, 2018), more high school dropouts (Cascio and Narayan, 2015), increased migration (Wilson, 2018), and higher crime rates (James and Smith, 2017; Bartik et al., 2019). However, few studies examine the long run consequences of a local boom, most concentrate on outcomes for male workers, and evidence at the worker and household level is scarce.[1]

Our paper makes two important contributions. First, it provides evidence on the short and long-run impacts of a local economic shock by gender. In the short run, we consider the effect of the economic shock on young workers who were already attached to the labour force at the time of the oil discovery. Given their young age, they could still make substantial changes in their career trajectories. In the long run, we examine the next generation of workers who were children at the time of the oil discovery and joined the labour force only after the shock. As they were exposed to the local economic shock as children, they could adapt their schooling, labour market entry, and family formation decisions in response to the shock. Second, we analyze the labour force participation, occupational, and within-couple dimensions of labour inequality and provide new insights for policies addressing the mechanisms underlying these understudied inequalities. We exploit the detailed information in the national Census and within-household data to understand how the oil discovery translated into changes in the labour supply and in the income shares of males and females within couples.

We present four key findings. First, our event-study estimates show that young working-age men earned significantly higher annual incomes, starting already one year after oil production began in 1971. In contrast, women in high oil regions had lower earnings than their counterparts in low oil areas. Importantly, prior to the discovery of oil, differences in income are small in

[1] Some notable exceptions are Jacobsen and Parker (2014), who show that, at the county level, natural resource booms can have long-term negative consequences when a boom turns into a bust; and Aragón et al. (2018), who look at impacts of coal mine closures for several decades, distinguishing between the effects on men and women.

magnitude and statistically insignificant, indicating that high- and low-oil regions were similar in terms of pre-discovery income. In contrast to the persistent improvement in the earnings of men, even after 20 years, the annual earnings of young working women in high-oil labour markets remained lower than those in the control regions.

Second, we exploit intra-household data on married couples and find within-couple dynamics to be an important factor in explaining the observed decline in earnings for women. Comparing the impact of the boom on earnings for married and unmarried workers, we show that marital status matters more for women than for men. While individual earnings among stably married women decline substantially, household earnings for these women increase. Overall, females' relative share of household earnings declines by 6%. This loss in the share of the household's income could be problematic, as previous evidence establishes a causal link between increases in gender equality and decreasing rates of domestic violence (Aizer, 2010).

Third, we show that the local economic shock leads to a 25% decline in female labour force participation. This decline comes at the expense of a reduction in full-time employment, while there is little intensive margin response among men who were already attached to the labour force. We further show that men moved into high-paying occupations following the boom, while women did not. The immediate income loss for women exposed to oil does not seem to depend on educational choices nor in any major way from the decision to have children.

Fourth, we find that among the next generation of workers—individuals who joined the labour force in the years after the discovery—young girls in high oil regions closed the pre-existing lifetime earnings gap with their peers in low oil regions. In contrast, male lifetime earnings in high oil regions relative to those of their low oil peers were similar for early and later cohorts. These next cohorts of workers were exposed to the economic shock in various ways at young ages, for instance through a rise in family income (Løken, 2010). In addition, they also

had greater flexibility to adjust major life decisions such as education, family formation, and labour force entry.[2] For these next generation of workers, a large variety of factors could adjust, both in terms of their individual labour supply and on the labour demand side. Therefore, we can only provide suggestive evidence of the mechanisms behind this result. Overall, the interesting finding from a long-term policy perspective is that the earning loss experienced by women during the economic boom was only temporary and did not carry on to the following cohorts of female workers.

Our study makes several contributions to different strands of literature. First, within-country studies are becoming increasingly popular for understanding the precise mechanisms behind the labour market outcomes due to the spillovers of localized industrial activities (Greenstone et al., 2010). In particular, natural resources offer a source of exogenous variation in economic conditions that are associated with increases in local economic activity and employment during booms.[3] For Norway, Løken (2010) and Løken et al. (2012) examine the relationship between family income following the Norwegian oil boom and children's educational outcomes while Bütikofer et al. (2018) assess how intergenerational mobility among men changed following the discovery of oil. Our study complements these earlier works by looking at the differential effects of the resource-driven boom on men and women. Only few studies adopt a within-country design to compare local labour outcomes for female and male workers.[4]

[2]We check whether our results are likely to be affected by migration, since young women growing up in high oil regions could have moved to Oslo or other low oil cities that offered high incomes. We show that migration is not a major driver of our results, neither in the short nor in the long run.

[3]See for instance Aragón and Rud (2013); Black et al. (2005); Jacobsen and Parker (2014); Michaels (2011); Marchand (2012); Fleming and Measham (2015); Autor et al. (2019); Bartik et al. (2019). One key issue examined by this literature is whether the resource sector offers some complementarities with other sectors, or instead crowds out manufacturing and other labour-intensive industries.

[4]Some notable exceptions are Maurer and Potlogea (2017), who find that oil discoveries in the US in the early 1900s increased labour force participation among single women. The study of Aragón et al. (2018) looks at closure of coal mines in UK and finds that men and women are substitutes in non-primary sector labour markets (manufacturing and services), and women were crowded out of these sectors, with effects that persist more than 20 years after the mine closures. Their findings are parallel to Kotsadam and Tolonen (2016), who find that during mining booms in Sub Saharan Africa, women shifted away from the agricultural sector into services, but overall female employment declined.

Our paper also contributes to the diverse literature on the responsiveness of spousal labour supply in compensating for labour market shocks and the importance of the "added worker effect" (Lundberg, 1985). Goux et al. (2014) find a decrease in spousal labour supply following a mandated reduction in the work-week in France that, while reducing hours worked, kept earnings constant. Autor et al. (2019) show that household income following disability insurance receipt is unchanged as spousal labour supply adjusts. While Stephens (2002) shows that spousal labour supply responds substantially following displacement in the United States, Halla et al. (2019) find less scope for household labour supply adjustments following job displacement in Austria. In contrast, structural estimation of a life-cycle model emphasizes the importance of household labour supply adjustments in smoothing adverse shocks (Blundell et al., 2016). In line with this literature, our findings point to the important role of within-household labour supply adjustments in response to local economic shocks.

Our work makes a third contribution to the literature by investigating women's labour market outcomes following a significant economic shock. In the case of negative shocks, the adverse consequences for women have been documented previously.[5] One of the largest shocks studied in this literature is the effect of World War II: following manpower mobilization towards one of the most gendered industries, the military, regions with higher mobilization rates experienced an increase in female labour supply (Acemoglu et al., 2004). The effects, however, were long-lasting only for highly educated women who could enter white-collar occupations (Goldin and Olivetti, 2013). The spillovers from these changes in labour demand were relevant also for the following generations of women (Fernández et al., 2004) and were linked to lower educational attainment and more precocious marriage and fertility choices (Jaworski, 2014). Given that the Norwegian oil boom was a substantial and long-lasting sectoral shock with gen-

[5] A study of Austrian plant closures found that job displacement reduced income and job-specific human capital for women in highly skilled occupations, decreasing average fertility by 5-10% (Del Bono et al., 2012)

eral equilibrium effects on other sectors, our findings based on longitudinal data on individual labour market outcomes over a long time horizon provide novel insights on whether, and under what conditions, women's earnings improve following a positive shock in a male-dominated sector.

The rest of the paper is organized as follows. Section 2 discusses the Norwegian oil discovery and section 3 describes the data sources. Section 4 presents our hypotheses, estimation strategy and results for young workers exposed to the local economic shock. Section 5 investigates the long term impact of the local boom on the lifetime income of the next generation of workers, and Section 6 concludes.

2 The discovery of oil and gas in Norway

The discovery of offshore deposits of oil and gas[6] in 1969 offers an attractive setting for studying whether the impacts of a large economic shock on labour market outcomes differ by gender. Up to the 1960s, the Norwegian economy had relied mostly on fishing, shipping, forestry and agriculture. Then on December 23, 1969, the company Phillips Petroleum announced to the Norwegian government the discovery of Ekofisk, the first 'giant' oilfield in Western Europe (Van Den Bark and Thomas, 1981).[7] This event marked the beginning of the Norwegian oil industry, which substantially changed the local economy in the following decades, with long-lasting socio-economic consequences (Bütikofer et al., 2018).

The discovery of any giant oil field constitutes a significant economic discontinuity, with major macroeconomic repercussions (Arezki et al., 2017). Oil findings of these dimensions are

[6]For brevity, throughout the paper we refer just to oil, but the resource discovery and the industry that developed around it also comprises a substantial natural gas sector.

[7]An oilfield is defined by the American Association of Petroleum Geologists as 'giant' if the ultimate recoverable reserves is greater or equal to 500 million barrels of oil equivalent before extraction began, including condensate and natural gas (Horn, 2011).

rare and unpredictable: despite significant investments in exploration, finding a giant oil field is quite a random process (Lei and Michaels, 2014).[8] For Norway, the first giant discoveries in the 1970s were even more unexpected because exploration companies had been drilling unsuccessfully in the Norwegian continental shelf for more than five years. Phillips Petroleum was the last company still exploring in 1969 and it seems that it would have abandoned its last exploration as well, had it not been cheaper to drill than to pay a fine to the Norwegian oil office for abandoning its exploration commitments (Sandbu, 2009). We therefore consider the discovery of the first giant oilfield as a random economic shock, plausibly exogenous in its timing, and impossible to anticipate by the local population.

The sudden oil boom initially affected only the few industries and areas specializing in the extraction and refinery of oil and gas. In particular, following the first find, the Norwegian authorities designated the largest city in Rogaland, Stavanger, as the country's main oil base, since it was the closest large city to the first field discovered, Ekofisk. Rapidly, many other sectors such as certain types of manufacturing and construction also benefited from the initial local economic boom following the discovery of oil. While the 'Dutch disease' could have destroyed some manufacturing industries in which women worked, Norway managed its petroleum sector carefully so to avoid the typical negative consequences of resource discoveries (Larsen, 2006).[9]

Figure S1 in Appendix A plots the location of the Ekofisk oil field and the city of Stavanger. Statoil, Norway's state-owned energy company, and the Norwegian Petroleum Directorate, were established with their headquarters there in 1972, soon followed by other companies (Løken, 2010). Over time, the spillovers from the oil industry spread beyond the first

[8] To see how unpredictable a giant finding is, consider that, since 1965, only 2% of all wells drilled around the world resulted in giant oil or gas discoveries (Toews and Vezina, 2017). One exemplary illustration comes from the Johan Sverdrup oilfield, one of Norway's largest discoveries, which was found in 2010 within few metres of where the French explorer Elf Aquitaine drilled but failed to find oil in 1971 (Kavanagh, 2013)

[9] Note that Norway did not have a sizeable manufacturing export sector before the oil boom, and mostly relied on primary goods production like fish and timber, so the crowding-out of other local manufacturing activities was not substantial (Bütikofer et al., 2018). The exchange rate did appreciate, but this affected uniformly exporters and importers in our treatment and control groups.

location for oil extraction and refineries, so that the definition of 'oil regions' in Norway needs to be discussed carefully. We do so in section 3.2, which defines the industries which comprise our definition of oil.

Even if the offshore oil and gas industry is not labour intensive, employing just above 80,000 workers in the whole country (2.5% of the working age population) at its peak in 2014,[10] the two municipalities with the highest ratio of employees in the petroleum industries, Sola and Stavanger (both in Rogaland), had 15.7% and 13.6% of local employment in oil-related industries, respectively (Ekeland, 2017). Therefore, the local shock should have generated some significant labour market and income effects, possibly with spillovers onto other local activities (manufacturing, services).

3 Data

3.1 Individual-level data

In order to examine the differential impacts of local demand shock resulting from discovery of oil by gender over the short and long run, the paper makes use of annual register based data as well as decadal Census data. Each of these are described below.

3.1.1 Registry data

Our main data source is the Norwegian Registry from Statistics Norway, which covers the entire population and follows individuals annually from 1967–2017. Using an anonymous personal identification number for all Norwegian residents, we merge individuals across four different registers from different administrative sources to create an individual-level panel. Importantly,

[10] Authors' calculation from https://fred.stlouisfed.org/series/LFWA64TTNOA647S.

individuals remain in the data at all points in time irrespective of whether they are employed or not.

First, we observe individuals in the central population register (*folkeregisteret*) yearly starting in 1970. The population register contains data on an individual's municipality of residence, gender, birth year, and marital status. Prior to 1970, yearly snapshots are available in 1965 and 1967, which provide the same information. In addition, we have detailed information on spousal connections and dates of marriage which permit the construction of household income.

Second, using the education register, we can define an individual's education as the highest completed level of schooling. Third, from the tax and earnings register, we observe annual pension-qualifying earnings dating back to 1967, prior to the first discovery of oil at the end of 1969. This measure of pension-qualifying earnings comprises total labour income, including any income earned from self-employment, as well as any taxable benefits received during the year.[11] We cannot extrapolate actual wages to construct a gender wage-gap, so we refer throughout the paper to annual earnings or income as defined above.

3.1.2 Census data

Our analysis also relies on the 1970 and 1980 Census data, which provide detailed information on individual employment, such as occupations classified according to the International Classification of Occupation (ISCO), industry of employment classified according to the International Standard Industrial Classification of All Economic Activities (ISIC), employment status including self-employment, as well as annual hours worked. Data on economic activity are collected based on the 12 months preceding the Census date, for example, hours worked in the 1980 Census is an annual measure of hours from November 1979 to November 1980. The

[11] Taxable benefits include public transfers such as parental leave, unemployment, or sickness benefits. We are not concerned that these benefits should affect our analysis since in Norway, they are determined at the national level, and thus should not differ systematically in relation to treatment status.

Census has near universal coverage, including all individuals registered as residing in Norway at the start of November in the Census year. While the yearly panel from the Registry is essential to study the annual evolution of individual earnings after the oil shock as well as to inform the similarity of those in treated and control areas prior to the discovery of oil, the Census data allows us to explore other outcomes, such as labour market attachment and occupational changes.

3.2 Local labour markets and oil exposure

We assign each individual to a local labour market (LLM), a geographic segmentation of the country that organizes Norway into 46 different units, as in Bhuller (2009). Local labour markets are constructed on the basis of commuting patterns between individuals' municipality of residence and work. These markets are formed irrespective of administrative boundaries, so they are less affected by political changes than counties and municipalities. In fact, municipalities in the same local labour market may belong to different counties.[12] This way, our assignment of geographic areas to treatment and control groups is less susceptible to political changes that could relate to oil and administrative decisions made within each county (such as the establishment of the Petroleum Directorate in Rogaland).

We follow Bütikofer et al. (2018) and measure exposure to the oil boom by assigning each individual to a local labour market on the basis of residence in 1965, before the oil discovery, thus avoiding the effect of endogenous relocations. To determine if a labour market was exposed to the oil shock, we use the share of employment in oil industries in 1980 as a proxy for the intensity of the oil treatment.[13] Following Brunstad and Dyrstad (1997), we include

[12]There are approximately 420 municipalities in Norway, and the average local labour market contains 9 municipalities.

[13]Data from the 1980 census represents the first point in time when data on industry is available after the discovery of oil as there was virtually zero oil production in 1970.

in this definition industries directly involved in the extraction and refinery of petroleum, but also secondary industries which support oil production, namely crude petroleum and natural gas production, petroleum refining, manufacture of products of petroleum and coal, manufacture of machinery, manufacture of transport equipment, and construction other than building construction.

Figure 1 depicts the spatial distribution of the employment share in oil (the intensity of the oil treatment). As in Bütikofer et al. (2018), we define three separate levels of exposure to oil: high, medium, and low. A local labour market with a high share of employment in oil is defined as having more than 10% of employment in oil. This employment share corresponds to the top quartile of LLM. Medium exposure is defined as those with between 7.5% and 10% employment in oil and low exposure is defined as less than 7.5%.[14]

3.3 Sample and summary statistics

In this section, we define our sample of individuals living in these treated and control areas. The first part of our analysis focuses on a sample of young individuals born between 1940-1949 (aged 20-29 at the time of the local boom in 1969). We focus on this group because these birth cohorts were already active in the labour force when the oil and gas industry started developing, but were still in an early career phase and could make significant changes to their labour supply. With older individuals, we would run into the problem of considering their retirement decisions when we look at long-term labour outcomes. Moreover, most key family decisions (such as marriage and children) were already set for most individuals in their 30's at that time. As a first baseline, we restrict the sample to those workers who had strong attachment to the labour force prior to the oil shock: those who had a positive income in all years over the period 1967–1969.

[14] Alternative definitions of oil such as defining treatment at the county level comparing the county of Rogaland, which includes the oil capital of Stavanger, to other counties in Norway as in Løken et al. (2012) produces similar results on income among the first generation of workers.

We then examine separately the changes in labour force participation along the extensive and intensive margins. In the second part of the paper, we examine labour outcomes for younger cohorts that were exposed to the oil shock during childhood or adolescence and started working afterwards.

Table 1 displays the characteristics of our sample of young workers. All values are measured in 1969, with males in the first column and females in the second column. In this sample, 15–16% lived in a high oil LLM in 1965, 19% in a medium oil LLM, and the vast majority in a low oil LLM. There is a stark difference in the average income levels between genders, with men earning about 50% more than the income of women. Women participated less in formal labour markets prior to the oil discovery, as the sample of men is substantially larger. While we focus on a sample of workers attached to the labour force, results throughout the paper are unchanged if we focus instead on all individuals irrespective of labour force attachment.

4 Hypotheses, estimation and results

This section presents our main hypotheses regarding the effects of the local economic shock in Norway on labour market outcomes of men and women, the empirical strategy used to test them, and the results for the young workers. After the baseline results, we investigate a number of mechanisms that could justify the observed divergence in male and female earnings.

4.1 Hypotheses

The discovery of oil increased labour demand in the previously non-existent oil industry and in related activities, such as construction work to build the extractive infrastructure. We assume that male and female workers were imperfect substitutes and the oil industry's labour demand

was mostly targeting men, both due to their individual characteristics (such as physical strength) and because of cultural norms.[15] However, the oil boom also generated economic spillovers towards other industries. The non-tradable sector at the local level should have largely benefited from the presence of the nascent oil and gas industry (services, retail, local goods, etc.). An expansion of the "spillover sectors" should plausibly create an increase in labour demand for both men and women.

However, even if the two types of workers are more highly substitutable in local non-tradable industries, the overall effect on male and female labour outcomes depends on the responsiveness of their labour supply. One of the key contributions that our data allows us to make is precisely to look at the dynamics of the labour supply of men and women, both in the short and in the long run. We can then account not only for the asymmetric labour demand side, but also for the labour supply response of individuals and households.

Overall, we test three hypotheses. First, in the short run, given that men were almost already at full employment,[16] the higher demand for male labour from the oil industry should lead to higher average wages for men, necessary to attract them from other occupations. The equilibrium effect on their aggregate earnings should depend on the elasticity of the labour supply (e.g. how many more hours men choose to work, if migrant workers were available to fill in the jobs, etc.).

Second, the effect on women is theoretically ambiguous: on the one hand, the non-tradable local sectors that benefited from oil spillovers could absorb female workers; on the other hand, women might experience a substitution effect as their partners earned higher incomes, and choose to stay home and work in household production (e.g. housekeeping, child-care, etc.).

[15] Anecdotal evidence suggests that for workers in offshore jobs, the work shifts lasted about 14 days, before a 28-day break. This demanding schedule away from home appeared to be less costly for men than women, especially those within the same households, since the norm was that women assumed the role of children's caretaker in the home.

[16] In 1970, 92% of all men born 1940–1949 are employed with some hours of work.

Third, in the long run, we expect greater substitutability between men and women both on the labour demand side and on the labour supply side: cultural norms could change, workers of both sexes could decide to acquire different forms of training and education, career and family planning could be adjusted more freely. Therefore, we do not expect the short run results to necessarily apply in the long run.

4.2 Impact of oil discovery on annual income

To test the above hypotheses, we begin by using an event-study approach to analyse the effects of the oil discovery in 1969 on the annual income of young workers. We estimate the following regression separately for men and women:

$$Y_{icbt} = \sum_{k=-3}^{10} \delta_k Oil_{ic}^k + \psi_c + \tau_b + \gamma_t + u_{icbt} \tag{1}$$

where Y_{icbt} denotes the log of real annual income of individual i residing in 1965 in LLM c of birth cohort b in year t, with $t = 1967, \ldots, 1980$. The index k represents the number of lags (forward or backward) from the time of the oil discovery. ψ_c captures time-invariant characteristics of each LLM, τ_b represents birth cohort-specific characteristics, and γ_t denotes year fixed effects. The income level in the year of oil discovery (1969, $k = -1$) is normalized to zero. To examine the labour market effects of exposure to oil, we define the treatment Oil_c^k to correspond to residence in high oil LLMs in 1965 and compare it to the control group, individuals in low oil areas. The estimated coefficients δ_k represent the average difference between individuals in high oil relative to low oil LLMs in each time period relative to the same difference prior to the oil discovery at $k = -1$. Pre-event coefficients δ_{-3}, δ_{-2} reveal any inherent differences in the evolution of income prior to oil discovery. We cluster the standard errors at the level of the initial (1965) local labour market of residence, assuming error independence across LLMs.

Figure 2 plots the evolution of the estimated δ_k coefficients in equation (1). Panel A presents results for males while Panel B presents results for females. For both groups, there are no significant differences between a treated and untreated LLM prior to the discovery of oil. This suggests that those in high and low oil LLMs had similar income paths before the discovery of oil. We find that ten years after the discovery, the impact of the oil discovery on the nominal incomes of both men and women is persistently different. On average, while men benefit from the local boom, women lose out.[17]

For men in high oil regions compared to men in low oil regions, the boom takes a few years to translate into an increase in income: the estimated impact is not significantly different from zero (at the 5% significance level) for the first year after discovery. This is reasonable considering the lag between the discovery and the actual start of production in June 1971. From two years after the oil discovery, the estimated impact on income continues to increase and, 10 years after the discovery of oil, the annual earnings for men in high oil regions are 6.4% higher than those in low oil regions, relative to the year prior to the discovery of oil ($t = -1$).

A different pattern emerges for women. Similar to men, the oil shock also takes time to translate into changes in income for women. However, earnings are significantly lower for women in high oil LLMs from four years after the discovery and onwards. Compared to those residing in low-oil LLMs, women in high oil regions earn significantly less after the boom. For the average young woman in a high oil region, income 10 years after the oil discovery is 10% lower than that of the average young woman in a low oil region.

Results in Appendix B repeat the analysis with income measured in levels rather than the

[17]It is important to emphasize that our results pertain to the nominal incomes of men and women over time, rather than real income, due to the lack of data on a regional CPI within Norway in the time period considered. It is plausible that prices in high oil LLMs were higher than those in low oil LLMs because of the economic boom, so that even if nominal incomes of men in high oil LLMs increased relative to those in low oil LLMs, as we document here, we cannot definitively conclude that their real incomes are higher as well. Moreover, if prices went up more rapidly in high oil LLMs, then our results on women's reductions in nominal income become even more poignant.

log of income, thus including all individuals in that age group even if they had zero income post-discovery. Measuring income in levels and including those with zero income results in similar patterns in income for both men and women, though the decline in income among women occurs earlier when income is measured in levels. As the income of women decreases over time, some women may drop out of the labour force entirely and earn no income in a particular year, a point which is examined in further detail in Section 4.3.2.

For robustness, results in Appendix C repeat the analysis comparing individuals in middle oil regions to those in low oil areas. Consistent with smaller impacts of the boom in middle oil areas, the effects are milder and men in middle oil areas experience a smaller income gain while women do not have a significant change in income.

We show that our results are robust to extending the time horizon in Appendix D, including the peak of the oil boom in the early 1980s, during a time of high oil prices, and the oil 'bust' in the middle of that decade. Up to 20 years after the boom, income gains for men in high LLMs are persistent and stable, while for women income losses are persistent, though less severe over time. In the rest of the paper, we will try to identify some plausible explanations for the loss in income experienced by women in high LLMs after the local boom, and whether these losses also accrued to the next generations of female workers.

4.2.1 Migration

Our results so far could be underestimating the changes in the local workforce resulting from migration into and out of the oil regions. Constructing the treatment and control groups using an individual's local labour market of residence *prior* to the oil discovery partly limits concerns about endogenous relocation of workers following the change in economic circumstances. However, if a large fraction of the population moved in response to the oil shock,

the average income in the treatment and control groups would capture an unrealistic group of workers, since many would no longer be living in the initial location. Indeed, the literature on resource discoveries often identifies some geographic mobility following resource discoveries. For instance, Wilson (2018) shows significant migration into oil regions following fracking booms. In order to assess whether geographic mobility is a driving force behind our results, we examine how many individuals move, where they move to, and whether there are differences in geographic mobility between high and low oil regions in Appendix E.

Differential rates of geographic mobility do not appear to be problematic for the results. Among both men and women, a negligible fraction of workers relocate from low to high oil local labour markets (LLMs) and the fraction of workers who move is similar between those in high and low oil LLMs. Additionally, Appendix E examines how the results of Figure 2 change when excluding movers. If differential mobility out of or into high oil LLMs strongly impacts the results of Figure 2, then excluding these movers would provide a different picture. Reassuringly, Appendix E reveals that results are unchanged when excluding movers.

4.3 Mechanisms

We explore some key mechanisms behind our previous findings. First, a plausible explanation for the lower earnings of women in high oil regions could be that among couples, as men earned higher salaries, their wives substituted away from paid labour (Section 4.3.1). Second, we investigate how changes in aggregate earnings depend upon labour supply adjustments at the extensive margin—changes in labour force participation—and at the intensive margin—changes in full-time employment (Section 4.3.2). Third, we examine changes in the distribution of high- and low- paying occupations for both men and women in high/low-oil regions, ranking jobs from the lowest to the highest earning occupations (Section 4.3.3). Finally, we examine

fertility and educational choices as additional mechanisms (Section 4.3.4).

4.3.1 Intra-household effects

The first margin of adjustment that could explain the lower income earned by women is changes in within-household income. While the individual income of women may decline, household income may be unchanged or even increase if higher earnings from the husbands compensate for declines in the income of women. To inform such intra-household dynamics, we proceed in two steps. First, we separate the sample of Figure 2 between married and non-married individuals in 1969. If the household is indeed a relevant unit of variation in earnings, then the income declines observed among married women should be even larger. Second, we examine intra-household reallocation of earnings within couples who were married prior to the oil discovery. We construct a sample of stable couples, defined as those who were married continuously since 1969 (or earlier) and continued to remain married through to 1980. Such 'stable' couples offer the opportunity to compare changes in individual income to changes in household income and ask whether women's position within the household was impacted by the discovery of oil.

Figure 3 compares the impact of the local shock on income among individuals who were married or unmarried at the time of the oil discovery. Our measure of marital status prior to the oil discovery abstracts from later marriages that followed the economic boom and hence were potentially endogenous, but note that the vast majority of men and women who were unmarried in 1969 eventually became married by 1980 (67% and 71% respectively). Bearing this in mind, both married and unmarried men benefited from the economic shock in terms of income, and the effects are virtually identical among the two groups (panel A). For women, however, marital status prior to the discovery of oil matters for the magnitude of the income losses experienced. While the effects 10 years after the oil discovery are similar, women who

were married prior to the discovery of oil experienced earnings losses double in size, 4–9 years after the discovery of oil, relative to women who were still unmarried in 1969.[18] Overall, these results conditional on initial marital status suggest that married women had less flexibility in making labour supply changes within the household and that these within-household adjustments could be an important channel for the observed differences in labour market outcomes: while all men earned more, women who were already married pre-discovery, on average, are the subgroup of women who lost the most annual income.

Figure 4 re-estimates equation (1) for the sample of stable couples using both the log of individual income and the log of household income. Household income is measured as the sum of individual income and spousal income, and is calculated also usign individuals born outside the birth years of the main sample.[19] For men in Panel A, household income and individual income follow the same pattern over time. However, the estimated effect of the oil discovery on household income is slightly smaller and is significant for a shorter time, such that from 7 years after the discovery of oil household income is not significantly different from zero at the 5% level. This suggests that, relative to low oil areas, wives of men in high oil regions tended to earn less than wives of men in low oil regions by 1980.

Panel B presents the same comparison for women. As seen previously, individual income declines strongly for stably married women in high oil regions and is significantly lower 10 years after the discovery of oil relative to stably married women in low oil areas. A different picture emerges for household income. Women in high oil regions have higher levels of household income compared to women in low oil regions from 5 years after the discovery of oil, and 10 years after discovery household income is 3.5% higher. While women's own income declines, the household as a whole is better off after the discovery of oil.

[18] Unmarried women earned approximately the same amount as married women in 1969.

[19] As men in the sample tend to marry younger women and women in the sample tend to marry older men, we match an individual to their spouse's income irrespective of whether the spouse is born between 1940–1949.

However, given the significant declines in individual income and significant increases in household income, on average, women's economic standing in the household declines. Figure 5 graphs men and women's standing in the household, measured by the fraction of own income in total household income, following the local shock. While young men' share of household income 10 years after the oil discovery is not significantly different from zero, young women's contribution to household income in high oil is 6% lower relative to the average fraction in 1969, an effect which is significant at the 5% level.

Our results suggest that intra-household adjustments following the discovery of oil are an important component behind the observed income declines among women. Declines in own income are larger among married women, for whom household income increases. However, such an increase comes at the expense of within-household income equality. Given the established link between gender equality and declining domestic violence (Aizer, 2010), it is unclear whether household welfare increases. While household income increases among women, relative earnings of women also decline within the household.

4.3.2 Labour supply in the short run

Next, we unpack the results on annual income by looking at changes in the labour supply. We first consider changes in labour force participation, followed by changes in full-time employment. We supplement the annual Registry data with self-reported Census data from the two waves of 1970 and 1980 as described in Section 3.1.2. As before, we focus on young individuals born between 1940-1949 who were already of working age at the time of the oil discovery. We use a difference-in-differences framework to estimate the effect of the oil discovery on labour market outcomes by gender:

$$Y_{icbt} = \beta_0 + \beta_1 Oil_c + \beta_2 Post_t + \beta_3 Oil_c \times Post_t + \psi_c + \tau_b + \gamma_t + u_{icbt} \quad (2)$$

where Oil_c is the oil exposure measure developed in equation (1) and $Post_t$ is an indicator =1 in the year 1980.[20] β_3 is the coefficient of interest, interacting the oil exposure with the post-discovery variable. Y_{icbt} corresponds to different labour market outcomes that allow us to examine different mechanisms. We examine both the extensive margin response, testing whether labour force participation changed, as well as intensive margin response, testing for any change in full-time employment following the discovery of oil.[21]

Labour market participation

First, we focus on the extensive margin of labour supply adjustment. The main outcome variable is an indicator equal to one whenever an individual is not employed, either because he is outside of the labour force (inactive) or unemployed. Table 2 presents the results for male and female workers in odd and even columns respectively. Columns (1) and (2) present results for the sample of workers as defined in Section 3.3 who have strong attachment to the labour force prior to the oil discovery. Columns (3) and (4) present results for those with weak attachment to the labour force, those who were excluded from the sample in Section 3.3.[22]

The first column of Table 2 reveals that, following the oil discovery, men were less likely to leave the labour force in high oil regions compared to those in low oil regions. Relative to the average rate of non-employment in 1970, this represents a 25% decrease in labour force departure. Conversely, women in high oil regions were more likely to leave the labour force following the oil discovery relative to women in regions of low oil: non-employment increases

[20] In the census data, we take 1970 as the pre-period: since the discovery of the first giant oil field was at the very end of 1969, and production did not start until 1971, we can take 1970 census responses regarding labour outcomes as 'untreated' even in the high oil regions.

[21] In terms of earnings, taking Y_{icbt} as a measure of annual income, the Census data confirms what we we found with the Registry annual data. Table S3 in Appendix F shows that men from the high oil regions gained around 12,000 NOK relative to men in the low oil areas by 1980, while women earned around 6,000 NOK less in 1980 compared to women in low oil areas.

[22] We define strong attachment to the labour force before the economic boom as having positive earnings in all years 1967–1969, as in our baseline results of section 4.2, while weak attachment is having zero earnings in at least one year from 1967–1969.

by 29%. Similar patterns are observed for the sample of those who had weak attachment to the labour force from 1967–1969 (columns 3 and 4), and though the magnitude of the impact is smaller, it suggests that the local boom also drew some men into the labour force (12% compared to their pre-boom average) and discouraged some women from entering the labour market (20%).

Full-time employment

Next, we examine whether there was labour supply adjustments on the intensive margin, conditioning on the sample of workers who were employed (of any hours). Annual hours in the Census data are classified according to four bins of annual hours worked: 1300 hours or more, 1000–1299, 500–999, and 100–499. We define a dummy for full-time employment equal to one for any amount of work entailing 1300 hours per year or more, corresponding to the highest of hours worked bins. Full-time employment may increase due to an increase in hours worked, namely a transition from part-time to full-time employment, or due to an increase in labour force participation, from not-employed to full-time.

Table 3 shows there is little intensive margin response among men who were strongly attached to the labour force as full-time employment did not increase following the discovery of oil. However, men who already worked above our threshold of 1300 hours may work more hours, and we cannot rule out some degree of intensive margin adjustment.

In contrast to men, women's probability of working full-time decreases significantly following the discovery of oil (by 6% relative to the mean in 1970). Such effects are even larger among women who were weakly attached to the labour force from 1967–1969: full-time employment declines by 11% among women in high oil. Not only did the local boom lead to small decreases in full-time employment among women already working, but it also substan-

tially discouraged women in high oil from joining the labour force in full-time employment.[23]

4.3.3 Occupational dynamics

Changes in the labour supply already explain part of the income trends identified: fewer women in oil regions worked full-time and were more likely to leave the labour force while men were less likely to leave the labour force. In addition, the discovery of oil may spur new job creation in specific types of work. We examine which occupations grow, which occupations contract, and whether changes in occupations among both men and women are concentrated among high or low paying occupations. Doing so informs the importance of changes in specific types of work in the strong gender differences in income among high oil workers.

Figure 6 plots the change in employment share between 1970 and 1980 by sector, gender, and exposure to oil. We only show the sectors with the largest changes in employment shares over this period. The sectors are ranked by the average income earned (from lowest to highest earning occupations). While there exists some overlap in the occupations which grow and contract from 1970–1980, the set of occupations reported in Figure 6 tends to differ by gender. For instance, while women see changes in nursing and housekeeping, men tend to see changes in engineering and manufacturing occupations such as furnace, workshop, and cement workers.

Among men, Panel A shows that the share of workers employed in most low-paying jobs (such as agriculture and fishing) declined relatively more in high oil, while the share in more high-paying occupations (such as industrial and services jobs) increased in 1980 compared to 1970. Clearly, men reaped the labour market benefits of the oil discovery: the increase in employment share was particularly stark in oil-related occupations in high oil relative to low oil markets, namely into engineering and technical jobs (the 21^{st} highest-paying job for men in

[23]Results in Appendix F.2 suggest that employment just less than full-time (1000–1299 hours annually) also decreased among women already working while employment with minimal hours worked (100–499 annually) increased.

1980) or oil production jobs (the 9^{th} highest-paying job). This shift in the male labour force out of low-paying agricultural jobs towards high-paying oil-related occupations, especially among men in high oil regions, is one factor behind the boost in male earnings established earlier.

A different picture emerges for women. Panel B shows that between 1970 and 1980, women in high oil LLMs moved out of some of the low-paying, agricultural activities, such as farm-helpers, but the majority of women did not move into the oil sector or other high-paying jobs. Instead, women moved into services and worked as housekeepers (the 264^{th} lowest-paying job among women in 1980), nurses (the 140^{th} lowest-paying job), and secretaries (the 74^{th} lowest-paying job). Overall, most women were not directly absorbed into the new, high-paying jobs created by the oil industry nor were occupational dynamics among women conducive to income gains.

4.3.4 Other mechanisms - children and education

Two other mechanisms could be relevant. First, given the fall in female earnings and the within-household reallocation of income shown in section 4.3.1, it is possible that families were making different fertility choices following the oil windfall. A plausible response to the positive income shock could have been to have more children. Appendix G shows that this was indeed the case, and both women and man had higher chances of having a child and a higher number of children. However, the magnitude of the effect is quite small. Combined with the substantial within-household reallocation observed in Section 4.3.1, even the small observed changes in fertility are consistent with the fact that women shift to household production following the discovery of oil.

Secondly, we consider possible adjustments in education and training: the drop in income for young women could be driven by the choice to substitute work for further education, since

the job opportunities for them were not so favourable immediately after the oil boom. Appendix H.3 shows that only men seem to invest more in schooling (although we find an impact of the oil shock on the years of education of small magnitude), while women do not significantly modify their educational attainments.

5 Long run impacts: young women catching up

Individuals who were too young to enter the labour force in 1969 had more flexibility in terms of job choice, education, and family formation decisions than their older peers. As a result, the labour market response of those exposed to the economic boom at younger ages may differ from those exposed when already older. Thus, we examine the lifetime income of those who were exposed to the oil shock as children at different ages. To do so, we extend the sample for our analysis to include individuals who were born between 1949 and 1966 and were aged four to 21 in 1970. We set as the reference group individuals aged 19–21 at the time of the oil discovery.

For the second generation of workers who joined the labour force after the first oil discovery, we use lifetime income as the main labour outcome of interest. This variable has two advantages compared to annual income when looking at long run impacts: first of all, the majority of our new sample is now composed of children who were still in school and bound by compulsory schooling laws at the time of the shock. They all entered the labour market later and at different times, depending on their cohort. Thus, it is more relevant to consider their overall earnings rather than the income of a specific year. Secondly, lifetime income is free from any potential life-cycle biases which might result from differences across the treated and control regions due to the oil shock. Women and men in high oil labour markets, for example, may enter employment at younger ages than those in low oil areas. Therefore, a relative gain

in income a few years following the oil discovery in high oil regions may reflect this differential life-cycle decision and not necessarily overall income gains. Following Haider and Solon (2006), we define lifetime income as the sum of an individual's income in the prime years of the average career path, namely between ages 30 to 45.

Figure 7 plots the lifetime income of nine cohorts, distinguishing between those residing in high and low oil LLMs prior to 1969. Panel A illustrates the evolution of the lifetime income gap between men in high versus low oil LLMs. The gap is the largest among men exposed to the oil shock at 16-18, compared to their older peers. However, after the 16-18 age bin, the gap in lifetime income between men in high and low oil LLMs is virtually identical for all younger cohorts.

For women, the dynamics are different. Panel B shows that women in high oil LLMs generally earned less than women in low oil LLMs. For cohorts who were younger at the time of the local boom, however, the gap in lifetime income between low and high oil LLMs closes. For those girls who were exposed to the oil shock when they were between four and six, we can see that the lifetime earnings gap between low and high oil LLMs vanished. This pattern suggests that while young working women in high oil regions had an income loss from the oil shock, women in younger cohorts possibly had the time and opportunity to adapt to the changing economic conditions and avoid the adverse labour market outcomes associated with the economic shock among older women.

Formally, we estimate the impacts of the oil discovery on lifetime income as follows:

$$LY_{icab} = \sum_{a=[4\text{-}6]}^{[19\text{-}21]} (Oil_c \times P_{ia})\alpha_a + \psi_c + \tau_b + u_{icb} \tag{3}$$

where LY_{icab} denotes the lifetime income of individual i in LLM c of age group a at the time of the oil shock in birth cohort b measured at the time of the oil shock, which includes birth

cohorts from 1949 to 1966. Oil_c is an indicator variable denoting whether an individual initially resided in a high oil local labour market. P_{ia} denotes the age bin of individual i in 1970, where $a = 4\text{-}6, 7\text{-}9, \ldots, 19\text{-}21$. The omitted reference group consists of individuals aged 19-21 in 1970. α_a represents the vector of coefficients of the interactions between age in 1970 and the oil or non-oil local labour market for each age group. ψ_c denotes the time-invariant differences across LLMs; τ_b represents differences across birth cohorts. Standard errors are clustered at the initial local labour market level. Table 4 shows the coefficients of the interactions for men and women in high oil (columns 1 and 2 respectively). The coefficient α_a represents the difference in lifetime income between individuals of age group a in high oil versus low oil compared to the difference in lifetime income between individuals aged 19-21 in high oil relative to those in low oil areas.

Table 4 presents the results of estimating equation (3), suggesting that age at the time of the oil discovery matters more for women than for men. With the exception of the 13-15 group where differences are significant at 10%, the impact of the local boom for younger men is not statistically different from the impact for those aged 19-21. This confirms what we saw graphically in Figure 7, namely that most boys experienced a constant earnings gain, independent of their birth cohort. For women, instead, the estimated coefficients are positive and large in magnitude. The differences in lifetime income observed in Figure 7 between young women in high/low oil regions and older women in high/low oil regions are significant. In particular, lifetime income in high oil relative to low oil regions for women aged 13-18 in 1969 increased by 4% relative to the 19–21 years old group, and for the 4-12 age group by 6–7%. While women attached to the labour force at the time of oil discovery tend to lose out, over time, younger women in high oil areas close the gap in lifetime income with their low oil counterparts.

As with the sample of workers already attached to the labour force at the time of the discov-

ery of oil, we examine potential mechanisms behind the earnings catch up of younger women in high oil areas in Appendix H. While early life conditions have lifelong implications (see, for instance, Cunha and Heckman, 2007), it is challenging to isolate the importance of any one specific factor to explain the change in earning patterns for women in high oil regions following the economic boom experienced in childhood. As such, results examining the importance of specific mechanisms in the long run are suggestive in nature. With this in mind, Figure S9 suggests an important role of increasing full-time employment across cohorts among women—such increases mirror the observed catch up in earnings—while migration and changing education decisions seem to not be particularly important. While the precise reasons behind the catch up of high-oil women in the long run are only suggestive, we establish that the loss experienced by women during the local economic boom is not long-lived and does not persist for the following generations of workers.

6 Conclusion

In most economies around the world, the earnings and labour supply of men and women differ systematically. However, it is difficult to identify the precise reasons why this is still the case despite years of policy initiatives to tackle gender inequality in the labour market. This paper exploits the discovery of oil and gas in Norway at the end of 1969 and the rich statistical data available for individuals and households at that time to uncover some of the causes for this differential. Our analysis shows that, on average, men residing in regions most exposed to oil immediately benefited in terms of income and employment, while working women dropped out of full-time employment and earned significantly less in the years following the boom. Furthermore, a decade after the oil discovery, a large share of men had moved into higher-paying occupations, while women did not. These aggregate effects on young working-age

women mask some interesting heterogeneity: women who were single at the time of the shock experienced smaller declines in their individual labour income compared to married women. In terms of overall household income, however, married women experienced moderate increases as their husbands' income rose.

A key novelty of our paper lies in our ability to track the dynamics of income and labour supply decisions for the same individuals over a long time horizon. Not only do we examine the effects and underlying mechanisms of the local shock on those already of working age at the time of the boom, but we also study the next generation of workers—those who were too young to be in the labour force during the first phases of the economic boom. We find that the youngest cohort of women did not suffer any lifetime income loss following the oil discovery, thus faring much better than women who were already in the workforce when the oil sector appeared. The differences in earnings dynamics between women already in the labour force at the time of the discovery and younger ones who grew up during the boom suggests that flexibility in making career-related decisions can have long-lasting effects on income. It is important to note that many factors could be affecting the observed long term outcomes: for instance, the wealth brought by the local economic boom could have catalysed socio-cultural changes that made it more acceptable for young girls to envision working full-time, even with working husbands, or for companies to demand female labour. A thorough exploration of these factors, however, is beyond the scope of the current study.

Overall, our findings indicate that the oil boom was primarily a male income shock, as women did not benefit economically from the arrival of oil and gas and its spillovers to other industries within the short to medium term. However, the losses for female workers were short-lived: in the long run, when new cohorts of women entered the labour market, the reduction in terms of earnings and labour market participation disappeared.

A number of important policy-relevant questions remain open for further analysis. For example, why did so few women switch into higher-paying jobs after the local boom like their male counterparts? What kind of constraints did women face at the time, such as household duties, childbearing and child care, and social taboos against women working in the oil sector? Lastly, what are the exact welfare consequences of this type of economic shock? We cannot evaluate in our study how changes in income translated into actual welfare experienced by these women. For example, it is possible that the intra-household reallocation of resources was welcomed by both spouses, and that the reduction in annual income reflected an optimal labour supply choice that married women made willingly. However, it is also possible that the lower earning status was forced upon these women by the new economic context, and they did not have an option other than to work less, and/or for lower wages. This distinction remains to be validated in future research.

References

Acemoglu, D., D. Autor, and D. Lyle (2004). Women, war, and wages: The effect of female labor supply on the wage structure at midcentury. *Journal of Political Economy 112*(3), 497–551.

Aizer, A. (2010, September). The gender wage gap and domestic violence. *American Economic Review 100*(4), 1847–59.

Allcott, H. and D. Keniston (2018). Dutch disease or agglomeration? The local economic effects of natural resource booms in modern America. *The Review of Economic Studies 85*(2), 695–731.

Aragón, F. M. and J. P. Rud (2013). Natural resources and local communities: Evidence from a Peruvian gold mine. *American Economic Journal: Economic Policy 5*(2), 1–25.

Aragón, F. M., J. P. Rud, and G. Toews (2018). Resource shocks, employment, and gender: Evidence from the collapse of the UK coal industry. *Labour Economics 52*, 54 – 67.

Arezki, R., V. A. Ramey, and L. Sheng (2017, 11). News shocks in open economies: Evidence from giant oil discoveries*. *The Quarterly Journal of Economics 132*(1), 103–155.

Autor, D., D. Dorn, and G. Hanson (2019). When work disappears: Manufacturing decline and the falling marriage market value of young men. *American Economic Review: Insights 1*(2), 161–78.

Autor, D., A. Kostøl, M. Mogstad, and B. Setzler (2019, July). Disability benefits, consumption insurance, and household labor supply. *American Economic Review 109*(7), 2613–54.

Bartik, A. W., J. Currie, M. Greenstone, and C. R. Knittel (2019, October). The local economic

and welfare consequences of hydraulic fracturing. *American Economic Journal: Applied Economics 11*(4), 105–55.

Bhuller, M. S. (2009). Inndeling av norge i arbeidsmarkedsregioner. Technical Report Notater 2009/24, Statistisk sentralbyrå.

Black, D., T. McKinnish, and S. Sanders (2005). The economic impact of the coal boom and bust. *Economic Journal 115*(503), 449–476.

Blundell, R., L. Pistaferri, and I. Saporta-Eksten (2016, February). Consumption inequality and family labor supply. *American Economic Review 106*(2), 387–435.

Brunstad, R. J. and J. M. Dyrstad (1997, 01). Booming sector and wage effects: An empirical analysis on Norwegian data. *Oxford Economic Papers 49*(1), 89–103.

Bütikofer, A., A. Dalla-Zuanna, and K. G. Salvanes (2018). Breaking the links: Natural resource booms and intergenerational mobility. Discussion paper no. 19/2018, NHH Dept. of Economics.

Cascio, E. U. and A. Narayan (2015). Who needs a fracking education? The educational response to low-skill biased technological change. Working Paper 21359, National Bureau of Economic Research.

Cunha, F. and J. Heckman (2007, May). The technology of skill formation. *American Economic Review 97*(2), 31–47.

Del Bono, E., A. Weber, and R. Winter-Ebmer (2012). Clash of career and family: fertility decisions after job displacement. *Journal of the European Economic Association 10*(4), 659–683.

Ekeland, A. (2017). Employment in the petroleum industry and related industries 2016 - Sysselsatte i petroleumsnæringene og relaterte næringer 2016. *Statistics Norway Rapporter 2017/27*.

Fernández, R., A. Fogli, and C. Olivetti (2004). Mothers and sons: Preference formation and female labor force dynamics. *The Quarterly Journal of Economics 119*(4), 1249–1299.

Fleming, D. A. and T. G. Measham (2015). Local economic impacts of an unconventional energy boom: The coal seam gas industry in Australia. *Australian Journal of Agricultural and Resource Economics 59*(1), 78–94.

Goldin, C. (2006, May). The quiet revolution that transformed women's employment, education, and family. *American Economic Review 96*(2), 1–21.

Goldin, C. and C. Olivetti (2013). Shocking labor supply: A reassessment of the role of World War II on women's labor supply. *American Economic Review 103*(3), 257–262.

Goux, D., E. Maurin, and B. Petrongolo (2014, January). Worktime regulations and spousal labor supply. *American Economic Review 104*(1), 252–76.

Greenstone, M., R. Hornbeck, and E. Moretti (2010). Identifying agglomeration spillovers: Evidence from winners and losers of large plant openings. *Journal of Political Economy 118*(3), 536–598.

Haider, S. and G. Solon (2006, September). Life-cycle variation in the association between current and lifetime earnings. *American Economic Review 96*(4), 1308–1320.

Halla, M., J. Schmieder, and A. Weber (2019). Job displacement, family dynamics, and spousal labor supply. *American Economic Journal: Applied Economics forthcoming*.

Horn, M. K. (2011). Giant oil and gas fields of the world. *AAPG Datapages GIS Open Files*.

Jacobsen, G. D. and D. P. Parker (2014). The economic aftermath of resource booms: Evidence from boomtowns in the American West. *The Economic Journal 126*(593), 1092–1128.

James, A. and B. Smith (2017). There will be blood: Crime rates in shale-rich U.S. counties. *Journal of Environmental Economics and Management 84*(C), 125–152.

Jaworski, T. (2014). "You're in the army now:" the impact of World War II on women's education, work, and family. *The Journal of Economic History 74*(1), 169–195.

Kavanagh, M. (2013). Abandoned oil discoveries enjoy revival. *Financial Times*.

Kearney, M. S. and R. Wilson (2018). Male earnings, marriageable men, and nonmarital fertility: Evidence from the fracking boom. *The Review of Economics and Statistics 100*(4), 678–690.

Kotsadam, A. and A. Tolonen (2016). African mining, gender, and local employment. *World Development 83*, 325 – 339.

Larsen, E. R. (2006). Escaping the resource curse and the Dutch disease? When and why Norway caught up with and forged ahead of its neighbors. *The American Journal of Economics and Sociology 65*(3), 605–640.

Lei, Y.-H. and G. Michaels (2014). Do giant oilfield discoveries fuel internal armed conflicts? *Journal of Development Economics 110*, 139 – 157. Land and Property Rights.

Løken, K. V. (2010). Family income and children's education: Using the Norwegian oil boom as a natural experiment. *Labour Economics 17*(1), 118 – 129.

Løken, K. V., M. Mogstad, and M. Wiswall (2012, April). What linear estimators miss: The effects of family income on child outcomes. *American Economic Journal: Applied Economics 4*(2), 1–35.

Lundberg, S. (1985). The added worker effect. *Journal of Labor Economics 3*(1), 11–37.

Marchand, J. (2012). Local labor market impacts of energy boom-bust-boom in Western Canada. *Journal of Urban Economics 71*(1), 165–174.

Maurer, S. E. and A. V. Potlogea (2017, September). Male-biased demand shocks and women's labor force participation: Evidence from large oil field discoveries. Working Paper Series of the Department of Economics, University of Konstanz 2017-08, Department of Economics, University of Konstanz.

Michaels, G. (2011). The long term consequences of resource-based specialisation. *Economic Journal 121*(551), 31–57.

Olivetti, C. and B. Petrongolo (2016). The evolution of gender gaps in industrialized countries. *Annual Review of Economics 8*(1), 405–434.

Sandbu, M. (2009). The Iraqi who saved Norway from oil. *Financial Times* (August 28).

Stephens, Jr., M. (2002). Worker displacement and the added worker effect. *Journal of Labor Economics 20*(3), 504–537.

Toews, G. and P.-L. Vezina (2017). Resource discoveries and FDI bonanzas; an illustration from Mozambique. OxCarre Working Papers 199, Oxford Centre for the Analysis of Resource Rich Economies, University of Oxford.

Van Den Bark, E. and O. D. Thomas (1981, 11). Ekofisk: First of the Giant Oil Fields in Western Europe. *AAPG Bulletin 65*(11), 2341–2363.

Wilson, R. (2018). Moving to economic opportunity: The migration response to the fracking boom. Technical report.

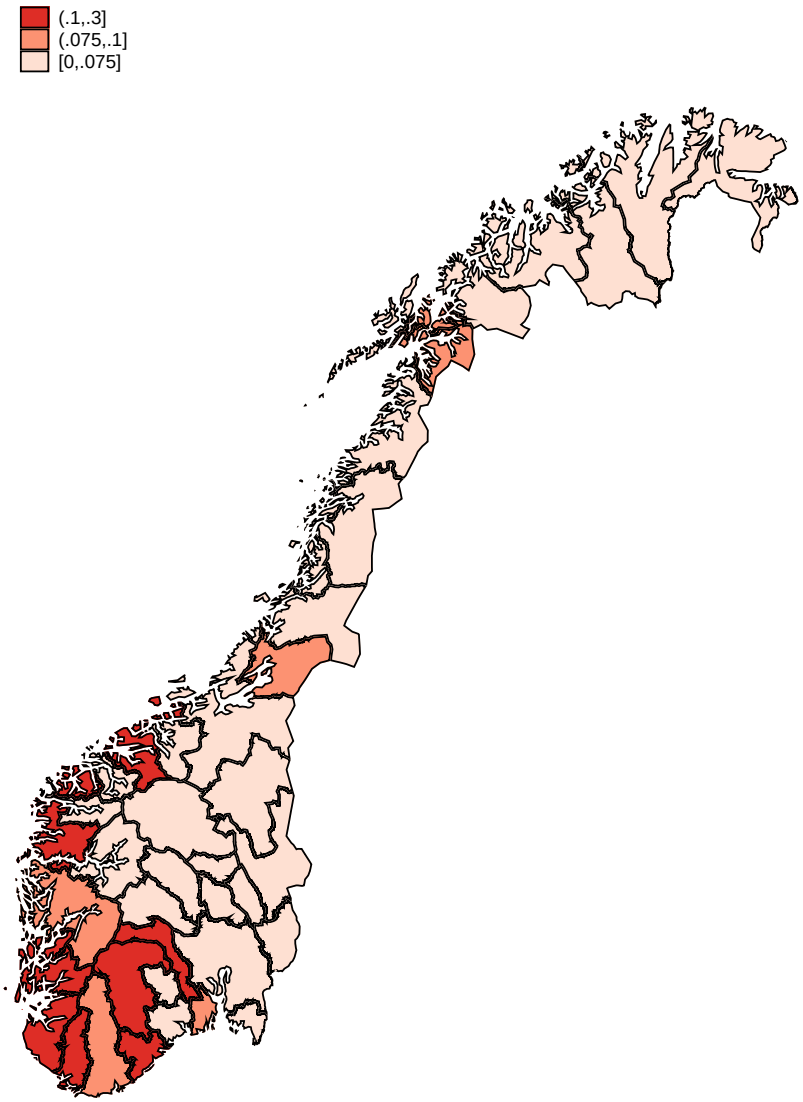
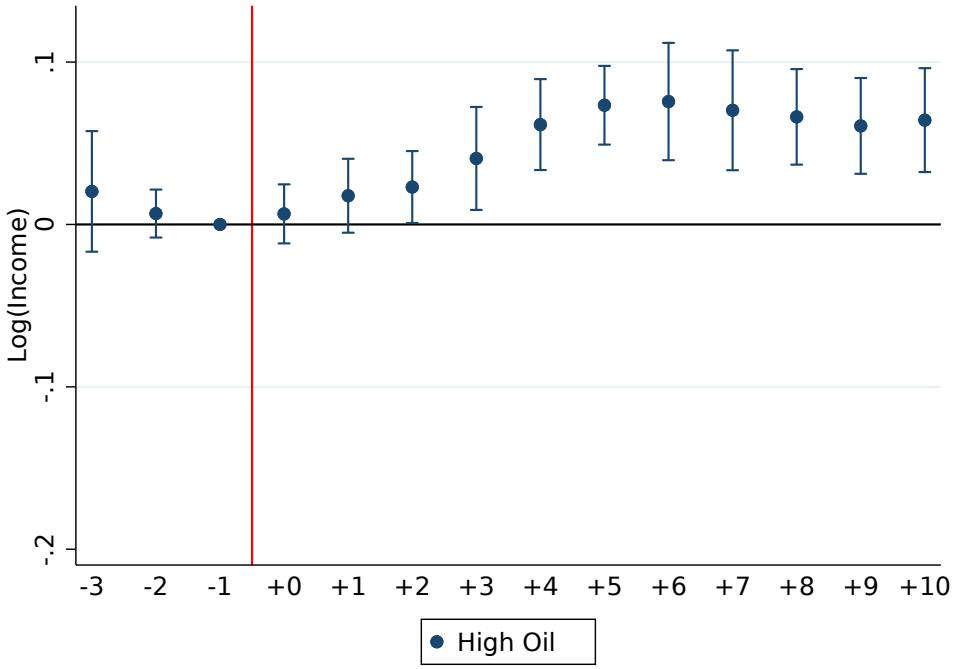


Figure 1: Geographic Distribution of the Influence of Oil Discovery. Exposure to oil is defined as the share of employment in an oil industry or secondary industry supporting oil production in each LLM. High oil (dark red): fraction of employment in oil larger than 0.1. Medium oil (orange): fraction of employment in oil between 0.075 and 0.1. Low oil (light pink): fraction of employment in oil less than 0.075.

Panel A. Men



Panel B. Women

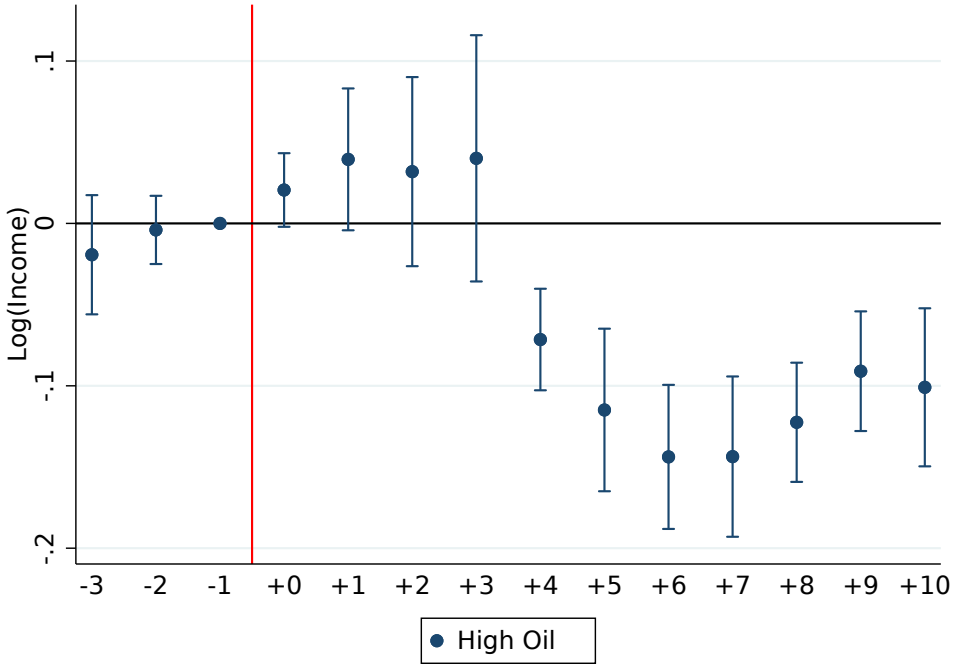
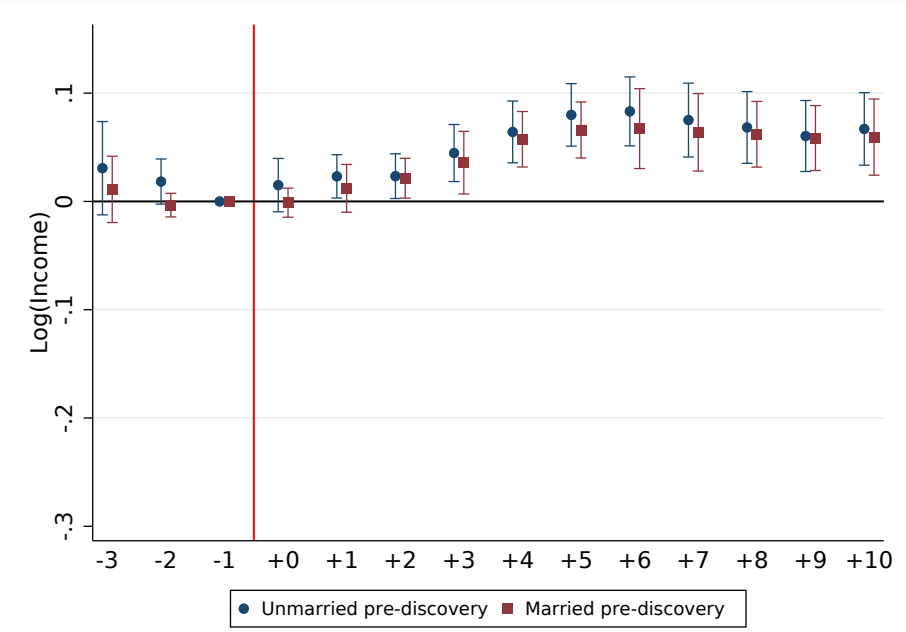


Figure 2: Estimated Effects of Oil Discovery on Log(Income) Over Time by Gender. Birth cohorts: 1940-1949. The figure plots the estimated impact of the oil discovery (δ_k) on annual log income by gender, comparing treated individuals who resided in a high oil LLM in 1965 to untreated in a low oil LLM in 1965 in equation (1) from separate regressions by gender. The red vertical line corresponds to the discovery of oil at the end of 1969. 95% confidence interval reported. Reference period -1 is normalized to zero.

Panel A. Men



Panel B. Women

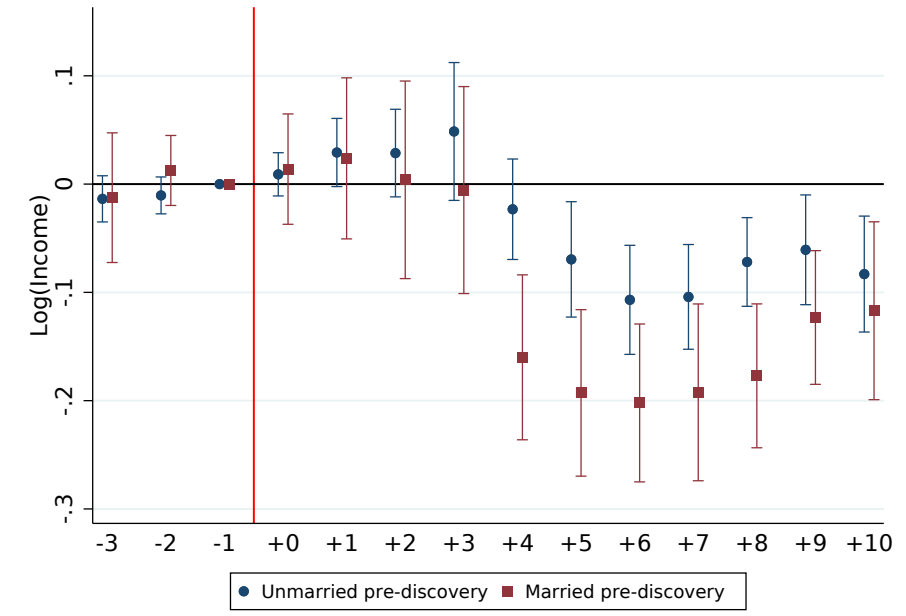
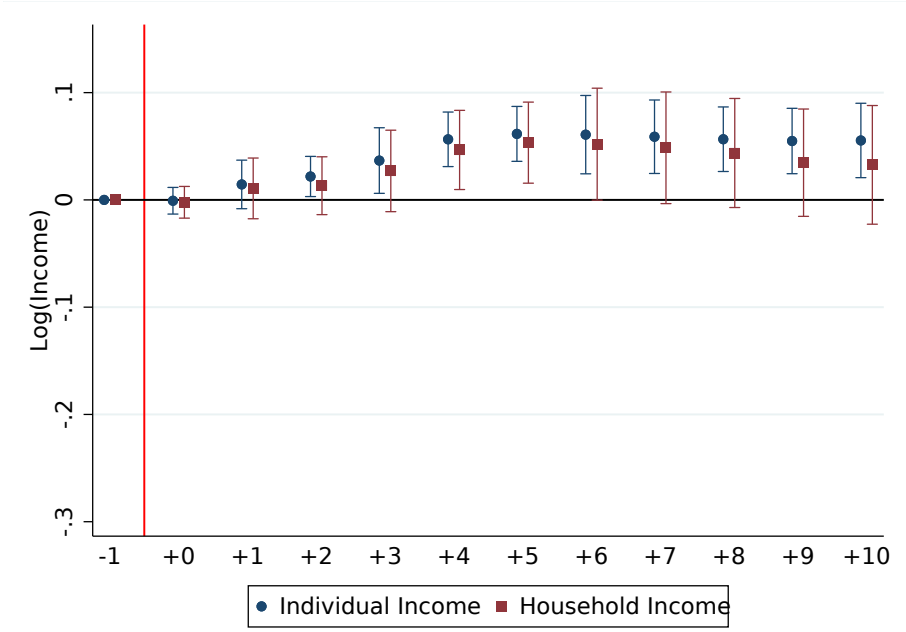


Figure 3: Estimated Effect of Oil Discovery on Log(Income) Over Time by Gender and Marital Status. Birth cohorts: 1940-1949. The figure plots the estimated impact of the oil discovery (δ_k) on annual log income by gender and initial marital status, comparing treated individuals who resided in a high oil LLM in 1965 to untreated in low oil LLM in 1965 in equation (1) from separate regressions by gender and marital status. Initial marital status is defined prior to the oil shock in 1969. The red vertical line corresponds to the discovery of oil at the end of 1969. 95% confidence interval reported. Reference period -1 is normalized to zero.

Panel A. Men



Panel B. Women

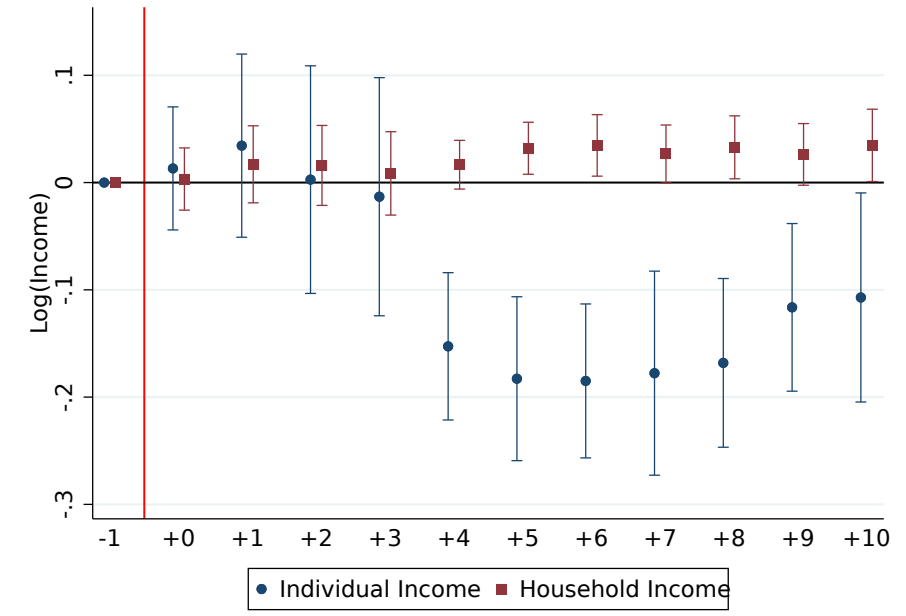


Figure 4: Estimated Effect of Oil Discovery on Individual and Household's Log(Income) Over Time by Gender. Birth cohorts: 1940-1949. The figure plots the estimated impact of the oil discovery (δ_k) on annual log income for single individuals and for their household by gender, comparing treated individuals who resided in a high oil LLM in 1965 to untreated in low oil LLM in 1965 in equation (1) from separate regressions by gender. Individual and household regressions are estimated using the same sample of stable couples defined as those who were married in 1969 (or earlier) through to 1980. Stable couples represent 38% and 35% of the sample in Figure 2 among men and women respectively. The red vertical line corresponds to the discovery of oil at the end of 1969. 95% confidence interval reported. Reference period -1 is normalized to zero.

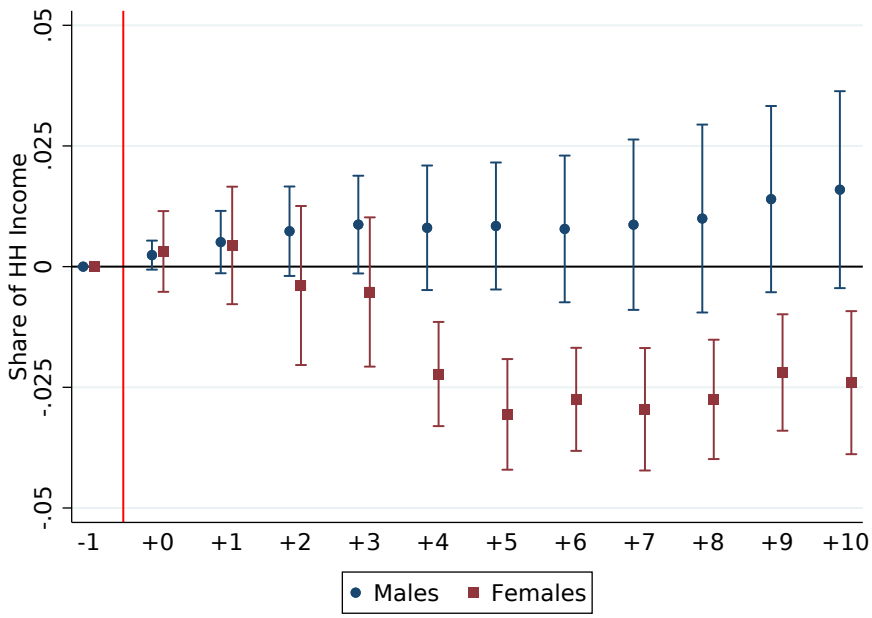
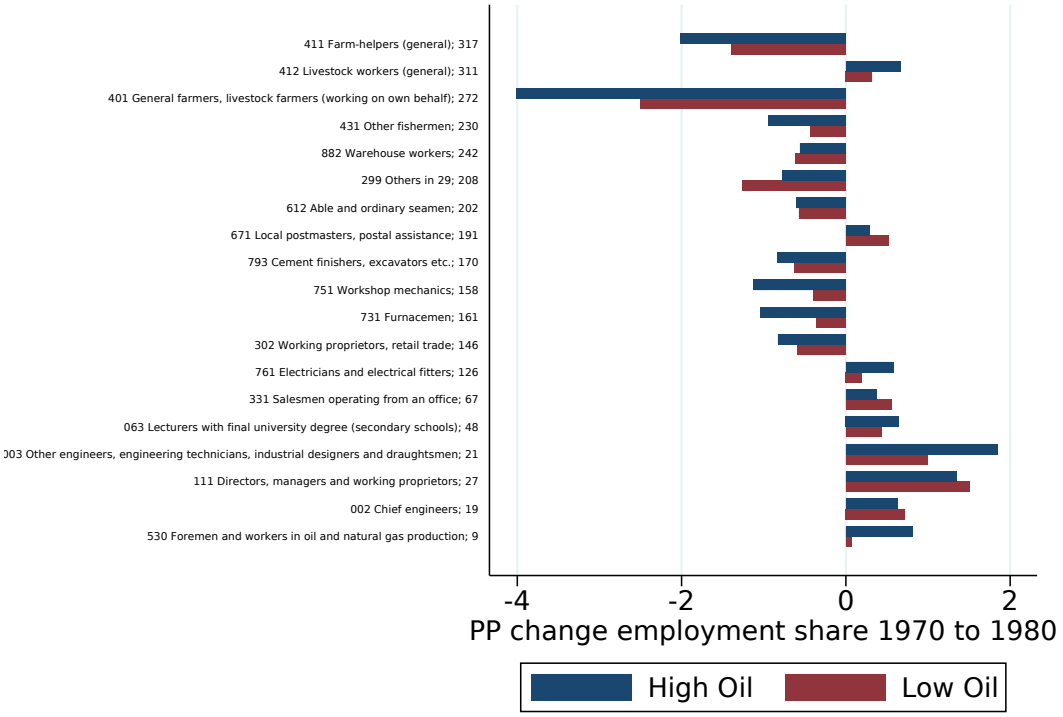


Figure 5: Estimated Effect of Oil Discovery on Individual Share of Household Log(Income) Over Time by Gender. Birth cohorts: 1940-1949. The figure plots the estimated impact of the oil discovery (δ_k) on the male and female share of their household's annual log income, comparing treated individuals who resided in a high oil LLM in 1965 to untreated in low oil LLM in 1965 in equation (1) from separate regressions by gender. Regressions are estimated using same sample of stable couples defined as those who were married in 1969 (or earlier) through to 1980. Stable couples represent 38% and 35% of the sample in Figure 2 among men and women respectively. The red vertical line corresponds to the discovery of oil at the end of 1969. 95% confidence interval reported. Reference period -1 is normalized to zero. Average share of household income in 1969 is 0.86 and 0.41 for men and women respectively.

Panel A. Men



Panel B. Women

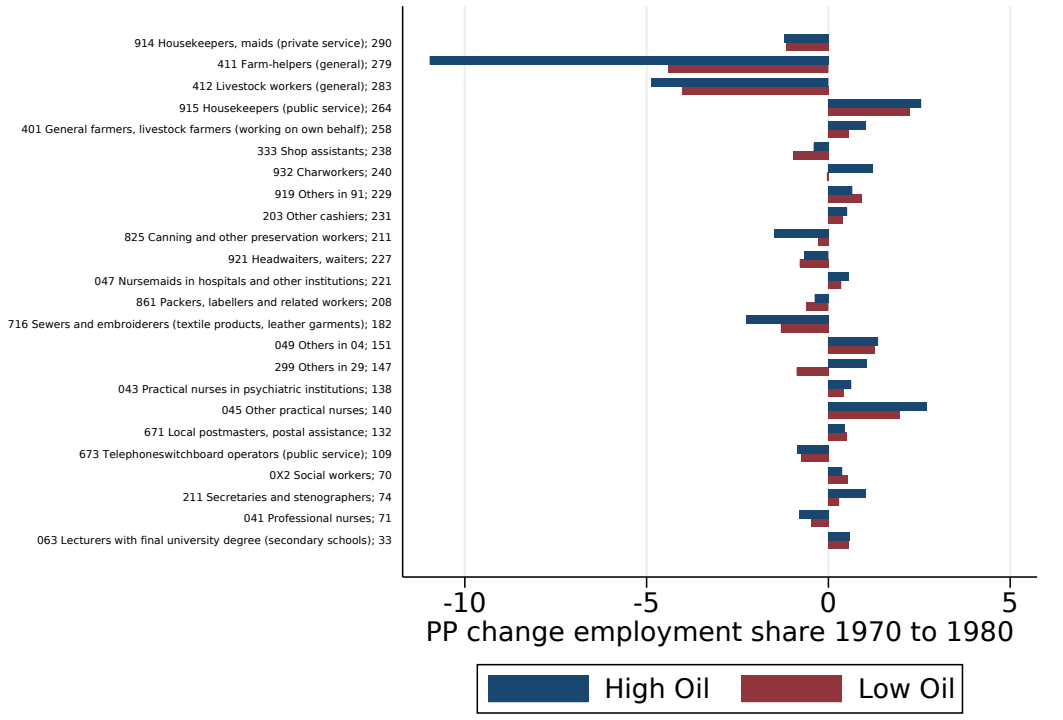
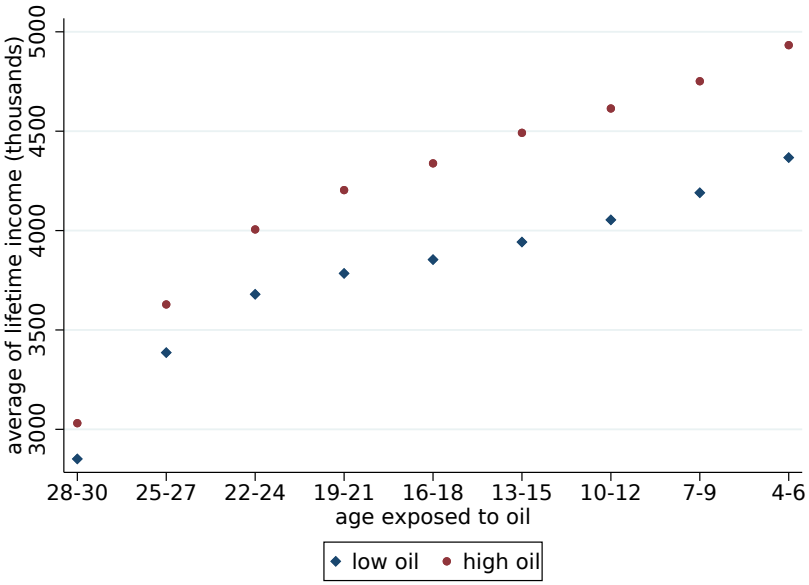
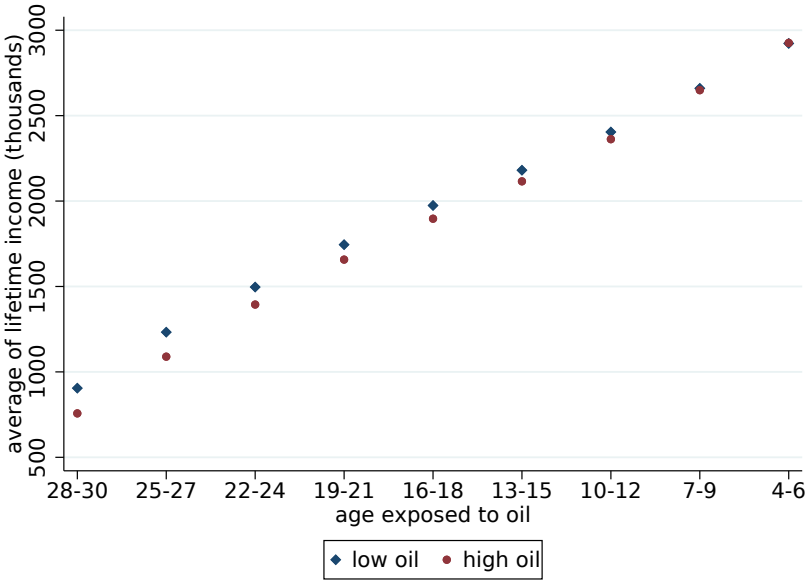


Figure 6: Change in Employment Shares between 1970 and 1980. The figure plots the percentage point changes in employment shares in high versus low oil LLM between 1970 and 1980 among occupations whose employment share increased/decreased by at least 0.5 percentage points. The number at the end of each occupation denotes the national rank of the occupation in terms of average income earned in 1980. Occupations classified according to the International Classification of Occupation (ISCO) system.



Panel A: Men



Panel B: Women

Figure 7: Lifetime Income Gap by Cohort. The figure plots the average lifetime income, measured from ages 30–45, of each age group by the age exposed to the local boom. The sample includes all individuals born between 1949-1966. High/low oil defined as residing in high/low oil LLM in 1965 (from birth for those born after 1965). Income measured in NOK, inflation adjusted to year 1998.

Table 1: Summary Statistics of Young Workers (Birth Cohorts 1940-1949) in 1969

	(1) Male	(2) Female	(3) Both Genders
Pension income (in 1998 NOK)	151,006.0 (66139.5)	105,745.2 (47373.5)	136,430.1 (64309.2)
Age	24.66 (2.730)	23.80 (2.619)	24.39 (2.725)
Living in High Oil LLM in 1965	0.167 (0.373)	0.147 (0.354)	0.160 (0.367)
Living in Medium Oil LLM in 1965	0.188 (0.391)	0.186 (0.389)	0.187 (0.390)
Living in Low Oil LLM in 1965	0.645 (0.478)	0.668 (0.471)	0.652 (0.476)
Married	0.611 (0.488)	0.603 (0.489)	0.608 (0.488)
Observations	182,570	86,724	269,294

Notes: Table reports means and standard deviations of demographic characteristics for men and women with positive income in the three years before the oil discovery as described in Section 3.3.

Table 2: Census Results - Not Employed

Sample:	Strong Attached 67–69		Weak Attached 67–69	
	(1) Not Emp. Male	(2) Not Emp. Female	(3) Not Emp. Male	(4) Not Emp. Female
Oil LLM=1	0.004***	-0.028***	0.001	-0.015**
	(0.001)	(0.007)	(0.007)	(0.006)
Post=1	0.014***	0.112***	-0.139***	-0.367***
	(0.001)	(0.005)	(0.009)	(0.003)
Oil LLM=1 $\times$ Post=1	-0.006***	0.050***	-0.025*	0.029**
	(0.002)	(0.013)	(0.013)	(0.013)
Initial LLM FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Observations	310938	149304	134306	270732
R^2	0.003	0.034	0.047	0.142
Mean Dep. Variable 1970	0.024	0.170	0.209	0.659

Notes: Table reports the difference-in-differences estimates of equation (2) separately by gender using a sample that includes birth cohorts between 1940-1949 (aged 21-30 in 1970). Dependent variable is a dummy variable indicating non-employment, defined as either outside the labour force or unemployed. Treatment is high exposure to oil based on 1965 residence. 'Strong attached' to LF defined as having positive earnings in all years 1967–1969, while 'weak attached' is having zero earnings in at least one year from 1967–1969. Standard errors clustered at the initial local labour market level are reported in parentheses. $^{***}\rho < 0.01$, $^{**}\rho < 0.05$, $^{*}\rho < 0.10$.

Table 3: Census Results - Full-Time Employment

Sample:	Strong Attached 67–69		Weak Attached 67–69	
	(1) Full Time Male	(2) Full Time Female	(3) Full Time Male	(4) Full Time Female
Oil LLM=1	-0.029***	0.011**	-0.024**	0.041**
	(0.005)	(0.005)	(0.010)	(0.017)
Post=1	0.063***	-0.275***	0.304***	-0.031**
	(0.006)	(0.009)	(0.018)	(0.013)
Oil LLM=1 $\times$ Post=1	0.006	-0.045***	0.001	-0.050*
	(0.010)	(0.013)	(0.019)	(0.025)
Initial LLM FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Observations	293879	112497	113303	136652
R^2	0.029	0.085	0.136	0.014
Mean Dep. Variable 1970	0.852	0.733	0.591	0.422

Notes: Table reports the difference-in-differences estimates of equation (2) separately by gender using a sample that includes birth cohorts between 1940-1949 (aged 21-30 in 1970). Dependent variable is a dummy variable indicating full-time employment, defined as being employed 1300 hours or more annually. Sample is restricted to those with any employment in 1970 and 1980. Treatment is high exposure to oil based on 1965 residence. 'Strong attached' to LF defined as having positive earnings in all years 1967–1969, while 'weak attached' is having zero earnings in at least one year from 1967–1969. Standard errors clustered at the initial local labour market level are reported in parentheses. ***$\rho < 0.01$, **$\rho < 0.05$, *$\rho < 0.10$.

Table 4: Impact of Oil Shock on Log(Lifetime Income) by Age in 1970

Sample:	Male	Female
	(1) Log(Lifetime Income) High Oil	(2) Log(Lifetime Income) High Oil
19-21	ref.	ref.
16-18	-0.008	0.215***
	(0.007)	(0.011)
13-15	0.015**	0.328***
	(0.005)	(0.016)
10-12	0.053***	0.444***
	(0.006)	(0.022)
7-9	0.135***	0.578***
	(0.013)	(0.017)
4-6	0.133***	0.625***
	(0.014)	(0.024)
Oil $\times$ 16-18	0.012	0.043**
	(0.008)	(0.017)
Oil $\times$ 13-15	0.024*	0.042**
	(0.012)	(0.017)
Oil $\times$ 10-12	0.012	0.060**
	(0.018)	(0.025)
Oil $\times$ 7-9	0.004	0.066**
	(0.020)	(0.028)
Oil $\times$ 4-6	0.020	0.072***
	(0.027)	(0.025)
Initial LLM FE	Yes	Yes
Cohort FE	Yes	Yes
Observations	430140	407651
R^2	0.014	0.045

Notes: Table reports the difference-in-differences estimates of equation (3) using a sample that includes birth cohorts between 1949-1966 (aged 4-21 in 1970). Dependent variable is lifetime income, defined as cumulative income earned between ages 30-45. Income measured in NOK, inflation adjusted to year 1998. Reference group is those aged 19-21. Treatment is high exposure to oil based on 1965 residence. Standard errors clustered at the initial local labour market level are reported in parentheses. ***$\rho < 0.01$, **$\rho < 0.05$, *$\rho < 0.10$.

A Giant oil fields in Norway

Figure S1: Giant offshore oilfields in Norway. The map shows the geographic distribution of giant oilfield discovered in Norway in the 1970s and 1980s, all situated offshore. For each cluster of discoveries, we report the name and year of only one field. Ekofisk, located south-west of Stavanger in the North Sea, was the first of these discoveries.

B Effect of shock on income measured in levels

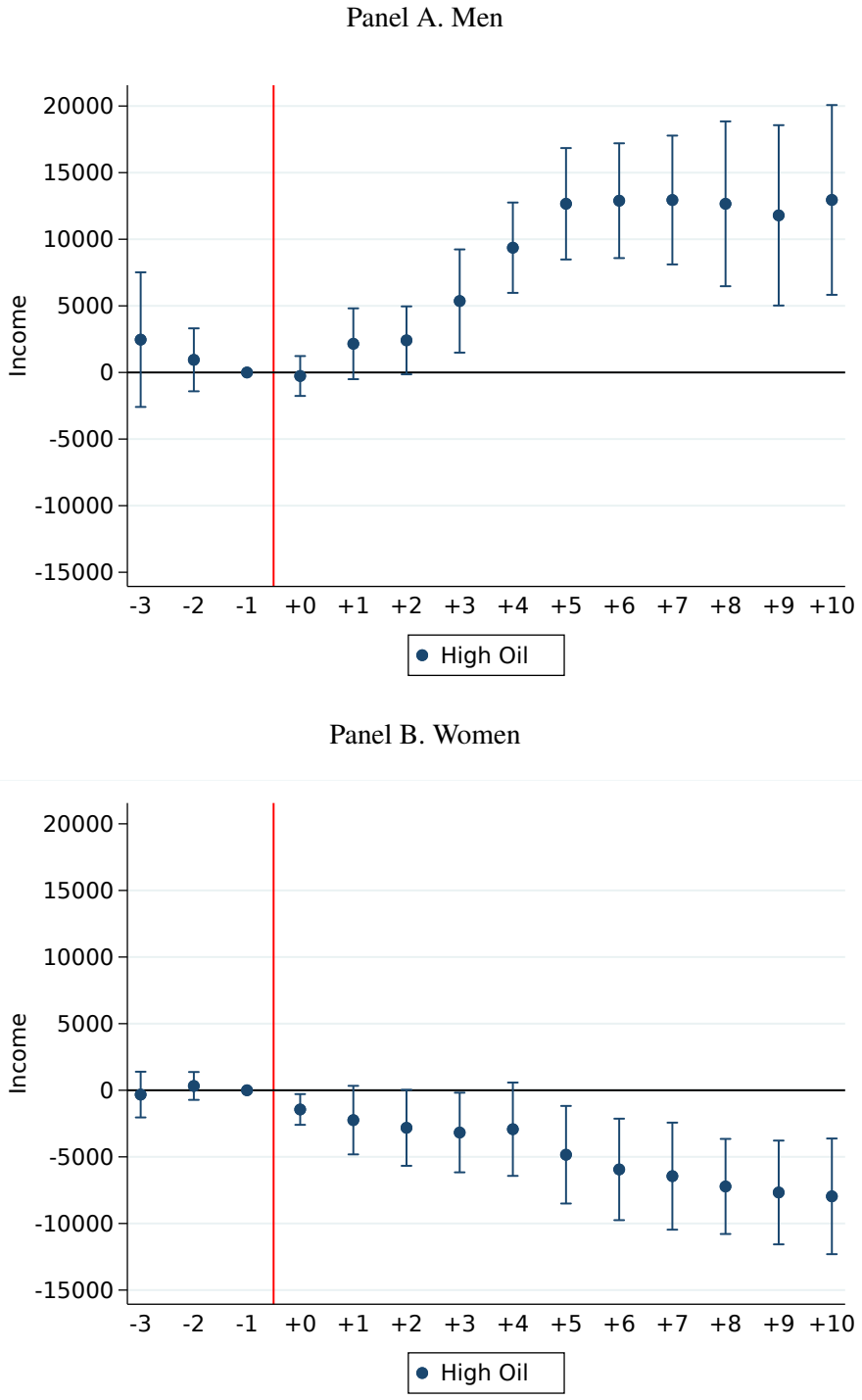


Figure S2: Estimated Effects of Oil Discovery on Income Over Time by Gender. Birth cohorts 1940-1949. The figure plots the estimated impact of the oil discovery (δ_k) on annual income by gender, comparing treated individuals who resided in a high oil LLM in 1965 to untreated in a low oil LLM in 1965 in equation (1). The red vertical line corresponds to discovery of oil at the end of 1969. 95% confidence interval reported. Reference period -1 is normalized to zero.

C Results of middle oil exposure

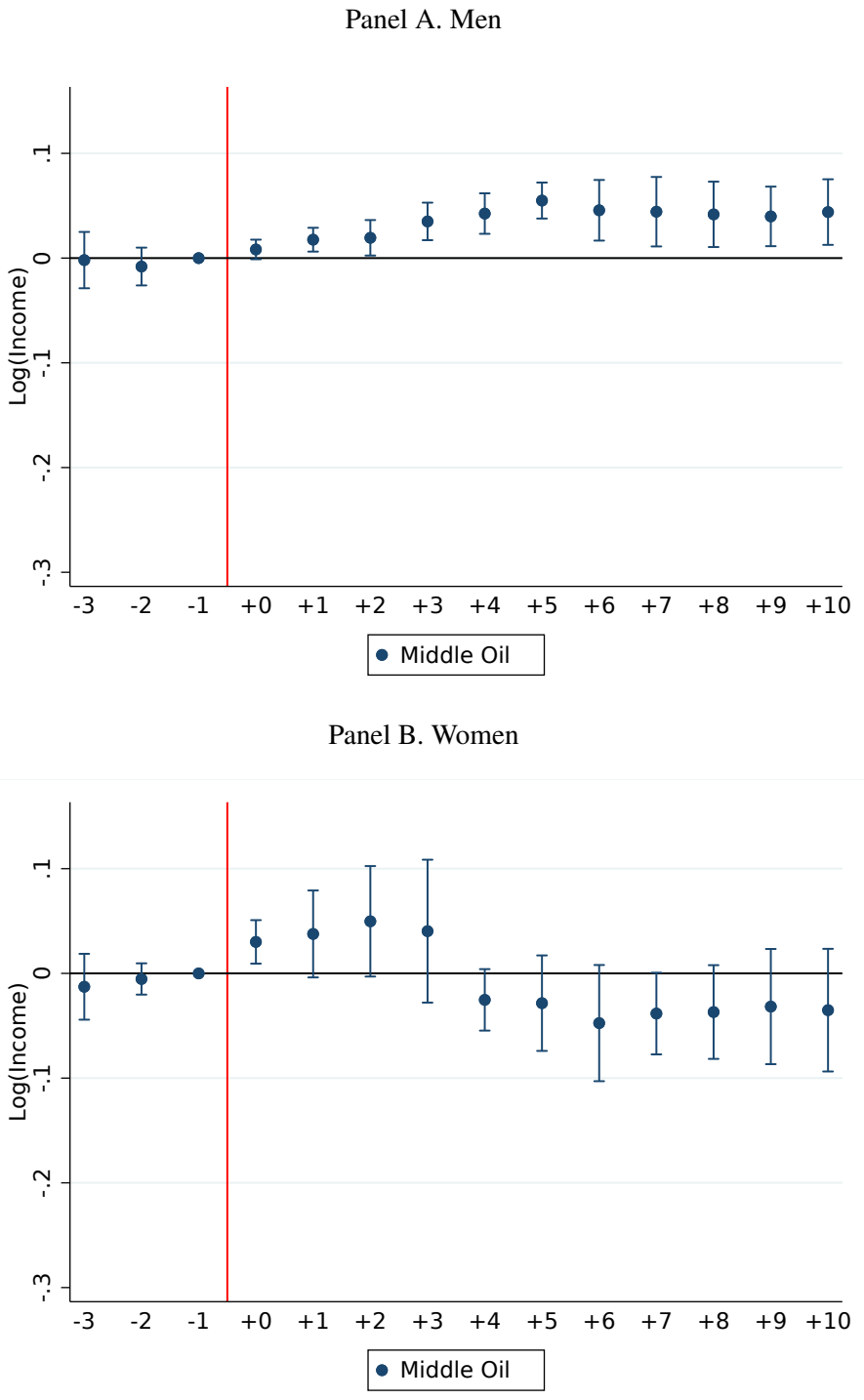


Figure S3: Estimated Effects of Oil Discovery on Log of Income Over Time. Birth cohorts 1940-1949. The figure plots the estimated impact of the oil discovery (δ_k) on annual log income by gender, comparing treated individuals who resided in a middle oil LLM in 1965 to untreated in a low oil LLM in 1965 in equation (1). Vertical line corresponds to discovery of oil at the end of 1969. 95% confidence interval reported. -1 normalized to zero.

Table S1: Census Results - Full-Time Employment

	Strong Attached 67–69		Weak Attached 67–69	
	(1) Full Time Male	(2) Full Time Female	(3) Full Time Male	(4) Full Time Female
Oil LLM=1	-0.051***	0.058***	-0.043***	0.045***
	(0.004)	(0.007)	(0.011)	(0.008)
Post=1	0.005	-0.295***	0.331***	0.111***
	(0.006)	(0.005)	(0.020)	(0.007)
Oil LLM=1 $\times$ Post=1	0.009	-0.020	0.008	-0.029*
	(0.007)	(0.014)	(0.022)	(0.015)
Initial LLM FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Observations	318926	156406	139338	279874
R^2	0.017	0.096	0.125	0.030
Mean Dep. Variable 1970	0.830	0.609	0.466	0.145

Notes: Table reports the difference-in-differences estimates of equation (2) using a sample that includes birth cohorts between 1940-1949 (aged 21-30 in 1970). Dependent variable is a dummy variable indicating full-time employment, defined as being employed 1300 hours or more annually. Treatment is middle exposure to oil based on 1965 residence. 'Strong attached' to LF defined as having positive earnings in all years 1967–1969, while 'weak attached' is having zero earnings in at least one year from 1967–1969. Standard errors clustered at the initial local labour market level are reported in parentheses. $^{***}\rho < 0.01$, $^{**}\rho < 0.05$, $^{*}\rho < 0.10$.

Table S2: Census Results - Not Employed

	Attached LF 67–69		Not Attached LF 67–69	
	(1) Not Emp. Male	(2) Not Emp. Female	(3) Not Emp. Male	(4) Not Emp. Female
Oil LLM=1	0.012***	-0.068***	0.014***	-0.043***
	(0.001)	(0.006)	(0.005)	(0.006)
Post=1	0.014***	0.112***	-0.139***	-0.367***
	(0.001)	(0.005)	(0.009)	(0.003)
Oil LLM=1 $\times$ Post=1	-0.004	0.032**	-0.004	0.017
	(0.002)	(0.013)	(0.010)	(0.012)
Initial LLM FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Observations	318926	156406	139338	279874
R^2	0.003	0.033	0.045	0.143
Mean Dep. Variable 1970	0.025	0.169	0.207	0.658

Notes: Table reports the difference-in-differences estimates of equation (2) using a sample that includes birth cohorts between 1940-1949 (aged 21-30 in 1970). Dependent variable is a dummy variable indicating inactive employment, defined as either outside the labour force or unemployed. Treatment is middle exposure to oil based on 1965 residence. Standard errors clustered at the initial local labour market level are reported in parentheses. ***$\rho < 0.01$, **$\rho < 0.05$, *$\rho < 0.10$.

D Do the effects of oil persist over time?

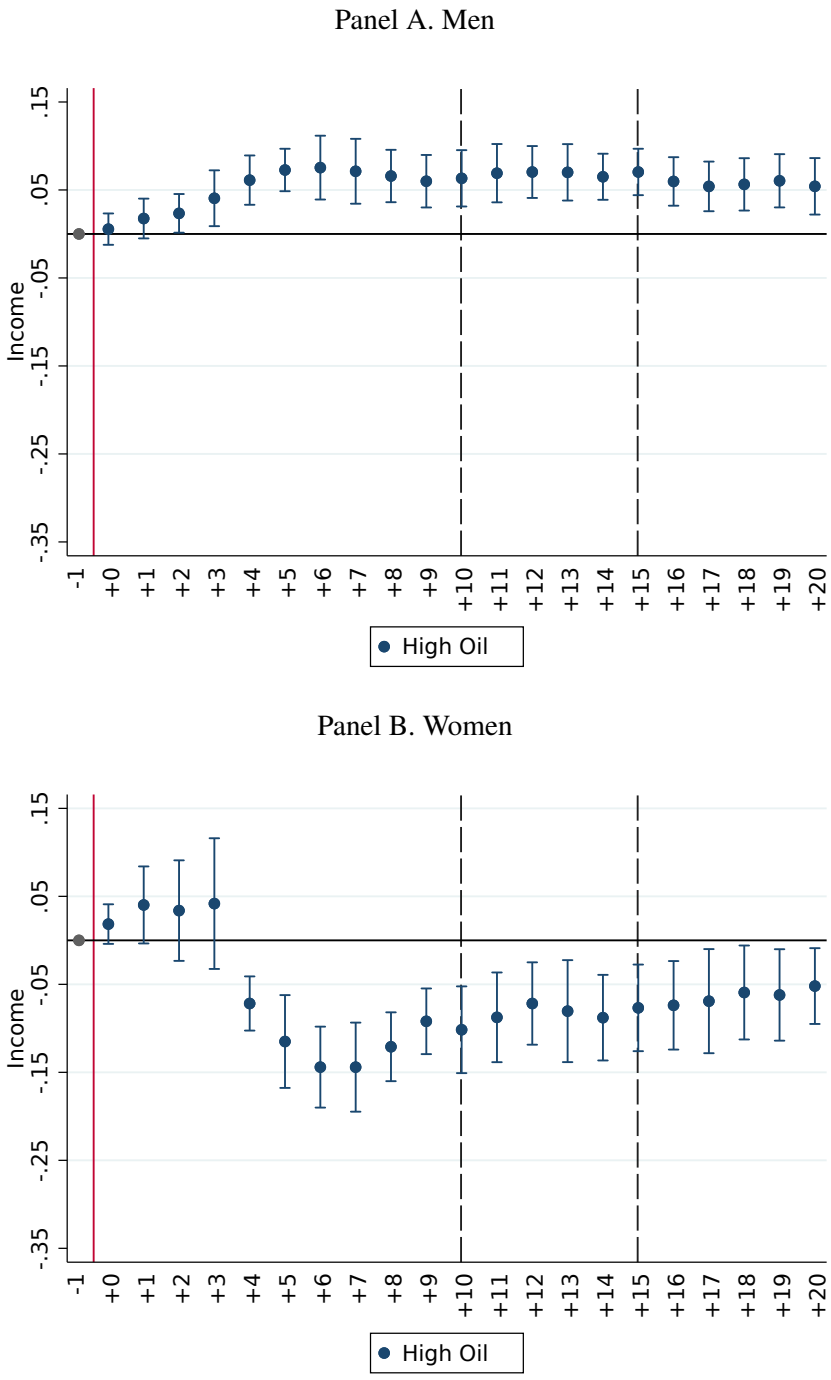


Figure S4: Estimated Effects of Oil Discovery on Log of Income Over Time. Birth cohorts 1940-1949. The figure plots the estimated impact of the oil discovery (δ_k) on annual log income by gender, comparing treated individuals who resided in a high oil LLM in 1965 to untreated in a low oil LLM in 1965 in equation (1). 95% confidence interval reported. Reference period -1 is normalized to zero. The red vertical line represents the discover of oil in 1969. The dotted vertical line at +10 corresponds to the peak of global oil price in 1980, while that at +15 corresponds to the trough of oil price in 1985.

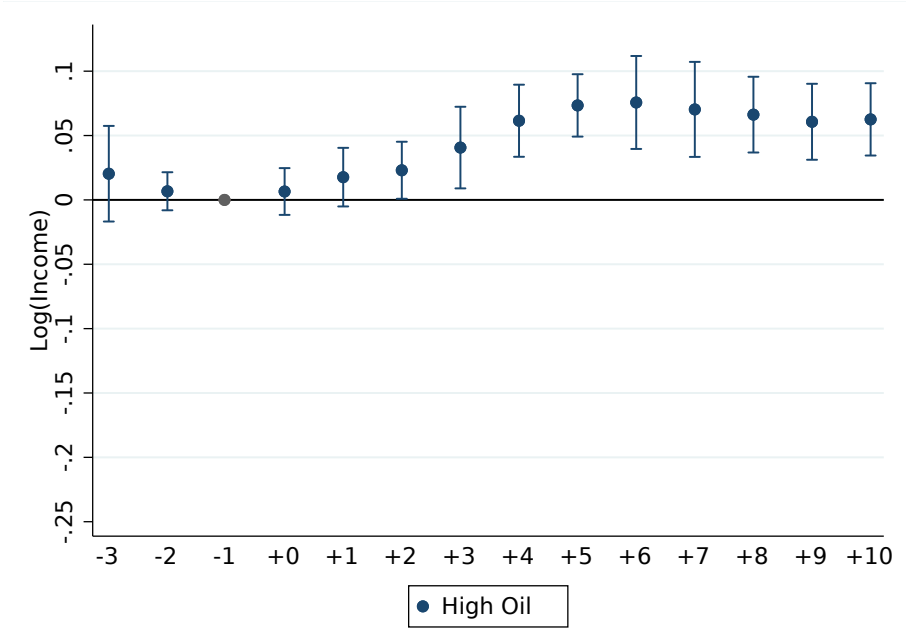
E The Importance of geographic mobility

While restricting the definition of high and low oil regions using an individual's LLM of residence *prior* to the oil discovery limits concerns of endogenous relocation, a large fraction of workers may relocate from both high and low oil LLMs. In particular, the existing literature documents substantial in-migration following an oil boom (Wilson, 2018).

The fraction of men in high and low oil LLMs who relocate is similar: 21% of those in high oil and 23% of those in low oil reside in a new LLM in 1980 compared to their LLM from 1965. Geographic mobility is relatively low over the period, and roughly similar between high and low oil LLMs. However, mobility patterns among those who do move may differ between high and low oil region movers. Among those who migrate and were initially residing in a high oil LLM, 25% relocate to another high oil LLM and 51% relocate to a low oil LLM. Among those who migrate and who were initially residing in a low oil LLM, 70% relocate to another low oil LLM and 13% relocate to a high oil LLM. As just 23% of low oil area men move to a new LLM by 1980, only 3% of those who initially resided in a low oil LLM reside in a high oil LLM in 1980. The most frequent destination among both high and low oil movers is Oslo, the financial centre of the country and a low-oil area. 23% of those who move from high oil LLMs and 25% of those who move from low oil LLMs ultimately reside in Oslo in 1980. This suggests that mobility into high oil regions among men is not a major concern.

Among women, 35% of those in high oil and 30% of those in low oil regions reside in a new LLM in 1980. Geographic mobility is higher among women relative to men, and slightly higher among women from high oil LLMs. As with men, the most frequent destination among both high and low oil movers is Oslo, where 25% of high oil movers and 27% of low oil movers ultimately settle. As with men, only 4% of those who initially resided in a low oil LLM reside in a high oil LLM in 1980, suggesting that mobility into high oil regions is not a major concern.

Panel A. Men



Panel B. Women

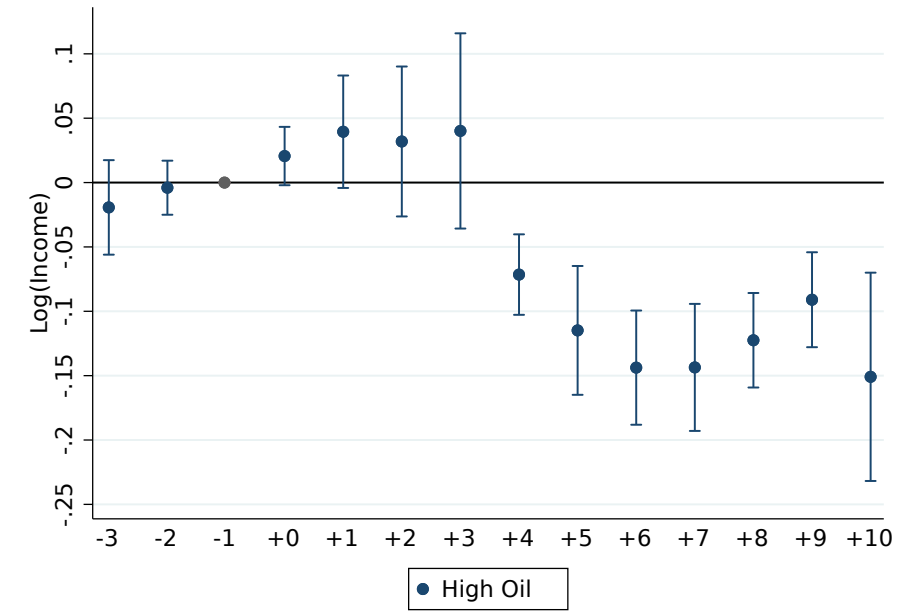


Figure S5: Estimated Effects of Oil Discovery on Income Over Time by Gender Excluding Movers. Birth cohorts 1940-1949. The figure plots the estimated impact of the oil discovery (δ_k) on annual log income by gender, comparing treated individuals who resided in a high oil LLM in 1965 to untreated in a low oil LLM in 1965 in equation (1). Excluded from the estimation sample are those who reside in a different LLM from the LLM they resided in in 1965. Vertical line corresponds to discovery of oil at the end of 1969. 95% confidence interval reported. Reference period -1 is normalized to zero.

F Additional Estimation Results - Census

F.1 Income

Table S3: Census Results - Income

	Male		Female	
	(1) Income High Oil	(2) Income Middle Oil	(3) Income High Oil	(4) Income Middle Oil
Oil LLM=1	-13721***	-17965***	239	5951***
	(2288)	(1380)	(1134)	(1037)
Post=1	102581***	102581***	40628***	40628***
	(2527)	(2531)	(841)	(843)
Oil LLM=1 × Post=1	12083**	5979**	-6274***	-4170*
	(4567)	(2892)	(2272)	(2079)
Initial LLM FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Observations	445244	458264	420036	436280
R^2	0.279	0.279	0.083	0.081

Notes: Table reports the difference-in-differences estimates of equation (2) by gender, using a sample that includes birth cohorts between 1940-1949 (aged 21-30 in 1970). Dependent variable is income measured in NOK, inflation adjusted to year 1998. Treatment is high (columns 1 and 3) or middle (columns 2 and 4) exposure to oil based on 1965 residence. Standard errors clustered at the initial local labour market level are reported in parentheses. ***$\rho < 0.01$, **$\rho < 0.05$, *$\rho < 0.10$.

F.2 Additional Hours Worked Bins

Table S4: Census Results - Employed 1000–1299 hours

Sample:	Strong Attached 67–69		Weak Attached 67–69	
	(1) 1000–1299 Hours Worked Male	(2) 1000–1299 Hours Worked Female	(3) 1000–1299 Hours Worked Male	(4) 1000–1299 Hours Worked Female
Oil LLM=1	0.020***	0.035***	0.033***	0.014***
	(0.004)	(0.002)	(0.005)	(0.003)
Post=1	-0.067***	0.008***	-0.145***	-0.008**
	(0.005)	(0.002)	(0.003)	(0.003)
Oil LLM=1 × Post=1	0.003	-0.010*	0.003	0.002
	(0.008)	(0.005)	(0.010)	(0.004)
Initial LLM FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Observations	293879	112497	113303	136652
R^2	0.031	0.001	0.063	0.002
Mean Dep. Variable 1970	0.105	0.135	0.192	0.167

Notes: Table reports the difference-in-differences estimates of equation (2) using a sample that includes birth cohorts between 1940-1949 (aged 21-30 in 1970). Dependent variable is a dummy variable indicating employment of 1000–1299 hours annually. Sample is restricted to those with any employment in 1970 and 1980. Treatment is high exposure to oil based on 1965 residence. 'Strong attached' to LF defined as having positive earnings in all years 1967–1969, while 'weak attached' is having zero earnings in at least one year from 1967–1969. Standard errors clustered at the initial local labour market level are reported in parentheses. $^{***}\rho < 0.01$, $^{**}\rho < 0.05$, $^{*}\rho < 0.10$.

Table S5: Census Results - Employed 500–999 hours

Sample:	Strong Attached 67–69		Weak Attached 67–69	
	(1) 500–999 Hours Worked Male	(2) 500–999 Hours Female	(3) 500–999 Hours Male	(4) 500–999 Hours Female
Oil LLM=1	0.004***	-0.022***	-0.009***	-0.024***
	(0.001)	(0.005)	(0.003)	(0.007)
Post=1	-0.000	0.143***	-0.063***	0.049***
	(0.001)	(0.006)	(0.005)	(0.004)
Oil LLM=1 × Post=1	-0.004***	0.015	-0.000	0.008
	(0.001)	(0.012)	(0.006)	(0.011)
Initial LLM FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Observations	293879	112497	113303	136652
R^2	0.003	0.043	0.019	0.008
Mean Dep. Variable 1970	0.025	0.079	0.097	0.203

Notes: Table reports the difference-in-differences estimates of equation (2) using a sample that includes birth cohorts between 1940-1949 (aged 21-30 in 1970). Dependent variable is a dummy variable indicating employment of 500–999 hours annually. Sample is restricted to those with any employment in 1970 and 1980. Treatment is high exposure to oil based on 1965 residence. 'Strong attached' to LF defined as having positive earnings in all years 1967–1969, while 'weak attached' is having zero earnings in at least one year from 1967–1969. Standard errors clustered at the initial local labour market level are reported in parentheses. $^{***}\rho < 0.01$, $^{**}\rho < 0.05$, $^{*}\rho < 0.10$.

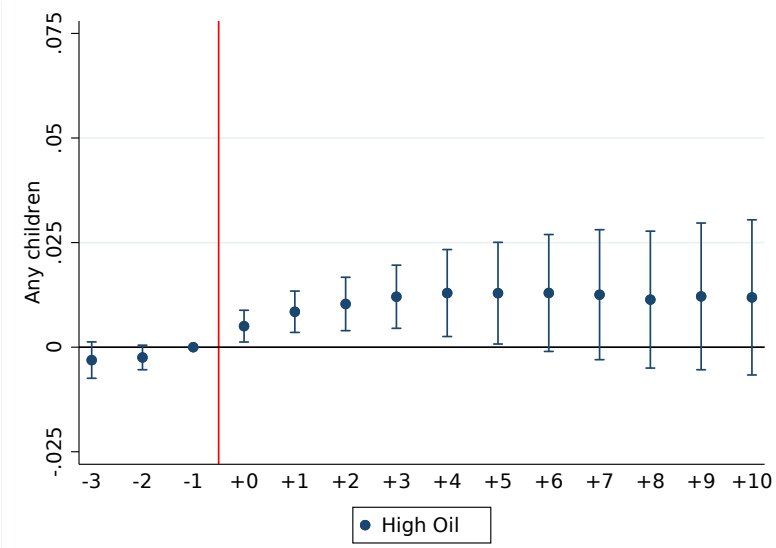
Table S6: Census Results - Employed 100–499 hours

Sample:	Strong Attached 67–69		Weak Attached 67–69	
	(1) 100–499 Hours Worked Male	(2) 100–499 Hours Worked Female	(3) 100–499 Hours Worked Male	(4) 100–499 Hours Worked Female
Oil LLM=1	0.005***	-0.024***	0.000	-0.032**
	(0.001)	(0.003)	(0.008)	(0.014)
Post=1	0.004***	0.124***	-0.095***	-0.010
	(0.001)	(0.003)	(0.012)	(0.015)
Oil LLM=1 $\times$ Post=1	-0.005***	0.040***	-0.004	0.041*
	(0.002)	(0.008)	(0.015)	(0.021)
Initial LLM FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Observations	293879	112497	113303	136652
R^2	0.002	0.047	0.039	0.002
Mean Dep. Variable 1970	0.017	0.053	0.120	0.208

Notes: Table reports the difference-in-differences estimates of equation (2) using a sample that includes birth cohorts between 1940-1949 (aged 21-30 in 1970). Dependent variable is a dummy variable indicating employment of 100–499 hours annually. Sample is restricted to those with any employment in 1970 and 1980. Treatment is high exposure to oil based on 1965 residence. 'Strong attached' to LF defined as having positive earnings in all years 1967–1969, while 'weak attached' is having zero earnings in at least one year from 1967–1969. Standard errors clustered at the initial local labour market level are reported in parentheses. ***$\rho < 0.01$, **$\rho < 0.05$, *$\rho < 0.10$.

G Fertility

Panel A. Men



Panel B. Women

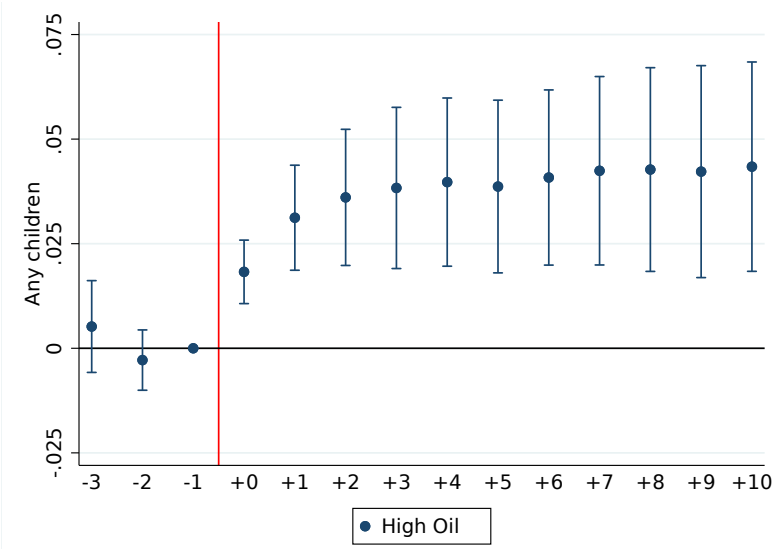
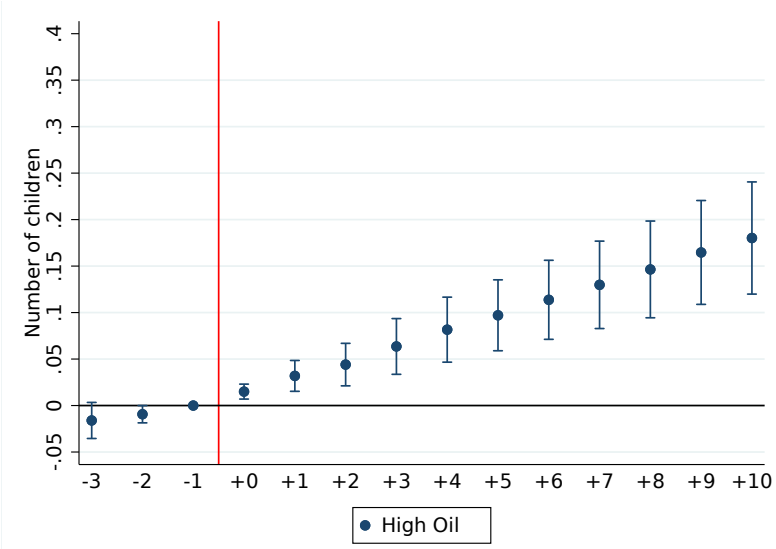


Figure S6: Estimated Effects of Oil Discovery on Having Any Children Over Time. Birth cohorts 1940-1949. The figure plots the estimated impact of the oil discovery (δ_k) on a dummy variable indicating the presence of any children, comparing treated individuals who resided in a high oil LLM in 1965 to untreated in a low oil LLM in 1965 in equation (1). 95% confidence interval reported. Reference period -1 is normalized to zero.

Panel A. Men



Panel B. Women

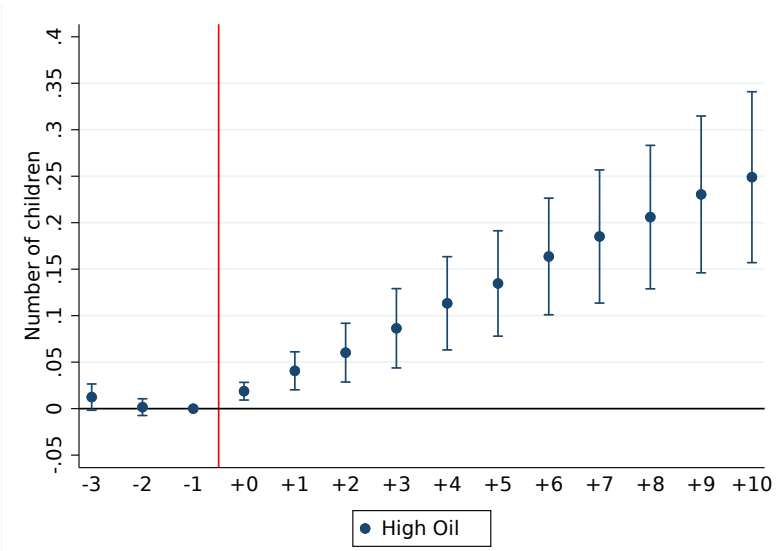


Figure S7: Estimated Effects of Oil Discovery on the Number of Children Over Time. Birth cohorts 1940-1949. The figure plots the estimated impact of the oil discovery (δ_k) on a dummy variable indicating the presence of any children, comparing treated individuals who resided in a high oil LLM in 1965 to untreated in a low oil LLM in 1965 in equation (1). 95% confidence interval reported. Reference period -1 is normalized to zero.

H Long-Run Mechanisms

Many potential factors could explain how younger cohorts of women closed the lifetime income gap with their peers in non-oil regions. Labour supply among younger women may increase relative to older women, as those who were children at the time of the economic shock had more time to consider and adapt their labour supply choices. In addition, younger women may alter their levels of education in response to the local demand shock, as documented by Black et al. (2005) and Cascio and Narayan (2015), who find a causal link between natural resource booms and changes in education. We present suggestive evidence that the reduction in women's earnings losses for the next generation of female workers is driven by changes in labour market participation. While many other economic and social factors may adjust simultaneously over such a long time horizon, it remains useful to examine how the labour supply and education decisions of the next generation depend on the age at which women and men are exposed to the economic shock and may play a role in explaining the recovery of women's income.

First, we show that different rates of long-term migration between women in high- and low-oil are similar across different ages of exposure, suggesting migration is not an important channel (Appendix H.1). Second, making use of employment status available annually from 1986–2017, we show that full-time employment measured at age 44 of older women in high-oil lags behind low-oil (Appendix H.2). However, similar to the catch up observed for earnings, full-time employment of those exposed to oil from 4–6 in high-oil overtakes women in low-oil, suggesting a role of labour supply decisions over time. Third, we find no evidence that girls modified their education decisions with respect to high school or post-secondary education in response to the local shock (Appendix H.3.).

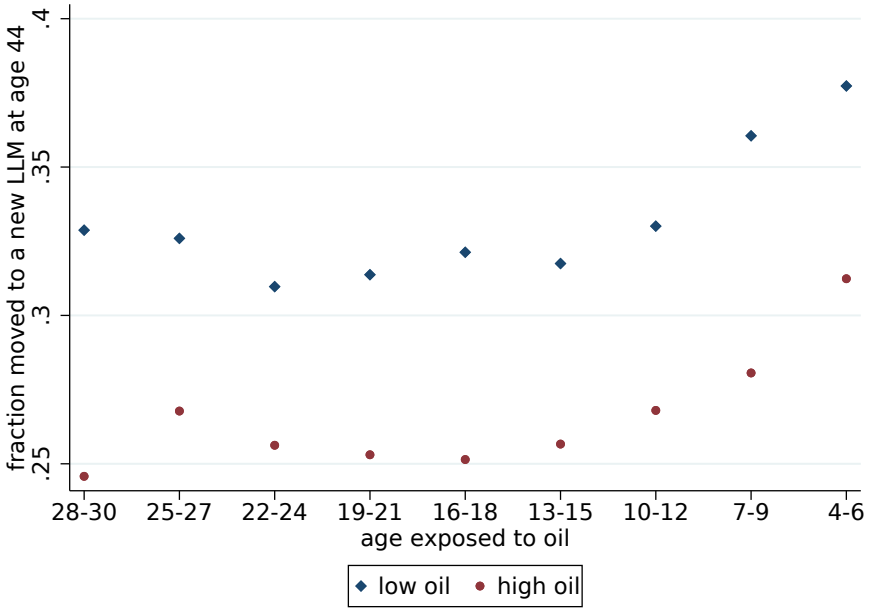
H.1 Migration

First, important differences in age at exposure suggest that the initial disadvantage among working age women disappears over time through the flexibility of the next generation to adapt formative decisions in response to the local economic boom. One channel through which lifetime income improves among the youngest women could be to different rates of migration. Wilson (2018), for example, documents substantial migration into oil regions following the fracking boom in the United States. We discussed previously that migration rates in the older generation did not differ substantially between high and low oil workers, but it is important to verify that this pattern also holds in the long run. Since the younger cohorts had more time to relocate to other labour markets in response to the economic boom, we need to ensure that the lifetime income gains we observe for high-oil women are not driven by women choosing to move to Oslo, for example, the business capital of the country. Since our definition of the treatment is based on the area of residence in 1965, prior to the local boom, if we observe extensive mobility in the long run, this could be the main margin of adjustment for female workers. Figure S8 rules out mobility as a key explanatory factor. Women in the high-oil regions tend to relocate systematically less than those living in low-oil areas, and the difference in migration rates between the two regions is stable across the youngest cohorts.

H.2 Labour Supply

We have already showed that young working women significantly reduced their participation in full-time employment in the aftermath of the boom. If this trend was only temporary, it could explain the observed catching up of female income in high oil regions in the next generation. Figure S9 illustrates that, indeed, while most cohorts of men in high oil labour markets had a higher share of workers in full-time employment than their low-oil peers by the age of 44, only

Panel A. Men



Panel B. Women

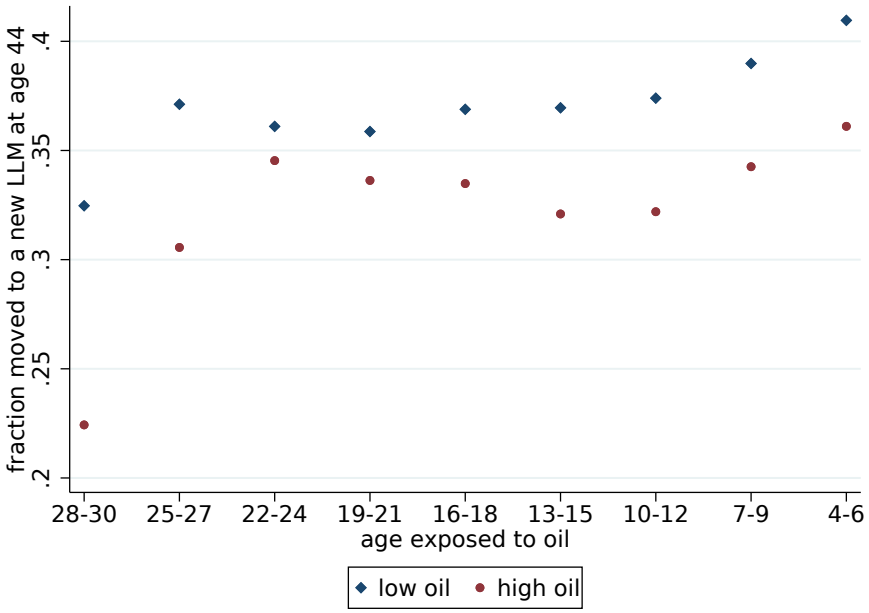


Figure S8: Share of migration to new LLM by cohorts and gender. The figure plots share who have moved to a different local labour market, measured at age 44, of each age group by the age exposed to the local boom. High/low oil defined as residing in high/low oil LLM in 1965 (from birth for those born after 1965).

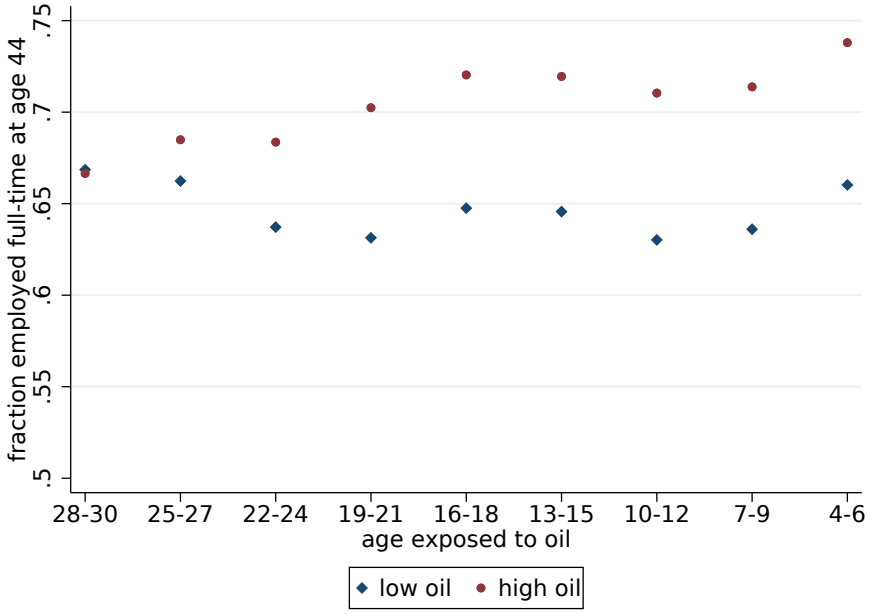
the youngest cohorts of women (aged 4–6 years old in 1969) had a larger fraction of workers in full-time employment than their low-oil counterparts. Consistent with the lack of income differences between young and older men in Table 4, the difference in full-time employment between men in high and low oil regions is stable between those aged 19–21 and those aged 4–6 at oil discovery. As the gap in full-time employment between women in the treated and control regions closes, so should the lifetime earnings gap, *ceteris paribus*. We then have a first indication that the catching-up in female lifetime earnings could come from an adjustment in full-time employment.

H.3 Education

Beyond a direct adjustment in full-time labour supply, it is also plausible that the local boom led to some long-term adjustments in education. The new labour market situation, with more high-paying jobs for men, but fewer ones for women, changed the opportunity cost of remaining in school - the foregone income from remaining outside of employment for an additional year. Thus, education and training could be one possible transmission channel of the oil shock that differs for the next generation of workers and could explain the catching-up of women's earnings in the high-oil regions. Since it takes a long time to train as petroleum engineers and other similar high-paying jobs that grew in demand after the economic boom, the next group of workers could benefit from the option to adjust educational choices after learning about the oil discovery.

Moreover, if children experienced a higher household income because of the economic boom, they could afford more education, and this could be more relevant for girls who otherwise would not invest in those types of training. Table S8 in the Appendix shows the interaction coefficients of the shock with two measures of education. Overall, we find no signifi-

Panel A. Men



Panel B. Women

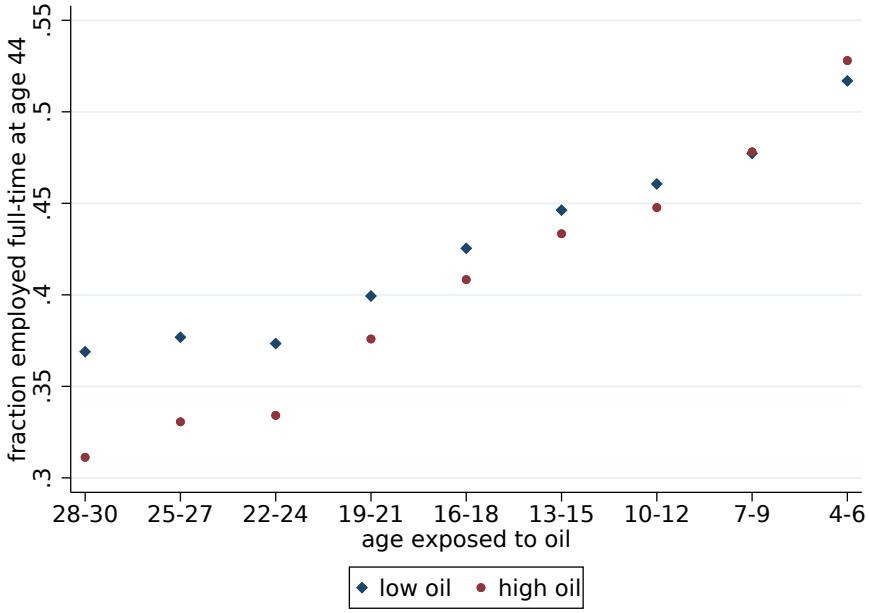


Figure S9: Share of full-time employment by cohorts and gender. The figure plots the share employed full-time, measured at age 44, of each age group. High/low exposure to oil is defined as residing in high/low oil LLM in 1965 (or from birth for those born after 1965). Employment information from annual employment data, where full-time employment defined as employment of at least 30 hours a week.

cant evidence that girls modified their educational trajectories in response to the local boom. Columns (1) and (3) examine the effect of the shock on high school completion for men and women of different age bins, respectively, while columns (2) and (4) examine the effect on post-secondary completion. In general, there are no substantial changes in these measures of education. Teenage boys aged 16-18 are slightly less likely to complete post-secondary education in the boom regions, while the youngest cohort of 4-6 years old are slightly more likely to finish high school, but there are no statistically significant changes for women. Thus, education seems to not be a major factor behind the catch up of younger women in high oil over time.

Table S7: Impact of Oil Shock on Years of Education of Young Workers

	Male	Female
	(1) Years of Education High Oil	(2) Years of Education High Oil
Oil LLM=1	0.083***	0.062***
	(0.008)	(0.007)
Post=1	0.693***	0.333***
	(0.012)	(0.008)
Oil LLM=1 $\times$ Post=1	0.041**	-0.012
	(0.016)	(0.013)
Initial LLM FE	Yes	Yes
Cohort FE	Yes	Yes
Observations	443816	419114
R^2	0.036	0.027
Mean Dep. Variable	10.274	9.737

Notes: Table reports the difference-in-differences estimates of equation (2) using a sample that includes birth cohorts between 1940-1949 (aged 21-30 in 1970). Dependent variable is completed years of education. Treatment is high exposure to oil based on 1965 residence. Standard errors clustered at the initial local labour market level are reported in parentheses. ***$\rho < 0.01$, **$\rho < 0.05$, *$\rho < 0.10$.

Table S8: Impact of Oil Shock on Lifetime Education of Next Generation (by Age in 1970)

	Male		Female	
	(1) Completed HS High Oil	(2) Completed Post-Sec High Oil	(3) Completed HS High Oil	(4) Completed Post-Sec High Oil
19-21	ref.	ref.	ref.	ref.
16-18	0.035***	0.033***	0.084***	0.065***
	(0.009)	(0.005)	(0.004)	(0.004)
13-15	0.088***	0.029***	0.146***	0.085***
	(0.009)	(0.005)	(0.006)	(0.005)
10-12	0.146***	0.018***	0.229***	0.111***
	(0.015)	(0.004)	(0.016)	(0.007)
7-9	0.193***	0.036***	0.315***	0.140***
	(0.018)	(0.005)	(0.016)	(0.010)
4-6	0.223***	0.062***	0.401***	0.185***
	(0.022)	(0.008)	(0.026)	(0.018)
Oil × 16-18	0.004	-0.010**	-0.003	-0.002
	(0.007)	(0.005)	(0.008)	(0.008)
Oil × 13-15	0.015	-0.002	-0.001	-0.003
	(0.009)	(0.008)	(0.009)	(0.010)
Oil × 10-12	0.025	0.000	0.000	-0.006
	(0.015)	(0.008)	(0.018)	(0.014)
Oil × 7-9	0.025*	-0.008	0.001	-0.011
	(0.014)	(0.012)	(0.023)	(0.020)
Oil × 4-6	0.050**	-0.000	0.013	0.001
	(0.020)	(0.014)	(0.034)	(0.029)
Initial LLM FE	Yes	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes	Yes
Observations	440881	440881	420067	420067
R^2	0.034	0.006	0.072	0.017

Notes: Table reports the difference-in-differences estimates of equation (3) using a sample of next-generation workers that includes birth cohorts between 1955-1966 (aged 4-19 in 1970, at the start of the boom). Dependent variable is a dummy variable indicating if a level of education (High school or Post-secondary education) was attained by the age 40. Reference group comprises those aged 19-21. Treatment is high exposure to oil based on 1965 residence. Standard errors clustered at the initial local labour market level are reported in parentheses. ***$\rho < 0.01$, **$\rho < 0.05$, *$\rho < 0.10$.

Issued in the series Discussion Papers 2019

2019

01/19 January, **Aline Bütikofer**, Christopher Cronin, Meghan Skira, "Employment Effects of Healthcare Policy: Evidence from the 2007 FDA Black Box Warning on Antidepressants"

02/19 February, **Ingar Haaland** and Cristopher Roth "Beliefs About Racial Discrimination and Support for Pro-Black Policies "

03/19 February, **Astrid Kunze** and Xingfei Liu, "Universal Childcare for the Youngest and the Maternal Labour Supply"

04/19 February, **Ingvild Almas, Alexander W. Cappelen, Bertil Tungodden**. "Cutthroat capitalism versus cuddly socialism: Are Americans more meritocratic and efficiency-seeking than Scandinavians?"

05/19 February**, Chang Koo Chi**, Kyoung Jin Choi. "Performance Measurement in Agency Models"

06/19 March, **Alexander W. Cappelen**, **Ranveig Falch** and **Bertil Tungodden.** "The Boy Crisis: Experimental Evidence on the Acceptance of Males Falling Behind"

07/19 March, Frode Skjeret, **Frode Steen** and **Timothy G.A Wyndham**. "Paywalls and the demand for online news"

08/19 April, **Ola. H. Grytten** and Viktoriia Koilo. "The Financial Instability Hypothesis and the Financial Crisis in Eastern European Emerging Economies"

09/19 April, **Alexander W. Cappelen**, Johanna Mollerstrom, Bjørn-Atle Reme and **Bertil Tungodden.** "A Meritocratic Origin of Egalitarian Behavior"

10/19 April, **Fanny Landaud**. "From Employment to Engagement? Stable Jobs, Temporary Jobs, and Cohabiting Relationships"

11/19 May, **Ola Honningdal Grytten** and Viktoriia Koilo. "Evidence of the Environmental Kuznets Curve in Emerging Eastern European Economies"

12/19 June. Rune Midjord, Tomás Rodríguez Barraquer, and **Justin Valasek.** "Robust Information Aggregation Through Voting"

13/19 June. Eva M. Berger, **Henning Hermes**, Guenther Koenig, Felix Schmidt, and Daniel Schunk. "Self-regulation Training and Job Search Behavior: A Natural Field Experiment Within an Active Labor Market Program"

14/19 June. **Henning Hermes**, Martin Huschens, Franz Rothlauf and Daniel Schunk. "Motivating Low-Achievers—Relative Performance Feedback in Primary Schools"

15/19 August. Viktoriia Koilo and Ola **Honningdal Grytten.** "The Blue Maritime C luster Crisis Financial Instability and Supply Chain Management Effects"

16/19 September. Jonas Andersson, **Fred Schroyen** and Gaute Torsvik. "The impact of international tax information exchange agreements on the use of tax amnesty: evidence from Norway"

17/19 September. Ingrid Kristine Folgerø, **Torfinn Harding** and Benjamin S. Westby. "Going Fast or Going Green? Evidence from Environmental Speed Limits in Norway"

18/19 September. Julie Riise, Barton Willage and **Alexander Willén.** "Can Female Doctors Cure the Gender STEMM Gap? Evidence from Randomly Assigned General Practitioners"

19/19 September**. Aline Bütikofer**, **Katrine V. Løken** and **Alexander Willén.** "Building Bridges and Widening Gaps: Efficiency Gains and Equity Concerns of Labor Market Expansions"

20/19 September. Richard Friberg, **Frode Steen** and **Simen A. Ulsaker**. "Hump-shaped cross-price effects and the extensive margin in cross-border shopping"

21/19 July. Mai Nguyen-Ones, and **Frode Steen. "**Market Power in Retail Gasoline Markets"

22/19 October. Tunç Durmaz and **Fred Schroyen.** "Evaluating Carbon Capture and Storage in a Climate Model with Endogenous Technical Change"

23/19 November. **Henning Hermes** and Daniel Schunk. "If You Could Read My Mind – An Experimental Beauty-Contest Game With Children"

24/19 December. **Vincent Somville.** "Having a Daughter Reduces Male Violence Against a Partner"

2020

01/20 January. **Laura Khoury**, Clément Brébion and Simon Briole. "Entitled to Leave: the impact of Unenployment Insurance Eligibility on Employment Duration and Job Quality"

02/20 January. Thomas Buser, **Alexander Cappelen**, Uri Gneezy, Moshe Hoffman and **Bertil Tungodden**. "Competitiveness, gender and handedness: a large-sample intercultural study"

03/20 February. **Patrick Bennett**, Chiara Ravetti and Po Yin Wong. "Losing in a Boom: Long-term Consequences of a Local Economic Shock for Female Labour Market Outcomes"

NORGES HANDELSHØYSKOLE
Norwegian School of Economics

Helleveien 30
NO-5045 Bergen
Norway

T +47 55 95 90 00
E nhh.postmottak@nhh.no
W www.nhh.no