Booming industry, wage spillovers and Dutch disease: Norway reported fit?

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Abstract

Using different definitions of relations to the Norwegian oil and gas (OG) industry along spatial and occupational dimensions by combining education and industry affiliation, and large changes at high level OG investments in the estimation period 2008–13, we identify wage spillovers from the OG industry interpreted as cost of living and demand effects. We use micro data covering all individual workers in Norway in this period, in total more than 11 million observations. After controlling for relevant individual and market related characteristics, we draw three main conclusions. First, the OG industry generate wage spillovers to other sectors depending consistently on occupational and spatial relations to the OG industry. The wage distribution related to the OG industry seems persistent but spillovers are smaller as compared to those from the OG establishing period 1970–82, and we offer three explanations for this: Coordinated wage setting, immigration and use of micro data. Second, traded goods industry is affected but not to such an extent as non-traded industries. Third, the channel of spillovers is industry affiliation and not education, which is consistent with the Norwegian system of wage formation.

Keywords: Dutch disease, resource movement effects, wage spillovers, labour submarkets, micro data.

JEL codes: J31, J61, Q32, Q33, R23

1 Introduction

Norway is often portrayed as a country that has avoided the resource curse by establishing a sovereign wealth fund (in 1990). Siphoning off the petroleum rent into a sovereign wealth fund will take care of the spending effect (SE) of the Dutch disease theory (Corden, 1984, Corden and Neary, 1982). However, having a highly profitable OG (oil and gas) industry will also give rise to the resource movement effect (RME) of the Dutch disease theory whereby capital and labour shift into the oil and gas industry. In this process, factor prices – including wages – are bid up, and other (tradable) sectors not having high-profit advantages may lose competitiveness and shrink.

This paper investigates types and strengths of possible spillover effects from the petroleum sector to different types of labour according to geographical location, individual educational background and industry affiliation in relation to the Norwegian OG industry. The theoretical framework for the empirical analysis is a partial equilibrium model of local labour markets (Brunstad and Dyrstad, 1997). Our period of analysis is 2008–13.

The topic is of general interest in the literature as there is now a growing empirically oriented literature on Dutch disease and the resource curse on intra-country data, cf. the review articles by Van der Ploeg (2011), Ploeg and Poelhekke (2017), and Marchand and Weber (2017). The conclusions from those studies are mixed (cf. Section 2). The topic is of particular interest to Norway as a small, open economy, and the recurrent theme in public debate on what Norwegians will have of living 'after oil'.

It is often argued that the centralised and coordinated wage bargaining system in Norway takes care of possible detrimental wage costs.[1] However, in the 1970s and the beginning of the 1980s wages in the Norwegian petroleum sector were set locally without coordination, and one feared that this expanding sector should generate detrimental wage effects onto traded goods industries. The analysis in Dyrstad (2017) provides evidence that wage formation in the petroleum sector became coordinated with the rest of the economy during the 1980s. However, during the years 2007–14 wages in Norwegian manufacturing industries, relative to wages in the OG industry, fluctuate a lot more than previously seen (see Fig. 1 in Dyrstad, 2017). On average, relative wages seem to stay constant in these years but taken together, there are indications that the wage formation system was under heavy pressure but stood on the ground. Hence, this is an interesting period to study in more detail to get knowledge on the possible channels of spillover effects from this booming sector.

[1] A description of the Norwegian system of wage formation and a comprehensive empirical analysis within the context of this system over the period 1900-2015 is given in Nymoen (2017).

The period 2007–2014 contains very sharp oil and natural gas price fluctuations, as shown in Fig. 1. After some years with smooth and steady price increases, except a particular peak in natural gas prices in late 2005, it took off in the beginning of 2007. Over the next one and a half year prices increase to levels five times as high as the beginning of the year 2000, thereafter falling steeply to very low levels in the end of 2008 (oil) and mid-2009 (natural gas). The price on natural gas since then shows some fluctuations but without any clear trend. The oil price increases almost continuously, and reaches a new peak in the spring of 2011. Since the spring/summer of 2011 to the summer of 2014, the oil price fluctuates around a high level with a very weak trend before it dives in the end of 2014.

Turning to the investment level in the petroleum sector, it is clear from the figure that – perhaps with lags – it correlates positively with the oil price, and became all time high in 2013/14. With rather small fluctuations, the annual average level of investments in the petroleum sector over the years 2008-10 was NOK 133 billions. In the next three years, the investment levels increased to NOK 215.4 billions in 2013, nearly 9 percent of continental Norway's GDP (Hungnes et al., 2016). The empirical analyses in this paper are carried out on data from years with variation in the activity level, some with almost no change in the petroleum activities (2008-10), and some with increases to very high levels (2011-13). The variation is driven by changes in investments, not changes in the extraction level, which has a negative annual average growth of 2.6 percent during 2008-13.[2] This means that the observed strong fluctuations in relative wages observed in Dyrstad (2017) coincide with large fluctuations in OG activities.

The differences in activity levels, driven by the exogenously given prices, is one part of our identification strategy. Another part is to utilize information on the geographical location of the OG industry. Its geographical pattern is that it is heavily concentrated to the southern and western part of Norway (see Fig. 4 for a map of today's producing oil fields). The reason is that the first OG resources were discovered, and extraction started, on the south-western part of the country's continental shelf, so spatial variation is determined in prehistoric times. Over the years, more fields were developed, and the last big one is the gas field *Snøhvit* outside *Hammerfest* far north. We define 'petroleum close regions' according to shares of employment in the OG industry. Also as part of our identification strategy, we define the workers' occupational relevance vis-à-vis the OG industry by combining information on educational background and industry affiliation. By comparing estimated effects along the dimensions educational background, industry affiliation, and geographic residence in relation to the OG industry, we identify two types of wage spillover effects; cost of living effects and demand effects.

There are several reasons for applying this model in the present study, which further results in several

[2] Source: `https://www.ssb.no/statistikkbanken/selectvarval/Define.asp?subjectcode=ProductId=MainTable=NRProduksjonInntnvl=PLanguage=0nyTmpVar=trueCMSSubjectArea=nasjonalregnskap-og-konjunkturerKortNavnWeb=nrStatVariant=checked=true`

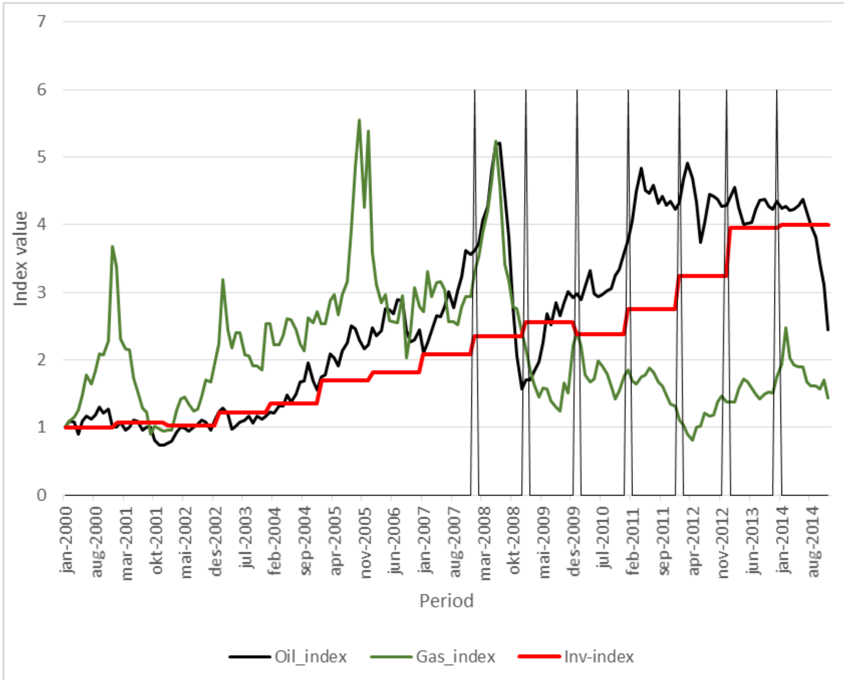


Fig. 1: Petroleum industry investments, oil and gas prices 2000-2014. Indices, January 2000 = 1. Sources: SN and EIA

contributions. First, the model is fully in line with today's modelling approaches (cf. the review in Section 2), which makes comparisons with the results from others possible. Second, by using the theoretical framework of Brunstad and Dyrstad (1997) (see Section 3), we can compare results from two very interesting but different periods of the Norwegian petroleum era, i.e., a turbulent building up period (1971-1982), and a period with a settled OG industry containing large changes at a very high activity level (2008-13): Are regional, occupational and industry impacts from the OG industry different in the years 2008-13 as compared to the turbulent 1970s with plant unions? Do the wage differentials from the beginning of the 1980s persist, or has the impact from the OG industry on the wage formation process changed? Comparing results from these two periods thus provide interesting information on long run adjustments within the same theoretical framework, and to the question of coordination of the wage formation process in Norway vis-à-vis the OG industry during the 1980s, cf. Dyrstad (2017). Third, as pointed out by, e.g., Ploeg and Poelhekke (2017), until recently most of the empirical analyses in the natural resource curse or Dutch disease literature are based on aggregate cross-country data giving several challenges, such as endogeneity problems and confounding factors connected to price development and institutional quality. They express hope of better identification strategies and datasets with 'finer resolution' (ibid., p. 206). We contribute in this respect by using individual panel data (see Section 4) with information on pay, education, country of origin, industry affiliation, geographical location, and activity changes in the OG industry driven by exogenous factors. At the same time, the institutional and political environments along several dimensions are stable across the country, and OG extraction decisions are made by the Norwegian parliament, not by local authorities. Fourth, the data set makes it possible to address the question of which types of workers are affected, and the importance of education versus industry affiliation. We also address the question of Dutch disease more precisely as we can identify traded and non-traded industries. Information on the workers' nationality and their place of residence and work make it possible to assess immigration has mitigating effects on the resource movement effect. Answers to these questions and the question of wage differentials' persistence are provided in Sections 5 and 6, with conclusions in Section 7.

2 Wage spillover effects

Wage spillover effects from a booming industry may occur along a geographical/spatial dimension and an education/industry (occupation) dimension. The following is a brief review of literature that has societal and institutional similarities to Norway but different labour market institutions, i.e., USA, Canada and Australia; are investigating wage and earning effects explicitly or implicitly related to the Resource Movement Effect (RME), not the Spending Effect (SE); and are reporting on spatial and/or occupational/industry dimensions.

Some studies only investigate effects on employment, and some only effects on wages, and vice versa. We include both in this review because there is (usually) an inverse relationship between wages and employment. Most studies use aggregate measures such as income per capita and family income, which do not take into account number of working hours. In the context of welfare implications of booming industries measured by income changes, such measure as income per capita seems relevant. However, this makes it more difficult to interpret wage spillover effects from a labour market perspective.

All studies are using some sort of quasi-experimental, difference-in-difference approaches, with treatment regions defined according to employment in the booming sector, resource abundance (number of extraction wells or mines), or regional income from the extraction industries. In addition, a boom-bust dimension is in many studies used for identification, often defined by resource price changes and technological shocks (e.g. hydraulic fracking). With one exception, no studies go into details on the occupational or industry dimension onto which wages will spill over as only very broad categories such as agriculture, construction, manufacturing, retail sales and services are used. This means that the difference between the tradable goods sector and the non-tradable goods sector, which is central in the Dutch disease literature, often is vague.

The studies can be put into one of two groups, one containing studies on rather long periods, i.e., 15 years or more, of which a majority use rather large geographical units, typically US states. The other contains studies using shorter periods, on average not much more than 10 years, and small geographical units, e.g., US counties. A majority in the first group concludes, or the results indicate, that the actual economy may have experienced Dutch disease (DD) or Resource Curse (RC), whereas the conclusions in the other group is very much opposite, i.e., no DD or RC. Hence, there seems to be a connection between the length of data periods, possibly also size of the chosen geographical units, and the economic impact of resource booms. However, all the studies show some kind of wage spillover effects from the booming industry to other industries and sectors.

Of the 11 studies in the first group, three conclude that there is no DD/RC. This relates to Carrington (1996), analysing the impact on wages of the booming oil Trans-Alaska Pipeline System (TAPS) construction project 1974-77 on data from the years 1968-84, and a possible reason could be good planning, e.g., that the TAPS' 'employees were hired under contracts negotiated with the Teamsters and other unions' (ibid., p. 191). Based on results from analyses of old oil-abundant US states (decennially data 1940-1990), Michaels (2010) conjectures that states with high wages due to oil extraction attract people, and if state institutions are strong, this may stimulate infrastructure development and more economic activity in other sectors. Also higher wages generated by resource extraction may have general positive effects by stimulating total factor productivity, indicated by Allcott and Keniston (2015) analysing all US counties 1967-2007.

Two studies present results that could be interpreted as 'conditional yes' to the question of DD/RC. Black et al. (2005) investigates the impact on employment and earnings per worker of the boom (1970-77) and bust (1983-89) in coal extraction at the county level in four US states in Appalachia. The estimated differences between construction and traded sector manufacturing are consistent with the RME explanation of DD but their general conclusion is that labor mobility made the boom favourable to the local economy. The second, Marchand (2012) on data from Western Canada 1971-2006, covering two booms and one bust in oil, gas and coal extraction, found on average the strongest positive spillovers on earnings per worker for employees in construction but statistically not higher than for traded goods industries.

The studies by Papyrakis and Gerlagh (2007), and James and Aadland (2011) are very similar, but the first one uses a shorter period and larger regional units (1986-2001, US states) compared to the second (1980-2005, US counties). Resources in those two papers cover minerals, oil, gas and coal but also agriculture, forestry, and fish. Overall, both conclude that the resource curse is valid as natural resource abundance reduces economic growth. However, it is interesting to note that the results in Papyrakis and Gerlagh (2007) indicate that higher quality of institutions, e.g., schooling, reduces the severity of DD, cf. Michaels (2010). James and Aadland (2011) comment that 'the resource curse tends to dissipate as the time horizon lengthens (although not uniformly)' (ibid., p. 445). Moreover, indicating that the counties have become less resource dependent over time. With US counties as regional units, and two separate boom periods (1969-74, 1975-81), one bust period (1982-85) and one post-bust (1986-96), all induced by oil price changes, the results in Jacobsen and Parker (2016) indicate higher unemployment compared to the pre-boom period. Douglas and Walker (2013) use panel data from 409 counties in the Appalachian region covering the time span 1970-2010 and two distinct boom cycles, and conclude that this region has suffered from its coal extraction in terms of slow economic development. The papers by Papyrakis and Raveh (2014) and Beine et al. (2015) both use data from Canadian provinces covering the periods 1984-2008 and 1987-2009, respectively. Both papers address the importance of the SE versus the RME of the DD hypothesis. The first concludes that DD explains 20 percent of negative growth in non-primary tradeable goods, of which RME stands for about 50 percent. Beine et al. (2015) find that the booming provinces increase their employment share in the non-tradable sector, and reduce the share in the tradable sector through the SE, but that the RME generated inflow of labour mitigates the DD effects.

Turning to the second group, they all use data mainly from the first decade of the millennium, and often motivated by inventions of new extraction technologies. Out of 11 studies nine are using US non-metropolitan counties as geographical units, and of these nine, seven conclude no DD/RC (Brown, 2014, Fetzer, 2014, Maniloff and Mastromonaco, 2014, Weber, 2012, 2014, Weinstein, 2014). The number of counties in these seven studies varies from 188 to all US counties. The link between them is that they all find, in varying degree and detail, positive spillover effects on wages in other broadly defined sectors and/or employment effects, but conclude generally that there is no Dutch disease or resource curse in the USA, with Weinstein (2014) as a possible exception on this conclusion. This is contrary to the conclusions in Cosgrove et al. (2015), who on data from Pennsylvania find that the shale gas development led to significantly higher employment and wages in construction that were offset by reduced manufacturing employment. Also Paredes et al. (2015), based on data from the same region, is in the same direction as Cosgrove et al. (2015) but more guarded. These two studies define properly Pennsylvania counties as treatment group and counties in the state of New York as controls, exploiting the New York moratorium on fracking to identify possible effects.

From Australia, Fleming and Measham (2015) and Fleming et al. (2015) use data from two years, 2001 (pre-boom) and 2011 (post-boom), to identify employment and income spillover effects. Fleming and Measham (2015) use the strongly growing coal seam gas (CSG) industry in Queensland to identify possible RME, and find that employment in the tradable goods sector agriculture is negatively affected pointing at RME and possibly DD. However, the estimated positive effect on manufacturing employment is not statistically significant. The Fleming et al. (2015) study refers to the country's experienced mining boom, and use all 449 local government areas as geographical units. The local effects seem to vary inversely across the country as the effects on non-mining employment in Western Australia are high, the effects on income are small. The opposite applies to the eastern part of the country (Queensland and New South Wales), as small, and even negative, employment effects go together with large positive income effects, indicating DD/RC in some parts of the country.

Data in the Norwegian studies by Dyrstad (1987), and Brunstad and Dyrstad (1997) cover only 11 years (1970-1982), thus belonging to our second group. However, there is a similarity to our first group as data refer to an early period, cf. e.g. Carrington (1996). On quarterly panel data (1971-82, ten Norwegian counties) Dyrstad (1987) estimated significant wage effects in petroleum close regions, but relatively small effects in regions more distant to the booming industry. On plant level data for different occupational groups covering the same time span, Brunstad and Dyrstad (1997) found very clear effects on hourly wages in local labour office areas and occupations close to the petroleum sector in Norway.

The above review shows that areas with booming industries experience wage spillovers, but unambiguous conclusions whether or not these effects are harmful RME are lacking. As already mentioned, this could be due to varying length of the investigating periods. But also different definitions of pay and regions, with corresponding variations in population size, industry structure and tightness of the corresponding local labour markets, use of broad industry categories, and except from Brunstad and Dyrstad (1997) absence of education and occupation, may contribute to explain different results.

Our review shows that the strength of the effects varies a lot, and are not consistent across studies. At least three confounding elements may contribute to explain this lack of consensus. First, most studies define pay very broad, and the definitions vary. Related to effects in the labour market, the relevant wage concept is pay according working hours. Second, the regional dimension is with almost no exception based on administrative areas varying w.r.t. population size, industry structure and tightness of the corresponding local labour markets. Third, broad industry categories are often used, and with one exception the occupational dimension is absent.

The questions we raise in this paper have clear relevance to questions addressed in the literature. First, are institutions of importance, and do they over time become more effective in handling labour market impacts of a booming sector, cf. Michaels (2010), and Papyrakis and Gerlagh (2007)? By using the same approach as Brunstad and Dyrstad (1997), results from two different periods, with changes in institutional settings in between (cf. Dyrstad (2017)), are comparable. This approach also gives knowledge on long run stability of wage differentials. Second, by using micro data we make it possible to point more precisely at which occupational groups and industries are affected, including the separation between tradeable and non-tradable industry workers. In particular, we address the importance of education relative to industry affiliation and occupation. Third, by utilizing variations in the activity levels of the booming sector, the role of resource prices and shocks in local labour markets is addressed, cf. the literature review regarding booms and busts. Fourth, as we use micro data containing information on workers' nationality and municipality of residence and work, it becomes possible to examine if migration has any mitigating effect on the resource movement effect (cf. Beine et al., 2015, Black et al., 2005).

3 Theoretical Framework

The degree and strength of wage effects from a booming industry will depend on the wage formation system. From a static point of view, one could argue that a centralized and coordinated system such as the Norwegian gives low regional and industry/occupational wage differentials, resulting in correspondingly large unemployment dispersion. This is also supported by for instance Vamvakidis (2009) who on data from EU regions found that countries with more centralized and coordinated wage bargaining have lower regional wage differentials than countries with more decentralized bargaining, so we would expect low regional spillovers and low regional variation in wages in Norway. Consistently, On Norwegian data Dyrstad and Johansen (2000) report low wage adjustments to changes in the regional unemployment rate. They also report a high degree of persistence in regional unemployment during the 1970s and 1980s, at the same level as Sweden and Canada, but considerably lower than e.g. Finland, Britain and Germany. The USA and Australia are extreme exceptions with negatively correlated regional unemployment rates over time (Layard et al. (2005), table 6, p. 294-95).

However, labour productivity in Norway has since the middle of the 1990s been at the same and above the level of the USA (Barth et al., 2014). This labour productivity performance indicates that the wage formation process in Norway must mimic some of the main forces of effective labour markets. From their analysis of the Scandinavian model, Barth et al. (2014) conclude that 'there is a strong complementarity between the Scandinavian non-market institutions and capitalist dynamics' (ibid., p.70). Connected to this it should be mentioned that an important measure contributing in this respect is that the bargaining parties are enclosed by a common, professional analysis of the country's economic situation.[3] Viewed against this background, it is justifiable to use the partial equilibrium model of labour submarkets in Brunstad and Dyrstad (1997) as theoretical framework for our empirical analysis.

The Brunstad and Dyrstad (1997) model consists of n different labour submarkets with non-negative labour supply elasticities and non-positive demand elasticities.[4] The cross-wage supply elasticities measure

[3]The so-called Technical Calculation Committee (TCC) was established in 1967. The four umbrella organizations of the trade unions are represented in the committee, as is also the employee side and the government. The head of TCC is a senior researcher from Statistics Norway, and TCC is equipped with a highly skilled secretariat composed of people from Statistics Norway and the Ministry of Finance, and others. The mandate of TCC is to elaborate a common understanding on possible wage developments and to provide forecasts on cost of living, and other parameters of relevance for the actual bargaining.

[4]The formal model and its comparative statistics are given in Brunstad and Dyrstad (1997).

degree of mobility between submarkets, and are assumed non-positive. Moreover, if wages increase by the same percentage in all submarkets, excess supply increases in all submarkets, by assumption. Market clearing wages are assumed in all submarkets. Increased demand from the OG industry for products produced by labour belonging to the actual submarkets increases the price of those products, unless supply is perfectly elastic. Hence, the product real wage in those submarkets goes down, and labour demand increases. This is the demand effect (DE) affecting labour with petroleum relevant education (PRE) and/or belonging to petroleum relevant industries (PRI), and is unambiguously non-negative.

A booming industry may increase local consumer prices, typically housing prices. The nominal wage effects generated by such price increases are the cost of living effects (CLE). Assuming 'normal' demand and supply elasticities, higher local consumer prices reduce labour supply and consequently increase the nominal wage rate but reduce the consumer real wage, which ceteris paribus generates emigration of labour and thus pressing down the wage level in markets experiencing inflow of labour. Hence, in general CLE is ambiguous. A stylized version of the model is one with only four (types of) submarkets, where the spatial and occupational dimensions have binary representation, see Table 1. Regionally there is only one petroleum close region (PCR=1) and one petroleum distant region (PCR=0).

Table 1: Different labour submarkets

Occupational dimension	**Regional dimension**	
	PCR=1	PCR=0
PRE=1 and/or PRI=1	**A** $(\tau + \pi + \sigma)$ DE≥0 CLE≥0	**C** (π) DE≥0 DE=0
PRE=0 and/or PRI=0	***B*** (τ) DE=0 CLE≥0	**D** (ω) DE=0 DE=0

The occupational dimension is also divided into two; one with petroleum relevant educated workers (PRE=1) or workers employed in petroleum relevant industries (PRI=1), or both. All the other workers are neither PRE nor PRI, i.e., do not have a petroleum relevant education (PRE=0) or an affiliation to a petroleum relevant industry (PRI=0). The OG industry and its workers are exogenous to the model and not included.

This stylized model is summarized in the following wage equation:

$$w_i = \omega + \tau\, PCR + \pi\, PRE(\cdot PRI) + \sigma\, PCR \cdot PRE(\cdot PRI),$$

implying that τ is a pure CLE, π is a pure DE and σ a mixture of CLE and DE. Thus, within this model with correctly defined PCR, PRE and PRI, and controlling for all other relevant factors for wage determination, the estimates of τ, π and σ will identify the regional and occupational spillover effects of a booming industry in terms of DE and CLE.

Alternative hypotheses explaining wage spillover effects are possible. The comparison mechanism in the theoretical model in Dyrstad (1987) is an additional or alternative mechanism generating wage spillovers. In that paper, this mechanism is motivated by an aim of the trade unions to minimize geographical and industry wage differences. Efficiency wage theories may also explain wage spillovers. The adverse selection model by Weiss (1980), the labour turnover model by Salop (1979) and the shirking model by Shapiro and Stiglitz (1984) could all explain why employers would want to increase wages if OG wages increase, e.g., because of a boom. Hence, we cannot rule out that our empirical model also capture such mechanisms.

4 Empirical design and data

In order to test our DE and CLE hypotheses we have to control for a large number of factors potentially influencing wages across individuals, such as individual human capital (education, work experience, age, personal abilities), and market conditions the industry in which the individual belongs to works under. For example, Haegeland et al. (1999) find positive but moderate returns to education on Norwegian data. Budría and Telhado-Pereira (2011) analyse the heterogeneity of returns within education groups for several countries in Europe, and report for Norway increased heterogeneity within the group of high-educated workers. Moreover, we have to control for wage discrimination between worker groups, for instance gender wage gap or wage discrimination among labour immigrants (Altonji and Blank, 1999). The results in Björklund et al. (2007) find inter-industry wage differentials in the Nordic countries, indicating that job characteristics matter.

Spatial wage differentials depend on the local composition of the labour force, agglomeration economies (higher productivity) and local non-human endowments, e.g., mineral deposits, waterfalls, and oil and gas resources (Combes et al., 2008). For instance, García and Molina (2002) aim to explain wage differentials for five regions in Spain by the composition of the labour force, and find that seniority, university level education, the use of a second language, type of industry, supervisory tasks and occupation were the variables exerting the greatest influence on wage dispersion. After controlling for heterogeneous variation of the workforce, Groot et al. (2014), testing agglomeration effects on wages, find that size of the regional labour market affects wages positively. Similarly, Carlsen et al. (2016) show the existence of agglomeration effects on wages in Norwegian data. In sum, our modelling approach is to estimate the following Mincer type equation (Mincer, 1974) with appropriate controls for the factors mentioned above:

$$
\begin{aligned}
log\, W_{i,k,r,j,t} = & \qquad (1) \\
\sum_{t=1}^{6} \tau_t\, PCR \cdot T_t + \sum_{t=1}^{6} \pi_{0t}\, PRE \cdot T_t + \sum_{t=1}^{6} \pi_{1t}\, PRE \cdot PRI \cdot T_t & \\
+ \sum_{t=1}^{6} \sigma_{0t}\, PCR \cdot PRE \cdot T_t + \sum_{t=1}^{6} \sigma_{1t}\, PCR \cdot PRE \cdot PRI \cdot T_t & \\
+ \beta \left(X_{i,k,j,t}\right)' + \theta_r + \delta_t + e_{i,k,r,j,t} &
\end{aligned}
$$

$W_{i,k,r,j,t}$ is nominal annual earnings of individual i, belonging to education group k, working in region r and industry j, in year t = 2008, ..., 2013. Our micro dataset comprise the total population of Norway registered in 2013 within the age group 15–74, covering the years 2008–2013, and it consists of more than 11 million individual observations in total. Self-employed workers are not included. We want to use observations from workers with full time workload but cannot get such information from the dataset, so as an alternative we excluded workers with an annual wage level below NOK 150,000.

Our parameters of interest are the τs, πs, and σs. If there are cost of living effects, the τs, and partly the σs, must occur in regions with a high activity level of the OG industry, and be geographically concentrated. PCR=1 is defined according to the share of workers employed in the OG industry in a particular region, so in order to become a PCR the region must be above a given threshold. We use different threshold values to check the robustness of our estimates, where we expect the effects to be stronger in the set of PCRs with the highest rates of OG activity. The demand effects, represented by the πs and partly th σs, relate to people with an education relevant for the OG industry (PRE=1) and/or are employed in industries (outside the OG industry) giving work experience and training possibly making them relevant for the petroleum sector (PRI=1). If both PRE=PRI=1, the individual is particularly petroleum relevant. This formulation makes it possible to test which of education and industry affiliation is most important. We give precise definitions of PCR, PRE and PRI later.

As mentioned in the preceding section, the estimates of the σs contain both DE and CLE because when PCR · PRE=1 (or PCR · PRE · PRI=1) we are considering workers with petroleum relevant education (or education and experience), working in the same region as the OG industry who will be exposed to both CLE and DE. The interaction terms with time dummies are important for identification of DE and CLE. Because the investment level is almost flat in the first three years (bust 2008-2010) but increases thereafter (boom 2011-2013), we expect that the effects are stronger in the last part of the period (see Fig. 1). If we do not see this pattern over time the interpretation of CLE and DE is hard to believe in.

For each individual worker we have a variety of variables describing individual characteristics plus market conditions and industry controls, captured in the vector $X_{i,k,j,t}$.[5] β is a corresponding vector of parameters. θ_r and δ_t includes regional and time fixed effects respectively. A full set of individual characteristics are used as controls in the chosen empirical specification, included stepwise to see how sensitive the estimates of the τs, πs and σs are. We estimate Eq. (1) with OLS.[6]

Eq. (1) is asymmetric because there is no PCR $\cdot$ PRI dummies. The PRI dummies are included in the set of industry controls in $X_{i,k,j,t}$. The reason we do not include a full set of PCR $\cdot$ PRI terms is because we want to keep the empirical specification close to the DE and CLE from our theoretical model. In order to obtain 'pure' CLEs, they should apply to all irrespective of industry affiliation. The σs may be a mix of CLE and DE, and we do not want to undermine the labour demand part of it, which is connected to skills and qualifications which means education (PRE) and/or occupation (PRE $\cdot$ PRI).

4.1 Petroleum close regions

The OG industry is defined by the NACE codes Extraction of crude petroleum (06.100), Extraction of natural gas (06.200), Other support activities for petroleum and natural gas extraction (09.109) and Support activities for other mining and quarrying (09.900),[7] implying that workers employed in firms registered with one of these NACE codes are categorised as OG workers. This group of workers consists of about 70 000 people over the period 2008–2013, and their wage distribution is given in Fig. 3. We use the number of workers in the OG industry by residence in each of the 426 different municipalities in Norway relative to the total number of workers living in these municipalities to define petroleum close regions, PCR.[8]

As pointed out in Section 2, booming regions are often defined by extraction levels, endowment levels, or by employment in the resource extraction industry. However, the oil and gas resources in Norway is not located in mainland ground but off-shore, below the continental shelf, and cannot be directly connected to regions. However, the mainland location of the petroleum industry follows from the extraction plan

[5] The complete variable list is presented in Table A.2

[6] We use the econometric software R (R Development Core Team, 2008) in the estimation. The main supporting R packages used in this paper were: *lm* for the OLS estimations, *foreach* for the parallel programming code (Analytics and Weston, 2015). We use a computer with 512 GB RAM of memory and 24 processing cores.

[7] See `https://www.ssb.no/en/nasjonalregnskap-og-konjunkturer/industries-in-the-national-accounts`

[8] Norwegian municipalities corresponds US counties but are on average much smaller.

set by the Norwegian Parliament, which again depends on the location of the petroleum resources.

In order to capture variations in the DEs and CLEs, we define three different threshold levels for a municipality to be included in a PCR; Low, Medium and High. PCR_L, PCR_M and PCR_H are regions covering municipalities with at least 2.5 percent, 5 percent and 10 percent OG workers, respectively. Fig. 2 shows the PCRs on a map of all municipalities in Norway. All of today's producing oil and gas fields are also included on the map (blue fields), and we see that the PCRs are closely connected to geographical location of the fields. In our data set PCR_H covers in total 85 666 workers, whereas PCR_M and PCR_L cover 208 710 and 535 284 workers, respectively, corresponding to 3.5, 8.6 and 22 percent of all employees in Norway.

4.2 Petroleum relevant labour

We define petroleum relevant labour in two ways, according to formal education and according to industry affiliation. The definition of petroleum relevant education, PRE, is based on six digit education codes, NUS.[9] The method we have used to extract the relevant codes is pragmatic, and consists of two steps. First, we group all workers within the OG industry with respect to the NUS codes. If we identify more than five workers with a specific NUS code, that group of workers is potentially petroleum relevant. In the next step, we check if that specific education code is relatively more common in the OG industry than outside this industry. In that case, workers with this code belong to the PRE group. For example, if 6 percent of the workers in the OG industry has a specific educational code, but 7 percent of the workers outside OG also has this code, we classify that code as not defining petroleum relevant education. In order to investigate the importance of education in more detail, we later (in Section 5) redefine the PRE group into three subgroups. In total 511 497 workers in the data set belong to the group with petroleum relevant education. All the PRE codes are listed in Table A.3.

Petroleum relevant labour along the industry dimension, PRI, is also divided into three sub-groups; Low, Medium and High, respectively denoted PRI_L, PRI_M and PRI_H. Like the definitions of the PCRs we use NACE codes to define the PRI variables. PRI_H includes workers belonging to 20 different five digit NACE code industries evaluated to be highly related to the OG industry, covering 108 161 workers in our dataset.[10] PRI_M comprises 360 649 workers belonging to industries with the first two digits of the 20

[9] The Norwegian NUS education codes are similar to the international education standard ISCED, and contains in total of 1.469 different codes in the dataset.

[10] These NACE codes are: 20110 Manufacture of industrial gases, 25400 Manufacture of weapons and ammunition, 27110 Manufacture of electric motors, generators and transformers, 27320 Manufacture of other electronic and electric wires and cables, 28120 Manufacture of fluid power equipment, 28130 Manufacture of other pumps and compressors, 28221 Manufacture of marine lifting and handling equipment, 28229 Manufacture of other lifting and handling equipment, 28920 Manufacture of machinery for mining, quarrying and construction, 28990 Manufacture of other special-purpose machinery n.e.c., 30113 Building of oil-platforms and modules, 33200 Installation of industrial machinery and equipment, 49500 Transport via

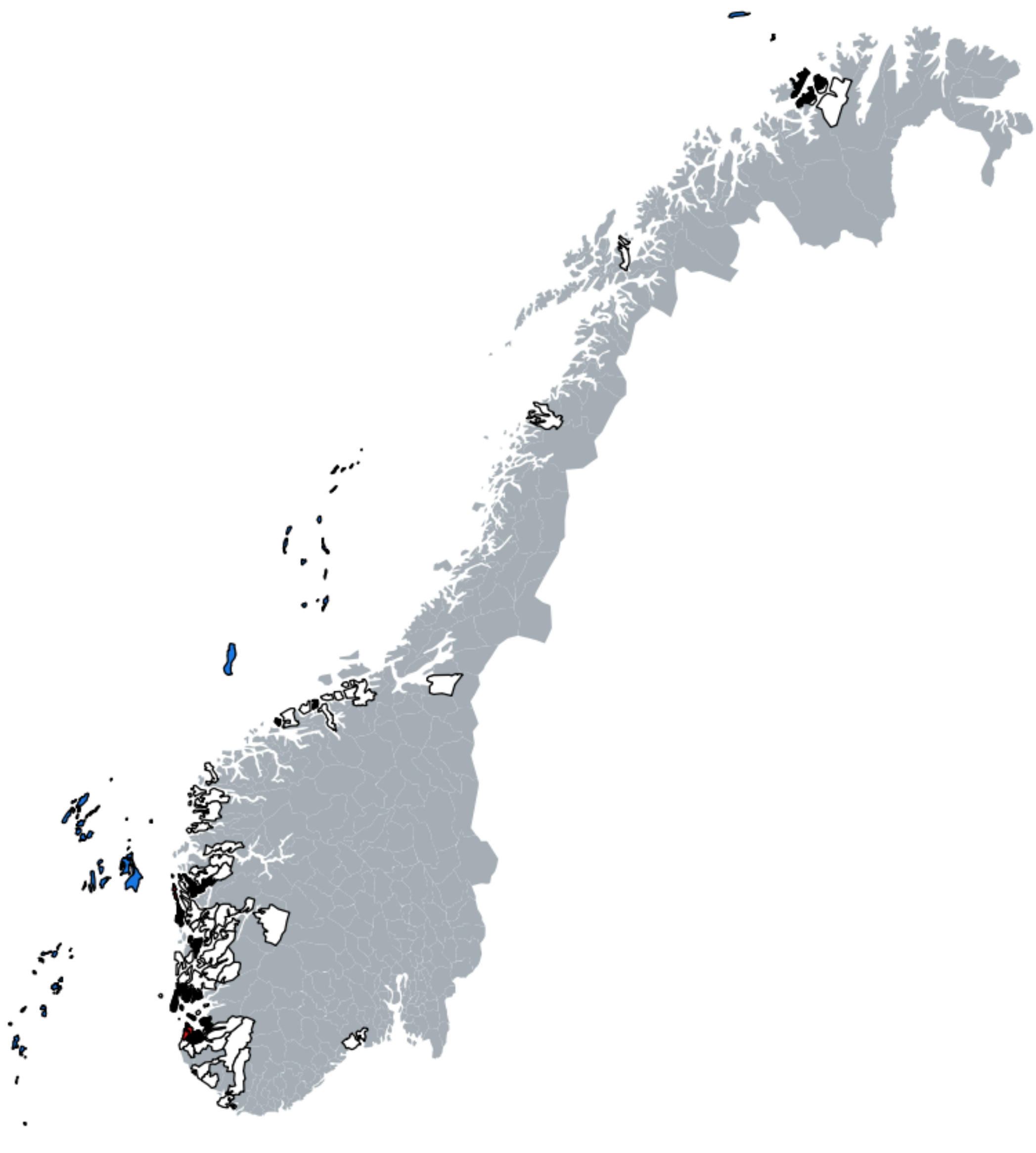


Fig. 2: Location of petroleum close regions: PCR_L (white), PCR_M (black) and PCR_H (red) and today's producing oil and gas fields on the continental shelf (blue) (QGIS Development Team, 2009).

NACE codes defining PRI_H. The definition of PRI_L is the same as the PRI definition in Brunstad and Dyrstad (1997), i.e., employment in manufacturing industries and construction, and comprises 374 206 workers.

4.3 Observations and wage distributions in the different labour submarkets

The dataset comprises the whole labour market of Norway 2008–2013, and consists of 2.428 million individual worker observations. In Table 2 we show the number of employees included in the nine combined PCR and PRI groups linked to the stylized submarkets defined in Table 1, using the definition as explained in Section 4.1 and 4.2, and the notation m(PCR,PRI), where m=A, B, C or D. Only 0.9 percent of the workers in the sample belong to the A(H,H) markets, i.e., the combination PCR_HPRI_H, and 5.2 percent under A(L,L). The size of the B markets vary positively with the size of the A markets, and the C markets negatively. The size of the D markets vary between 62 and 76 percent.

Table 2: Number of workers (in thousand) in different submarkets (cf. Table 1) according to definitions of PCR and PRI. PRE=1 i all alternatives.

Sub-	PCR:	H	M	L	H	M	L	H	M	L
markets	PRI:	H	H	H	M	M	M	L	L	L
A	σ_0	***22***	***51***	***126***	***22***	***51***	***126***	***22***	***51***	***126***
	σ_1 (PCR · PRE · PRI=1)	5	11	23	9	21	50	6	17	42
B	(τ: A+B)	***63***	***157***	***409***	***63***	***157***	***409***	***63***	***157***	***409***
C	π_0	***489***	***460***	***385***	***489***	***460***	***385***	***489***	***460***	***385***
	π_1 (PRE · PRI=1)	59	53	41	142	130	101	131	120	95
D	(Base category)	***1,854***	***1,760***	***1,508***	***1,854***	***1,760***	***1,508***	***1,854***	***1,760***	***1,508***
Total		***2,428***	***2,428***	***2,428***	***2,428***	***2,428***	***2,428***	***2,428***	***2,428***	***2,428***

Wage distributions for the A(H,H), B(H,H), C(H,H), A(L,L), B(L,L) and C(L,L), are given in Fig. 3. We have dropped the groups in the middle, PCR_MPRI_M in Table 2, in order to make Fig. 3 readable, but include the wage distributions for the OG workers and the base category in the D(L,L) submarkets for comparison reasons.[11]

The average wage level in each submarket fits our a priori expectations. At the bottom are those not

pipeline, 50204 Supply and other sea transport offshore services, 52223 Offshore supply terminal, 71122 Geological surveying, 71129 Other technical consultancy, 71200 Technical testing and analysis, 74101 Industrial design, product design and other technical design and 74909 Other professional, scientific and technical activities n.e.c.

[11] The dashed vertical lines in Fig. 3 represent the average wage for each group. Workers with less than 150 thousand NOK in annual earnings are not included in the figure, nor in the regression analyses. The average wage level in each group: D(L,L) 419.423, B(L,L) 413.922, C(L,L) 566.982, A(L,L) 581.317, B(H,H) 440.102, C(H,H) 700.708, A(H,H) 784.520, OG 894.873

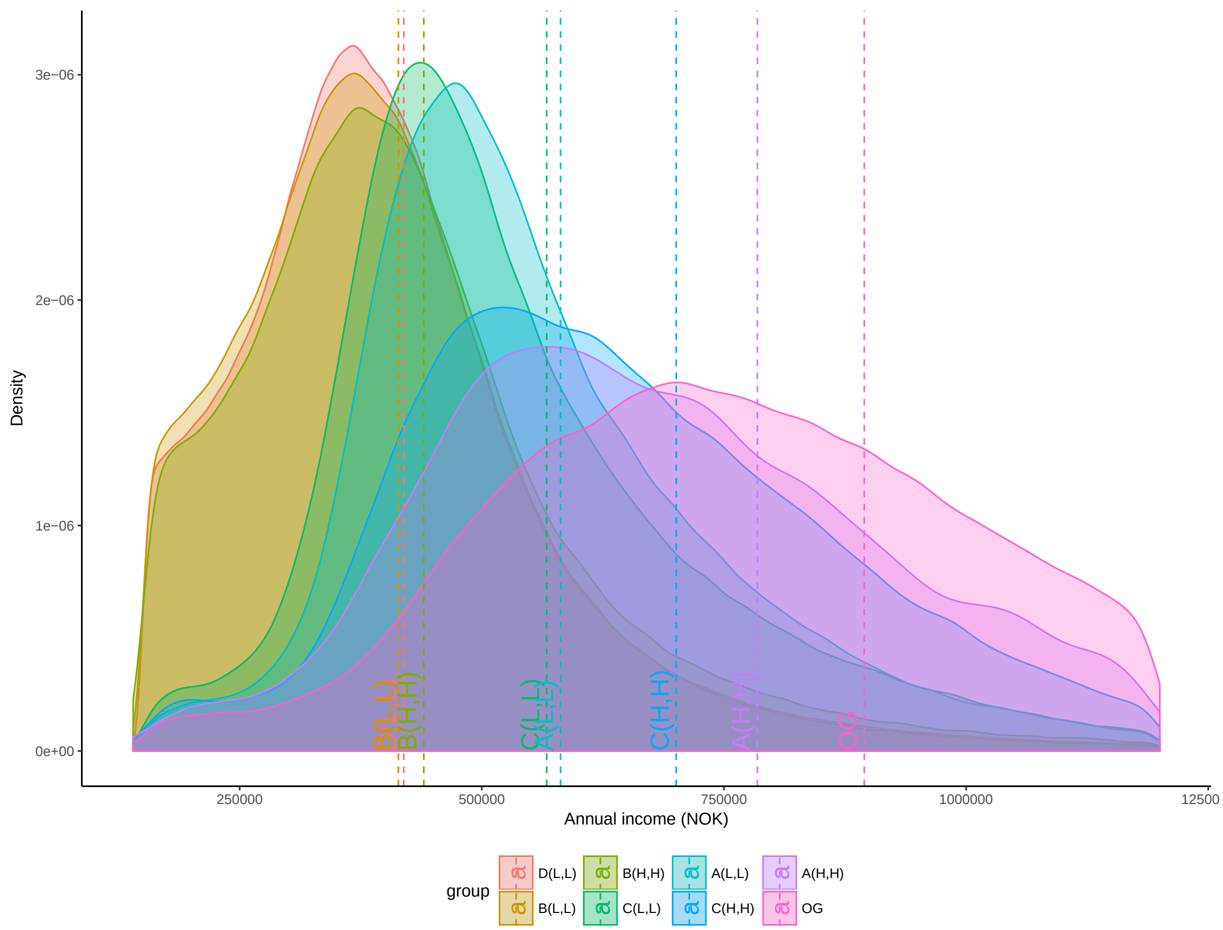


Fig. 3: Wage distributions according to submarkets 2008–2013

engaged with the OG industry at all, our D market, and at the top, we have the OG workers, with the A, B and C markets in between. Without exception, the closer to the OG industry, the higher is the average wage level. The ranking of the submarkets is A(H,H), C(H,H) and B(H,H), and is the same as for the $PCR_L PRI_L$ submarkets, though the difference between A(L,L) and C(L,L) is small but in that case the number of workers in the A markets is large, cf. Table 2. Taken together this clearly indicates that both the occupational and regional dimensions may be important.

5 Results

Table A.1 presents estimates of the main parameters of interest, the σs, πs and σs, for the years 2008 and 2013. The estimates referring to the years in between are an important part of our identification strategy, and will be presented in Section 5.2. The results in Table A.1 come from model specifications with the three different combinations of the PCR and PRI definitions, keeping the definition of petroleum relevant education (PRE) the same in all nine models, cf. Section 4.2. We expect the demand effects (DE) and cost of living effects (CLE) to be stronger the more narrow definitions of PCR and PRI we use.
We have tried several model specifications regarding control variables. The common one chosen in Table A.1 includes time dummies and 20 variables to capture differences in age, gender, type of household and family relations, country of origin, firm size, work relation, and market conditions measured by degree of centrality (agglomeration) and regional unemployment. In addition, we have included 144 dummy variables to control for industry affiliation and education. All the included variables are listed in Table A.2.

Model specifications with only time dummies and the 20 individual and market related variables, give lower explanatory power and influences the estimates of the parameters of interest as they become much larger in such plain models, particularly the closer PCR and PRI are to 'high'. This applies along the PRI dimension, affecting primarily the estimates of the πs and σs. This is reasonable, because not correcting for industry affiliation and education means that such differences will be captured by the estimates of the πs and σs, which are related to occupation and education. Wage formation in Norway is highly coordinated with negotiating parties both on the employer and employee side organized according to industry, and the employee side is to some extent also organized according to education level. On this background it seems most correct to include both industry and education dummies in the models. However, the differences between the estimates of the parameters of interest in 2008 and 2013, are almost identical irrespective of which controls we include.

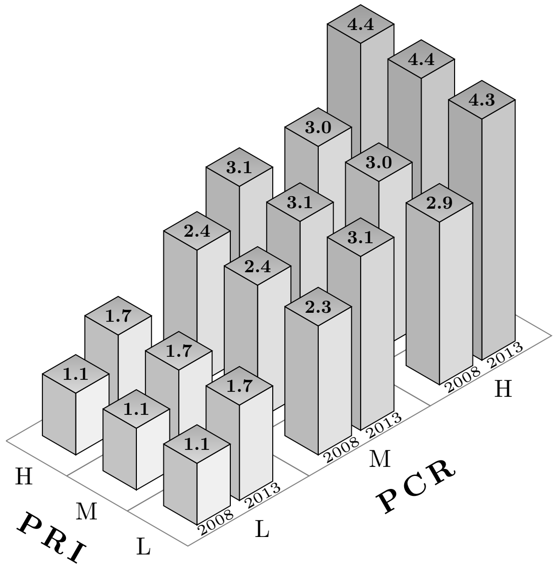
The estimated parameters for the 20 individual and market related variables are identical in all specifications of PCR and PRI, and similar to those obtained by others. For instance, the wage premium for living in the largest cities in Norway are in line with the static urban wage premium estimated in Carlsen et al. (2016), and the estimated relation between wages and regional unemployment is exactly the same as in Dyrstad and Johansen (2000).

5.1 Effects along the regional and industry dimensions

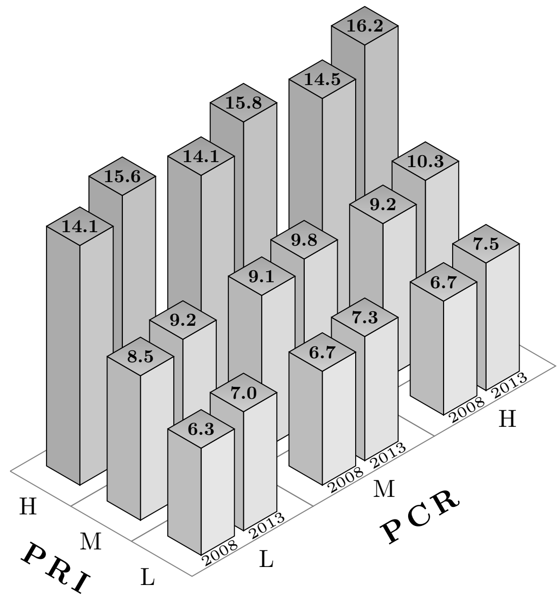
The estimated parameters of interest are shown graphically in Fig. 4. Starting with Fig. 4a, we see how the estimated τs, capturing cost of living effects (CLE), vary according to the definitions of PCR and PRI. The first block in each row corresponds to the year 2008, and the second to 2013. There is not much variation in the PRI dimension, as the estimates are almost identical for each year. However, there is a very clear increasing pattern along the PCR dimension, saying that the more petroleum close a region becomes, the stronger is the effect irrespective of industry relevance. This indicate that our estimates are capturing a CLE.

Turning to the estimated demand effects (DE) intended captured by the parameters, Fig. 4b shows a clear variation in the PRI dimension in line with expectations: The more petroleum relevant industry an employee belongs, the stronger is the effect. As there is not much variation along the PCR dimension, this also indicate that we are capturing a demand effect.

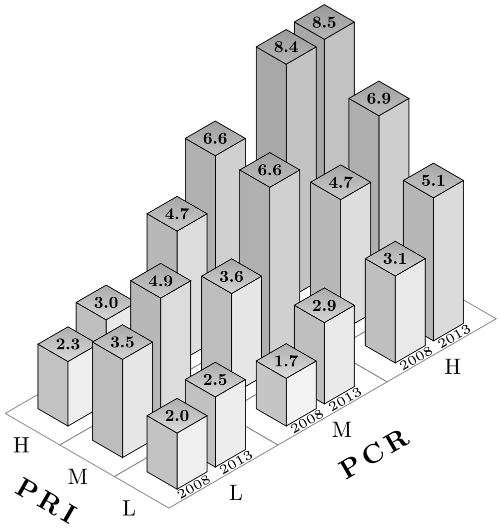
The estimated σs may capture both DE and CLE, and Fig. 4c shows a very clear pattern with increasing effects along both the PCR and PRI dimensions. This same picture appears in Fig. 4d, where all three corresponding parameter estimates are added up. From Fig. 4d it follows that the wage level in the wide group (PCR_LPRI_L) was 9.4 percentage points above the average non-petroleum regions and occupations in 2008, but 11.2 percentage points above in 2013, i.e., the DE and CLE have increased the average wage level in these submarkets by 1.8 percentage points. The same calculation for the very narrow submarket (PCR_HPRI_H) gives 25.9 percent higher wage level in 2008 and a 29.1 percent higher level in 2013, which corresponds to DE and CLE of 3.2 percentage points. Consistent with the theoretical model, the effect is stronger for narrow (PCR_HPRI_H) than for wide submarkets (PCR_LPRI_L), and overall Fig. 4 shows this pattern of effects in most alternatives when we move from L to H along both dimensions. We elaborate more on these effects in Section 6.



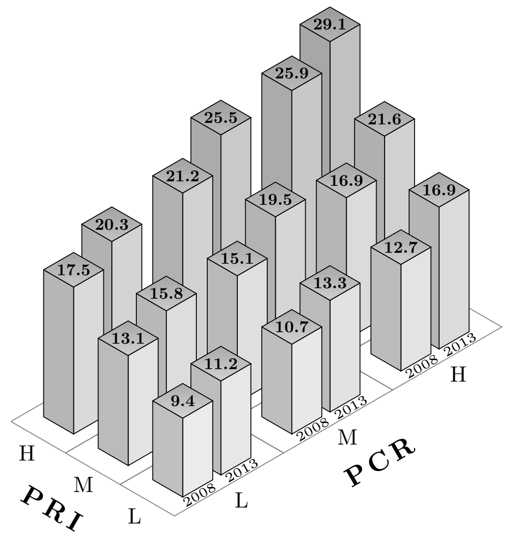
(a) Magnitude of τ effect



(b) Sum of π_0 and π_1



(c) Sum of σ_0 and σ_1



(d) Sum of all effects

Fig. 4: CL and DE along the regional and industry dimension.

5.2 Effects along the 'boom-bust' dimension

Another part of our identification strategy is to assess how the parameters of interest develop over time. Fig. 5 depicts the time variation of the estimates of τ, π_0, π_1, σ_0 and σ_1, and their sum (tot). To make the development more visible, the estimates are normalized to 1 in 2008 except the σ_1 estimates. We expect higher effects in 2009 than 2008 because OG investments increase between these two years and follows a trend like development from previous years, cf. Fig. 1 in the Introduction. As the investments drop from 2009 to 2010, we expect smaller effects in 2010. From 2011 till 2013 investments increase considerably, implying larger effects in these years than the previous, and in total smaller effects in the period 2008-10. It is somewhat misleading to call the latter a 'bust period', so in the following we call it the 'waiting' period as compared to the 'boom' period 2011-13.

First, it is a remarkably parallel development in the CLE parameter τ along the regional dimension, as the upper three graphs refer to PCR_L, the three in the middle refer to PCR_H, and the lower group PCR_M. The industry dimension does not matter. The time development is very much in accordance with our expectations for PCR_L and PCR_H as the estimates increase from 2008 to 2009, and drop a little in 2010. For the PCR_M group the parameters stay almost constant in these two years. In the years afterwards, the parameters increase continuously with the exception of the PCR_L in 2012, but taken together we get a picture according to expectations. However, the correlations between the OG investment index from Fig. 1 and the estimated parameters give the strongest correlation for PCR_M (0.97) and the weakest for PCR_L (0.87). It is also interesting to note that the relative position of the parameters does not change over these years.

Turning to DE, we first note that the development of the π_0s estimates, which capture only the effect of having a petroleum relevant education (PRE), show a very similar time pattern irrespective of how the petroleum close regions and relevant industries are defined, ending up a little lower than in 2008. This time picture does not contradict with our 'waiting-boom' expectation but the correlation is weak.

The π_1 estimates vary much more, saying overall that it is of importance in which industries employees with petroleum relevant education are working. First, the time development for those working in highly petroleum relevant industries (PRI_H) is very trend like, and the waiting-boom pattern is vaguely seen. Second, for petroleum educated workers in medium relevant industries (PRI_M), the development is parallel both between groups and in relation to the waiting-boom pattern. This time pattern is similar for the least relevant industry (PRI_L) when petroleum relevant regions are defined most intensively (PCR_H), however the demand effects are much stronger. Third, the demand effects when we apply the widest defined petroleum regions (PCR_L and PCR_M), and use the least relevant petroleum industries (PRI_L), we obtain the clearest waiting-boom pattern with much lower effects in 2009 and 2010 but sharp increases in the following years. The correlation coefficients between the OG investment index and the π_1 estimates vary between 0.90 and 0.996, confirming the above features.

The estimates of σ_0 and σ_1 capture both DE and CLE. The estimated σ_0s, which capture the education part (and not industry affiliation), have a rather parallel development but do not follow our expected waiting-boom pattern. Looking at the estimated σ_1s, which capture the combined education and industry DE and CLE, the picture is highly mixed both regarding the waiting-boom pattern, and the regional

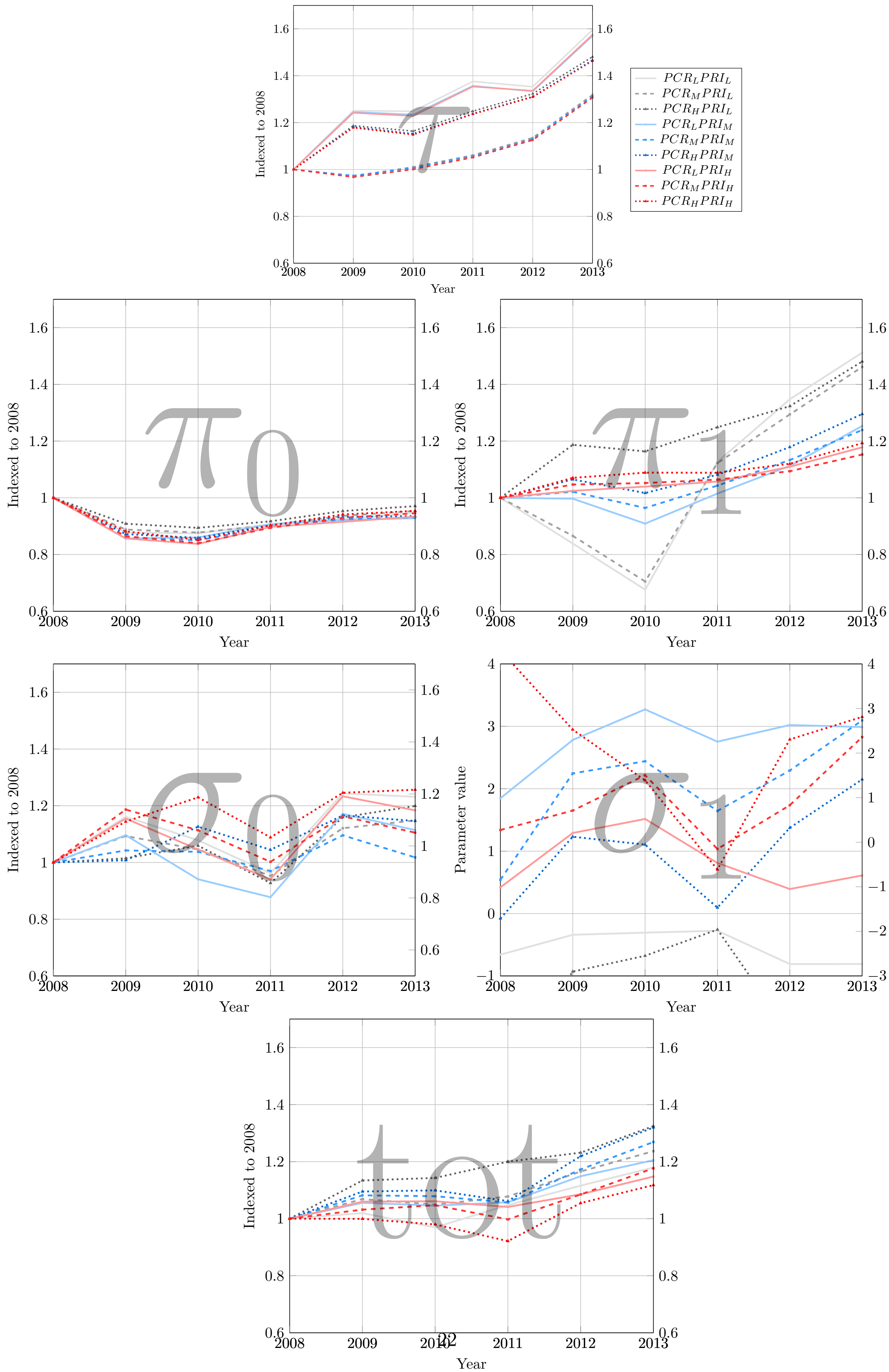


Fig. 5: 'Boom-bust' pattern in the CL and DE over time period 2008–2013.

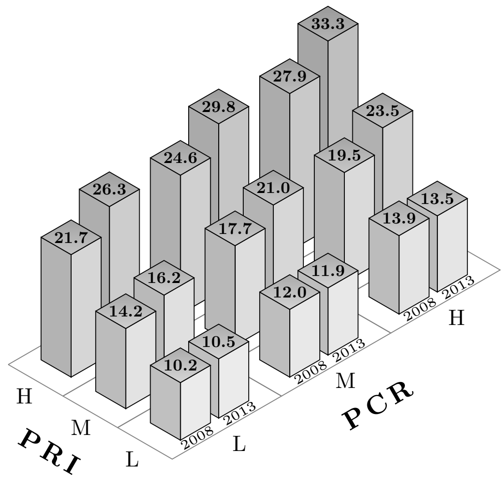
and education/industry dimensions. However, from 2011 the effects increase very much for PRI_H workers in PCR_H and PCR_M regions.

In order to get an overall picture we add up all the estimated parameters, and get the graphs in the lower part of Fig. 5 (tot). The waiting-boom pattern is clear in the sense that the effects are higher in 2009 than 2008, and that they stay almost constant from 2009 to 2010. The increases in 2012 and 2013 are also in line with the changes in OG investments. The effects drop from 2010 to 2011, with one exception, which is due to the estimated σs. However, the correlation between these total effects and the OG investment index is on average 0.92.

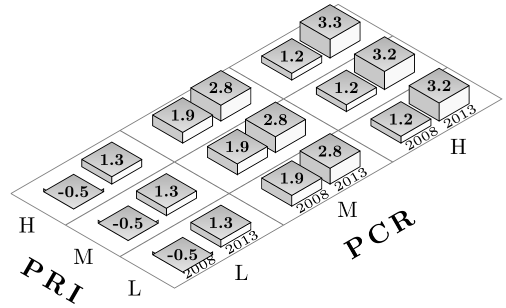
5.3 Effects on traded and non-traded goods sectors

An important aspect of the Dutch disease theory is to what extent is the traded goods industry affected by a booming industry. We address possible resource movement effects on the traded and non-traded goods industries, and the public sector, by estimating the model with a new set of PRE and PRI dummies; one for traded goods industries, one for non-traded goods industries, and one for the public sector.[12] The PRI and PCR dimensions are the same as above. Adding up the estimated parameters of interest corresponding to these three sectors we get the picture in Fig. 6a–Fig. 6c, which has the same interpretation as Fig. 4.

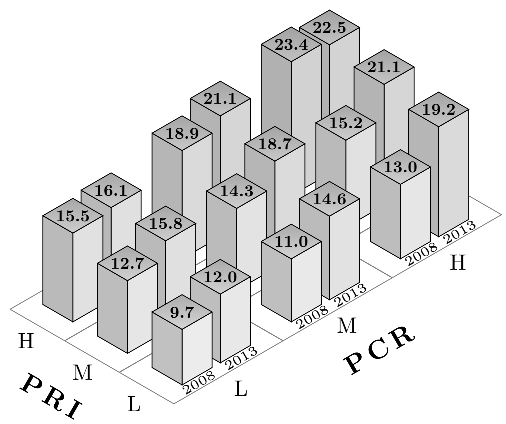
[12]See last column of Table A.2 for which industry that falls into which sector.



(a) All effects for non-traded sector workers



(b) All effects for public sector workers



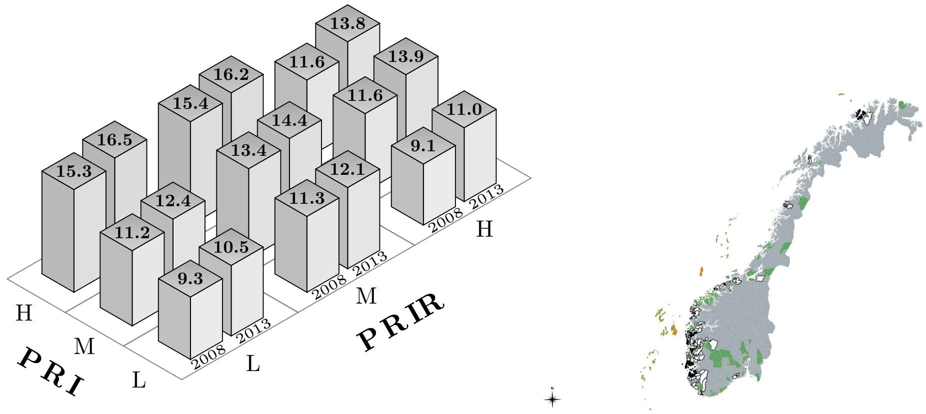
(c) All effects for traded sector workers

Fig. 6: CL and DE by sector

5.4 Alternative petroleum close regions

After 50 years of petroleum activities, the service and supply industry is well established, and internationally competitive and active. It is partly located within the PCRs as defined in the preceding sections, and partly in other regions. As a robust check of choice of PCRs we redefine the PCRs to petroleum relevant industry regions, PRIR. The PRIRs are defined in the same way as the PCRs, the difference being that instead of using threshold values regarding employment shares in the OG industry, we apply the same threshold values regarding the service and supply industry's share of total employment in the corresponding municipalities.

As this is a robust check regarding the spatial dimension, those PCRs overlapping with the PRIRs are excluded in the regression analysis where the PRIRs are included in parallel to the PCRs in Eq. (1). The map in Fig. 7b marks the PRIRs as green areas. The results for the PRIRs are presented in Fig. 7a with the same interpretation as Fig. 4d, and show a less clear picture of increasing wage effects along the occupational and regional dimensions.



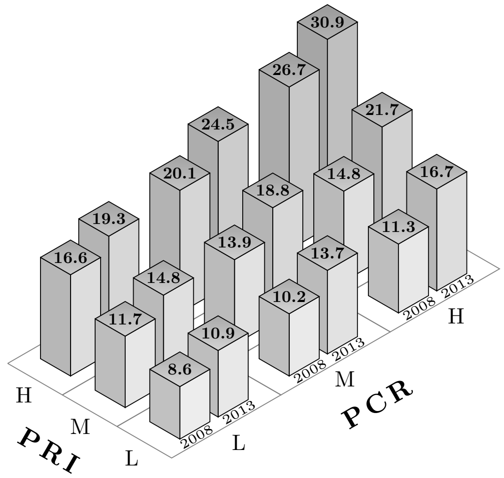
(a) Sum all effects in PRIRs

(b) Green regions are defined as PRIRs.

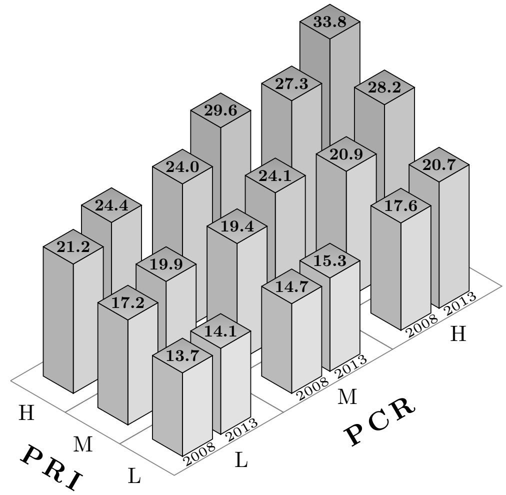
Fig. 7: CL and DE in the PRIRs

5.5 The importance of education level

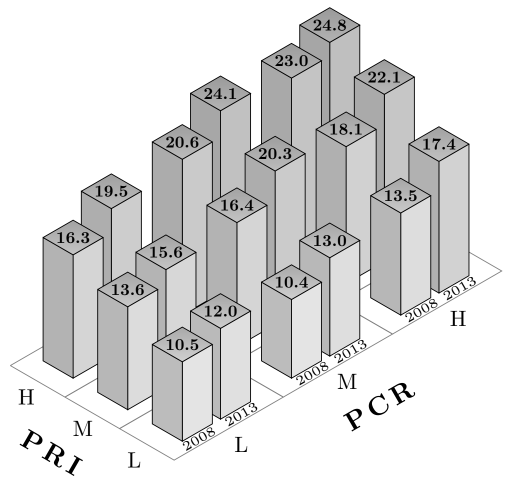
Education seems to be important, particularly in combination with industry, but the picture is mixed-up. We therefore re-specified the model by separating the PRE variable into three different education dummies; one corresponding to those with a Master's degree or a PhD ($PRE_H = 1$), one corresponding to those with three years education at the university level or a Bachelor's degree ($PRE_M = 1$), and one corresponding to those with no such education ($PRE_L = 1$). It is important to note that those who are educated as skilled blue collar workers fall into this latter group. The results are presented in Fig. 8a–Fig. 8c, respectively.



(a) All effects for low educated



(b) All effects for medium educated



(c) All effects for high educated

Fig. 8: CL and DE effects for three types of educated workers

6 Discussion

In this section we discuss the results from Section 5 related to the research questions raised in the introduction.

6.1 Permanent wage differentials – or long run equalization adjustments?

While the year 1971 was the start-up year of the oil and gas production, the year of 2013 – on the other hand – could be the peaking point of the OG era of Norway, and most likely – from 2013 onwards wage spillovers from the OG will never be more spreading than in 2013. Going backwards in time, by comparing the estimated wage differentials in 2008 with those after the main building up period of the OG sector in 1982, we obtain important long run information on the development of the differentials over a quarter of a century. Brunstad and Dyrstad (1997) estimated the OG wage premium in 1982, defined as the sum of the DE estimates, to be 31 percent above the estimated general wage level for the most OG relevant occupations. The CLE, i.e., the estimated τs, were much smaller, 4 percent, for the most OG close regions. Hence, in total the OG industry at the most generated a 35 percent higher wage level in 1982, and for the least but relevant occupational groups 11 percent higher as a maximum. The estimates in this paper for approximately similar occupations and regions as in Brunstad and Dyrstad (1997), give differentials in 2008 very similar but lower, between 9.4 percent and 21.2 percent in 2008.[13] Thus it seems clear that the wage spillovers from the establishing period has transmitted into permanent wage differentials, but they have not increased during the period. On the contrary, the development have been slightly in the opposite direction.

Beside the fact that the years 1971–1982 and 1983–2008 are different periods, which by itself may play a role, we think that three factors may contribute to explain the dampened wage differentials. The first is that we use another data set, where worker heterogeneity seems to account for about 50 percent of the raw wage differentials. Worker heterogeneity in the data set applied by Brunstad and Dyrstad (1997) was limited to groups of workers at the plant levels. Thus, the point made by Ploeg and Poelhekke (2017) regarding datasets mentioned in the Introduction, could be important. Second, more coordination of the wage formation process in Norway vis-à-vis the OG industry during the first part of the 1980s. In this respect our results therefore point at the importance of institutions, and confirm the results in Dyrstad (2017) that the Norwegian government was successful with respect to the aim of more coordination. Third, and also addressed in the literature is the role of (im)migration. The EU expansion in 2004 and 2007 opened up for more labour immigration to Norway, where the period after 2007 is especially a high labour immigration period in Norway. Interestingly, this coincide with the first year of our dataset, 2008.

[13] PCR_H was not a part of the analysis in Brunstad and Dyrstad (1997). Therefore PCR_MPRI_H in Fig. 4d is the most comparable estimate to the highest estimate in Brunstad and Dyrstad (1997).

In order elaborate on the importance of immigration in this period, we divide the number of workers with petroleum relevant education (PRE) into two separate groups, Norwegian workers and foreign workers. Education is the only relevant background variable to use as we do not have information on previous work experience. Table 3 shows the number of workers in these two groups, with low, medium and high education (cf. Section 5.5), in 2008 and 2013, and the change between these two years. The immigration of PRE workers has been substantial, particularly in the OG industries. The number of Norwegian PRE workers increased in total by nearly 65 percent, whereas the percentage for foreign PRE workers is 135. In the non-traded goods industries there was an increase of Norwegian PRE workers of 8.8 percent in total, but a small increase in traded goods industries, 0.6 percent. For foreign PRE workers the percentages are respectively 59 and 47. These numbers thus indicate that immigration may have been wage dampening during this period.

Table 3: PRE workers divided by Norwegian and foreign workers

	PRE in OG sector			**PRE in Traded sector**			**PRE in Non-traded sector**		
Education level	**2008**	**2013**	**Δ**	**2008**	**2013**	**Δ**	**2008**	**2013**	**Δ**
Low Norwegian	10 855	18 352	7 497	49 734	49 305	-429	106 966	116 394	9 428
Low Foreign	851	1 619	768	4 300	4 864	564	9 727	12 545	2 818
Medium Norwegian	4 460	7 216	2 756	14 646	15 160	514	59 426	62 462	3 036
Medium Foreign	759	1 873	1 114	2 942	4 950	2 008	12 697	20 858	8 161
High Norwegian	4 811	7 333	2 522	6 731	7 069	338	26 503	30 951	4 448
High Foreign	1 241	3 233	1 992	2013	3 803	1 790	8 384	15 527	7 143
Sum Norwegian	20 126	32 901	12 775	71 111	71 534	423	192 895	209 807	16 912
Sum Foreign	2 851	6 725	3 874	9 255	13 617	4 362	30 808	48 930	18 122

6.2 Wage spillovers 2008–13

Summing up all the effects, we get a clear picture of increasing spillovers, measured as the difference between 2008 and 2013, the closer to the OG industry the actual submarket is, both occupationally and regionally. The only exception is the occupationally most relevant and regionally closest group ($PCR_H PRI_H$), but this group maintains its position as the one with the highest relative wage level. Related to this it is interesting to note that the immigration information in Table 3 show that many, and relative to Norwegian workers many more, foreign workers were recruited to the OG sector during the years 2008–2013, which may contribute to explain effects not fully in accordance with our expectations regarding the estimates of the σs, cf. Section 5.2 and Fig. 5.

The total picture is not so monotonically increasing along the regional and occupational dimensions as the pictures of the separate and 'pure' CLE and DE, cf. Fig. 4. The reason is the estimated σ parameters, which according to our theoretical framework may capture both CLE and DE. The differences between the estimates referring to 2008 and 2013 are interpreted as CLE and DE, so in the following we denote these effects as $\Delta\tau = \tau_{2013} - \tau_{2008}$, $\Delta\pi = \pi_{2013} - \pi_{2008}$, and $\Delta\sigma = \sigma_{2013} - \sigma_{2008}$. The 'pure' CLE, $\Delta\tau$, is - with one very small exception – identical along the industry dimension, but increases steadily along the regional dimension the closer to the OG industry. The 'pure' DE, $\Delta\pi$, is almost constant along the regional dimension but vary along the occupational dimension as they would if they catch demand effects; 1.5–1.7 for the most relevant occupations (PRI_H), 0.7–1.1 for medium relevant occupations (PRI_M), and 0.6–0.8 for the least relevant (PRI_L). The estimated general wage level in 2013 was 16.2 percent above the 2008 level [see the estimates of δ_{2013} in Table A.1]. Thus, the estimated largest total effect ($\Delta\tau$+$\Delta\pi$s+$\Delta\sigma$s) is 33.5 percent ($PCR_H PRI_M$) above the general wage increase 2008–13, and the lowest 10 percent ($PCR_L PRI_M$). The results we get are lower but within the range of the results in Brunstad and Dyrstad (1997).

The importance of $\Delta\tau$, $\Delta\pi$s, $\Delta\sigma$s relative to the total effect ($\Delta\tau$+$\Delta\pi$s+$\Delta\sigma$s) varies according to block in Fig. 4d. This means that for the geographically closest and occupationally most relevant groups the CLE counts for not much more than 10 percent of the total effect. For occupationally less relevant groups in OG close regions, CLE counts for approximately 1/3 of the total effects. Alternatively, we could separate the regional effects ($\Delta\tau$+$\Delta\sigma$s) from the regionally independent effects ($\Delta\pi$s), which gives dominant regional effects varying between 46 and 82 percent, depending on specification.

The relative importance of CLE and DE in our study has one possible difference and one similarity to the findings in Brunstad and Dyrstad (1997). The possible difference regards one group in our study, the occupationally least relevant (PRI_L). For this group the CLE counts for 31–33 percent of the total effect, irrespective of the three definitions of the PCRs. This is almost identical to Brunstad and Dyrstad (1997) for their occupationally least relevant groups located geographically close. This lack of geographical variation in the relative importance of CLE, may indicate that our CLE estimates for this particular group capture other effects than cost of living, e.g., comparison mechanisms from trade union preferences aiming at minimizing geographical differences (Dyrstad, 1987), or efficiency wage mechanisms. However, it could be a coincidence that the estimated increasing τs for this group occur together with proportionally increasing total effects when the geographical distance to the OG sector is reduced.

The similarity regards that the relative importance of CLE decreases as the workers become occupationally more relevant, underlining that we are estimating demand effects. The CLE is relatively strongest for the group defined as the most OG relevant along both dimensions, 44 percent, but this is because the total effect in this group is relatively low. The estimated parameters capturing the CLEs vary only along the geographical dimension, as mentioned above. For the other five groups, the CLE means relatively much less, on average 18.5 percent, with a variation of 16–25 percent, which is more in line with the findings in Brunstad and Dyrstad (1997). However, it is important to note that the different submarkets have maintained their relative position. This is consistent with the demonstration in Dyrstad (2017) that a change occurred in the wage formation system in the OG industry in the beginning of the 1980s, and his showing that in spite of much larger fluctuations in relative wages, on average relative wages seem to stay constant.

6.3 Dutch disease

The OG industry's impact on the traded goods industry is directly related to Dutch disease. We estimate rather large CLE and DE for the traded goods industry for the two least OG relevant occupations, and the effects become larger the geographically closer to the OG industry. For the most petroleum relevant occupations, the effects are small, even negative, and there is no geographical OG direction (see Fig. 6). The reason could be a restructuring of traded goods sector in PCR_H or that the sector moved or have become more important in regions outside the PCRs. We performed a sensitivity analysis regarding the effects along the regional dimension by including the PRIR regions, where the internationally oriented service and supply industry is highly present. There was wage spillover effects in these regions also, but to a much lower degree than with the PCRs. The effects illustrated in Fig. 4d are in the interval 1.8–4.7 percentage points, whereas the effects in the PRIR version have a much smaller range, only 0.8–2.3 percentage points, cf. Fig. 7a, and an unclear regional and occupational pattern.

The industries defining the PRIRs belong to the traded goods sector, thus the effects we find in these regions are effects on wages for traded goods sector workers. In the light of Dutch disease, these small wage spillovers in the PRIRs seem unproblematic. The PRI_H group of workers in PCR regions are in the service and supply industry to the OG sector, thus the effects we see for these workers will not necessarily follow a traditional traded sector pattern according to the Dutch disease hypothesis. However, workers in the PRI_L group belong to the broader traded sector workers. For these workers we see the lowest relative wage level but there are wage spillovers also for these workers during the period.

For the non-traded goods industry the effects become stronger the closer to the OG industry along both dimensions, which is according to expectations as these industries may increase prices to compensate for higher wage costs. Regarding public sector workers, who also belong to a non-traded goods sector, the differences in relative wages are small, as are also the estimated spillover effects. There is some regional variation corresponding to our theoretical model, but the occupational dimension is flat.

The weak and ambiguous wage spillover effects in the traded goods industry could imply that Norway has escaped from Dutch disease. The pronounced effects for the low and medium relevant occupations, which are petroleum relevant, indicate that this conclusion may be hasty. Most important in relation to the Dutch disease hypothesis, our results show important differences between traded and non-traded goods industries, where wage spillover effects to the latter are very clear.

6.4 Occupation or education?

Petroleum relevant education seems not to be important. In fact, the estimated $\Delta\pi_0$s are small and even negative for all market groups, and become important only in combination with industry, the $\Delta\pi_1$s. When we combine petroleum relevant education with petroleum close regions, the $\Delta\sigma_0$s, the effects are positive but not large. Again, in combination with industry, the $\Delta\sigma_1$s, all the effects are positive and some are very large, showing large fluctuations over the years. Because the industry dimension seems so important, these findings are compatible with coordinated wage bargaining with parties on both sides organized as they are, namely according to industry.

Going further into this by differentiating between employees with university degrees ('High'), college or similar university degrees ('Medium'), and those with at the most upper secondary school ('Low'), all in combinations with industry, we get for all three educational groups pictures of monotonic increases in the industry-regional dimension, cf. Fig. 8. Looking behind these aggregate numbers, the high educated have a different pattern along the industry-regional dimension compared to low and medium educated workers. For these workers the regional dimension through the estimated σs contribute negatively to the total effects, implying that spatial closeness to the OG industry for high educated is not important to the DE effects.

Related to this, it is interesting to note that averaging over the different groups, we get the least effects for the High educated, 2.8 percentage points. The medium educated get an average of 3.8 percentage points while the low educated has the largest effect, 4.2 percentage points. Again, from Table 3 we see that immigration may have dampened the wage affects as employment growth is much larger for high than for medium and low educated foreign workers. The growth for PRE_L is 90 percent, for PRE_M 147 percent, and PRE_H 160 percent, giving an inverse relationship to the average wage effects. The corresponding numbers for Norwegian workers are 69, 61 and 52 percent. The group Low educated contains highly skilled blue collar workers, not only unskilled. Hence, this finding cannot be taken for the benefit of a hypothesis that a booming sector attracts low-educated workers due the availability of well-paid jobs in the booming sector, as discussed in several papers, e.g., Black et al. (2005), Papyrakis and Gerlagh (2007), and Douglas and Walker (2013).

6.5 Limitations

We have used the workers' annual earnings as dependent variable in this study, i.e., we have not accounted for number of worked hours. Hence, increases in annual earnings could be due to longer working hours, which is not wage spillovers. If we capture longer working hours instead of wage spillovers, we have an upward bias in our estimates of CLE and DE. As the estimated effects are rather moderate, e.g., compared to Brunstad and Dyrstad (1997) who use hourly earnings as wage variable, we do not think this is an important limitation regarding our results.

As pointed out in the literature, education is correlated with an unobserved variable like ability (Card, 1999). We are not able to control for if, in particular, the unobserved ability is clustered towards the PRE dummies. Although, we believe that a possible ability bias in the coefficients is less present in the way we analyse the DEs than in the traditional returns to education analyses.

The work horse in economic analyses, demand and supply, has been applied as analytical tool to capture cost of living and demand effects in labour submarkets. We argued in Section 3 that this is a reasonable approach. However, the results could possibly be consistent with predictions from efficiency wage models or models where comparison or envy effects appear on the supply side through trade union preferences.

7 Conclusion

Our strategy for identifying wage spillover effects from the oil and gas industry to other parts of the labour market is based on definitions of how close various labor submarkets are to this industry along occupational and regional dimensions. The fundamental assumption for the analysis is that if the OG industry generates wage spillovers to other parts of the economy, such effects must appear to labor occupationally relevant for this industry, and geographically located close to it. We have operationalized this identification strategy by three main definitions along both the occupational and spatial dimensions. In addition, we have assessed changes in the parameters of interests over time, because if there are spillovers, they must be larger in the 'boom' period 2011–2013 than the 'waiting' period 2008–2010. The results indicate that this is a fruitful strategy, as we in general get very clear regional and occupational patterns with larger effects the closer to the OG industry, and the effects are larger in the 'boom' than 'waiting' period.

Three main conclusions follows from our analyses: First, the occupational and spatial wage distribution related to the OG industry seems persistent over a long period, consistent with our results of considerable wage spillovers from the OG industry to the rest of the economy. However, the effects are slightly lower now as compared to the establishing period of the Norwegian petroleum industry, in spite of a heavy activity level in OG industry, with large changes in investments. We substantiate three explanations to the dampened effects: institutionalized wage coordination, immigration, and use of micro data. All three explanations are central in the literature, as pointed out in Section 2. The importance of institutions are explicitly addressed by Michaels (2010), and Papyrakis and Gerlagh (2007), and we interpret the results in Carrington (1997) that the wage agreements made in advance of the TAPS project were important for its labour market success. Regarding immigration, Carrington (1996), Black et al. (2005) and Beine et al. (2015) point at labour mobility as an important mechanism for handling a boom. By using data with a lot more information than in all other studies we have seen within this field of research, we provide answers to the demand of better identification strategies and datasets with 'finer resolution' (Ploeg and Poelhekke, 2017).

Second, the traded goods industry seems not to have escaped spillover effects, though the effects are weaker than for non-traded goods industry and in general. The results in other studies regarding the impact on the traded goods industries are at best ambiguous, also when we restrict comparison to similar resources as in this study. For instance, Komarek (2016) did not estimate negative effects on the traded goods industry, whereas Cosgrove et al. (2015) and Paredes et al. (2015) find positive wage spillovers and higher employment in the non-traded sector construction, possibly at the cost of reduced manufacturing employment.

Third, education means less for wage spillovers than industry affiliation, which is consistent with the Norwegian model of coordinated wage bargaining as both the employer and employee sides are organized according to industry. Another explanation equally likely is that relevant work experience through industry affiliation is more important than formal education per se.

Within our theoretical framework, the estimated wage spillovers come through demand and cost of living effects, which are healthy in an institutionalized and efficient functioning system of wage formation. However, it seems too early to report Norway fit with respect to Dutch disease.

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Table A.1: Results of CLE and DE effects under nine scenarios of PCR and PRI.

	Dependent variable:								
	log Wage								
	$PCR_L PRI_L$	$PCR_M PRI_L$	$PCR_H PRI_L$	$PCR_L PRI_M$	$PCR_M PRI_M$	$PCR_H PRI_M$	$PCR_L PRI_H$	$PCR_M PRI_H$	$PCR_H PRI_H$
δ_{2013}	0.163***	0.161***	0.162***	0.161***	0.162***	0.163***	0.161***	0.162***	0.163***
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
$\tau_{2008}(PCR)$	0.011***	0.023***	0.029***	0.011***	0.024***	0.030***	0.011***	0.024***	0.030***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
$\tau_{2013}(PCR)$	0.017***	0.031***	0.043***	0.017***	0.031***	0.044***	0.017***	0.031***	0.044***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
$\pi_{0,2008}(PRE)$	0.047***	0.049***	0.050***	0.044***	0.045***	0.045***	0.045***	0.047***	0.048***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\pi_{0,2013}(PRE)$	0.045***	0.047***	0.049***	0.041***	0.041***	0.042***	0.042***	0.045***	0.046***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\pi_{1,2008}(PRE \cdot PRI)$	0.016***	0.018***	0.017***	0.041***	0.046***	0.047***	0.096***	0.096***	0.097***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
$\pi_{1,2013}(PRE \cdot PRI)$	0.025***	0.026***	0.026***	0.051***	0.057***	0.061***	0.114***	0.111***	0.116***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
$\sigma_{0,2008}(PRE \cdot PCR)$	0.027***	0.049***	0.057***	0.017***	0.035***	0.048***	0.022***	0.034***	0.042***
	(0.002)	(0.003)	(0.004)	(0.002)	(0.003)	(0.004)	(0.002)	(0.002)	(0.003)
$\sigma_{0,2013}(PRE \cdot PCR)$	0.033***	0.056***	0.069***	0.019***	0.035***	0.055***	0.026***	0.038***	0.053***
	(0.002)	(0.003)	(0.004)	(0.002)	(0.003)	(0.004)	(0.002)	(0.002)	(0.003)
$\sigma_{1,2008}(PRE \cdot PCR \cdot PRI)$	−0.007**	−0.032***	−0.026**	0.018*	0.005	−0.001	0.004	0.013**	0.042***
	(0.003)	(0.004)	(0.006)	(0.003)	(0.004)	(0.006)	(0.004)	(0.006)	(0.008)
$\sigma_{1,2013}(PRE \cdot PCR \cdot PRI)$	−0.008***	−0.027***	−0.018**	0.030***	0.031***	0.021***	0.006*	0.028***	0.032***
	(0.003)	(0.004)	(0.007)	(0.003)	(0.004)	(0.006)	(0.004)	(0.005)	(0.007)
R^2	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.441	0.440

Notes: (i) Significance levels of 0.05, 0.01, and 0.001 are denoted by *, **, and ***. (ii) All models include 11.108.211 millions observations and all controls specified in Table A.2 are also included in all the models.

A Data and groupings

Table A.2: Micro data variables

List of variables		Sector
Dependent variable		
Wage	log yearly income	
Independent variable		
Year2009	a (1,0) dummy for year 2009	
Year2010	a (1,0) dummy for year 2010	
Year2011	a (1,0) dummy for year 2011	
Year2012	a (1,0) dummy for year 2012	
Year2013	a (1,0) dummy for year 2013	
Work relation	a (1,0) dummy if main work relation	
Employee	a (1,0) dummy if employee (not self-employed)	
Age	age of the individual in representative year	
Age^2	age of the individual in representative year squared	
Gender	a (1,0) dummy if male	
Singel household	a (1,0) dummy if living in a single household	
Couples without children	a (1,0) dummy if living in a household with children	
Size of establishment	the number of workers (full and part-time)	
Industry dummies		
Crop and animal production, hunting and related service activities	a (1,0) industry dummy if works in industry	
Forestry and logging	a (1,0) industry dummy if works in industry	T
Fishing and aquaculture	a (1,0) industry dummy if works in industry	T
Mining and quarrying	a (1,0) industry dummy if works in industry	Excluded
Manufacture of food products, beverages and tobacco products	a (1,0) industry dummy if works in industry	T
Manufacture of textiles, wearing apparel and leather products	a (1,0) industry dummy if works in industry	T
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	a (1,0) industry dummy if works in industry	T
Manufacture of paper and paper products	a (1,0) industry dummy if works in industry	T
Printing and reproduction of recorded media	a (1,0) industry dummy if works in industry	NT
Manufacture of coke and refined petroleum products	a (1,0) industry dummy if works in industry	T
Manufacture of chemicals and chemical products	a (1,0) industry dummy if works in industry	T
Manufacture of basic pharmaceutical products and pharmaceutical preparations	a (1,0) industry dummy if works in industry	T
Manufacture of rubber and plastic products	a (1,0) industry dummy if works in industry	T
Manufacture of other non-metallic mineral products	a (1,0) industry dummy if works in industry	T
Manufacture of basic metals	a (1,0) industry dummy if works in industry	T
Manufacture of fabricated metal products, except machinery and equipment	a (1,0) industry dummy if works in industry	T
Manufacture of computer, electronic and optical products	a (1,0) industry dummy if works in industry	T
Manufacture of electrical equipment	a (1,0) industry dummy if works in industry	T
Manufacture of machinery and equipment n.e.c.	a (1,0) industry dummy if works in industry	T
Manufacture of motor vehicles, trailers and semi-trailers	a (1,0) industry dummy if works in industry	T
Manufacture of other transport equipment	a (1,0) industry dummy if works in industry	T
Manufacture of furniture; other manufacturing	a (1,0) industry dummy if works in industry	T
Repair and installation of machinery and equipment	a (1,0) industry dummy if works in industry	T
Electricity, gas, steam and air conditioning supply	a (1,0) industry dummy if works in industry	T
Water collection, treatment and supply	a (1,0) industry dummy if works in industry	T
Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	a (1,0) industry dummy if works in industry	T
Construction	a (1,0) industry dummy if works in industry	NT
Wholesale and retail trade and repair of motor vehicles and motorcycles	a (1,0) industry dummy if works in industry	NT
Wholesale trade, except of motor vehicles and motorcycles	a (1,0) industry dummy if works in industry	NT
Retail trade, except of motor vehicles and motorcycles	a (1,0) industry dummy if works in industry	NT
Land transport and transport via pipelines	a (1,0) industry dummy if works in industry	NT
Water transport	a (1,0) industry dummy if works in industry	NT
Air transport	a (1,0) industry dummy if works in industry	NT
Warehousing and support activities for transportation	a (1,0) industry dummy if works in industry	NT
Postal and courier activities	a (1,0) industry dummy if works in industry	NT
Accommodation and food service activities	a (1,0) industry dummy if works in industry	NT
Publishing activities	a (1,0) industry dummy if works in industry	NT
Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	a (1,0) industry dummy if works in industry	NT
Telecommunications	a (1,0) industry dummy if works in industry	NT
Computer programming, consultancy and related activities; information service activities	a (1,0) industry dummy if works in industry	NT
Financial service activities, except insurance and pension funding	a (1,0) industry dummy if works in industry	NT
Insurance, reinsurance and pension funding, except compulsory social security	a (1,0) industry dummy if works in industry	NT

List of variables		Sector
Activities auxiliary to financial services and insurance activities	a (1,0) industry dummy if works in industry	NT
Real estate activities (excluding imputed rents)	a (1,0) industry dummy if works in industry	NT
Imputed rents of owner-occupied dwellings	a (1,0) industry dummy if works in industry	NT
Legal and accounting activities; activities of head offices; management consultancy activities	a (1,0) industry dummy if works in industry	NT
Architectural and engineering activities; technical testing and analysis	a (1,0) industry dummy if works in industry	NT
Scientific research and development	a (1,0) industry dummy if works in industry	NT
Advertising and market research	a (1,0) industry dummy if works in industry	NT
Other professional, scientific and technical activities; veterinary activities	a (1,0) industry dummy if works in industry	NT
Rental and leasing activities	a (1,0) industry dummy if works in industry	NT
Employment activities	a (1,0) industry dummy if works in industry	NT
Travel agency, tour operator reservation service and related activities	a (1,0) industry dummy if works in industry	NT
Security and investigation activities; services to buildings and landscape activities; office administrative, office support and other business support activities	a (1,0) industry dummy if works in industry	NT
Public administration and defence; compulsory social security	a (1,0) industry dummy if works in industry	P
Education	a (1,0) industry dummy if works in industry	P
Human health activities	a (1,0) industry dummy if works in industry	P
Social work activities	a (1,0) industry dummy if works in industry	P
Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	a (1,0) industry dummy if works in industry	NT
Sports activities and amusement and recreation activities	a (1,0) industry dummy if works in industry	NT
Activities of membership organisations	a (1,0) industry dummy if works in industry	NT
Repair of computers and personal and household goods	a (1,0) industry dummy if works in industry	NT
Other personal service activities	a (1,0) industry dummy if works in industry	NT
Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	a (1,0) industry dummy if works in industry	NT
Activities of extra-territorial organisations and bodies	a (1,0) industry dummy if works in industry	NT
Geographical variables		
Centrality dummy group by eighth centrality levels		
Regional unemployment rate	log unemployment rate in region	
Country of origin dummies		
Norway	a (1,0) country dummy if from Norway	
Rest of Nordic countries	a (1,0) country dummy if from other Nordic countries	
Baltic and Polen	a (1,0) country dummy if from Baltic countries or Polen	
Rest of Europe	a (1,0) country dummy if from other European countries	
Rest of the World	a (1,0) country dummy if from countries outside Europe	
Education dummies		
No education and pre-school education	a (1,0) education dummy if highest education level	
Primary education	a (1,0) education dummy if highest education level	
Lower secondary education	a (1,0) education dummy if highest education level	
Upper secondary education, basic education	a (1,0) education dummy if highest education level	
Upper secondary, final year	a (1,0) education dummy if highest education level	
Post-secondary non-tertiary education	a (1,0) education dummy if highest education level	
First stage of tertiary education, undergraduate level	a (1,0) education dummy if highest education level	
First stage of tertiary education, graduate level	a (1,0) education dummy if highest education level	
Second stage of tertiary education (postgraduate education)	a (1,0) education dummy if highest education level	
Unspecified	a (1,0) education dummy if highest education level	

Table A.3: Definition of education codes relevant for the OG

Education code (NUS)	Name Education code	Education Level	OG Workers	Not OG Workers
558405	Vocational school education, well service	Low	7	0
558404	Vocational school education, drilling	Low	49	1
558403	Technical vocational school, petroleum production programme, two-year	Low	255	24
458402	Drilling operations, upper secondary level 3 (Vg3)	Low	225	30
458406	Well drilling and rigging, cementation, upper secondary level 3 (Vg3)	Low	58	8
458405	Well drilling and rigging, completions, upper secondary level 3 (Vg3)	Low	106	18
358401	Well technology, upper secondary level 2 (Vg2)	Low	57	10
458403	Well drilling and rigging, coiled tubing, upper secondary level 3 (Vg3)	Low	307	61
558402	Technical vocational school, petroleum production programme	Low	161	40
455246	Cranes and lifting equipment, upper secondary level 3 (Vg3)	Low	118	37
558401	Technical vocational school, drilling technology programme	Low	320	112
458407	Oil production engineering, upper secondary, final year	Low	20	13
455140	Remote operated vehicle operations, upper secondary level 3 (Vg3)	Low	9	6
455308	Gunsmithing, Advanced Course III	Low	16	29
358402	Oil production technology, upper secondary, basic education	Low	72	167
455212*	Tanning, upper secondary level 2 (Vg2) and upper secondary level 3 (Vg3), special pathway	Low	539	1387
555105	Technical vocational school, process engineering	Low	139	407
452201	Chemical processing, upper secondary level 3 (Vg3)	Low	728	2232
458410	Well drilling and rigging, sea-floor installations, upper secondary level 3 (Vg3)	Low	7	26
455102	Automation, upper secondary level 3 (Vg3)	Low	544	2210
455224	Maritime engineering, upper secondary, final year	Low	54	262
555202	Maritime engineering, post-secondary non-tertiary education	Low	161	818
455139	Automation, upper secondary level 4 (Vg4)	Low	173	971
455232	NDT inspection, upper secondary level 3 (Vg3)	Low	23	130
455302	Instrument and toolmaker, upper secondary level 3 (Vg3)	Low	61	365
552202	Technical vocational school, chemistry and processing, two-year	Low	10	60
555101	Technical vocational school, automation technology programme	Low	81	573
455216	Industrial machinery mechanics, upper secondary level 3 (Vg3)	Low	919	6765
555205	Technical vocational school, mechanical engineering programme	Low	728	5689
555207	Technical vocational school, technical operations	Low	30	251
455229	Engine mechanic, upper secondary level 3 (Vg3)	Low	51	433
555201	Sole engineer course	Low	14	128
455116	Flight systems mechanic, upper secondary level 4 (Vg4)	Low	22	203
455226	Materials management, Advanced Course II	Low	302	2791
455231	Ship engine mechanic, upper secondary level 3 (Vg3)	Low	115	1091
481304	Training for ships mates	Low	19	184
355216	Marine workshop processes, Advanced Course I	Low	76	761
554101	Technical vocational school, computer science programme	Low	22	226
481399	Maritime navigation, unspecified, upper secondary, final year	Low	6	69
355210	Marine engineer trainee programme	Low	16	194
455225	Machine operation, Advanced Course II	Low	459	5595
481302	Seaman, upper secondary level 3 (Vg3)	Low	318	3936
483202	Training for stewards, upper secondary, final year	Low	57	720
355108	Refrigeration technology, upper secondary, basic education	Low	9	116
552201	Technical vocational school, chemical engineering programme	Low	21	280
381305	Course for third mates	Low	19	265
455113	Aircraft engine mechanic, upper secondary level 4 (Vg4)	Low	6	84
455230	Motorcycle repair, upper secondary level 3 (Vg3)	Low	12	171
482901	Safety and security services, upper secondary level 3 (Vg3)	Low	27	385
555209	Technical vocational school, mechanical engineering programme, two-year	Low	27	381
559902	Technical vocational school, unspecified subject group	Low	17	240
455115	Avionics systems repair and maintenance, Advanced Course III	Low	6	86
452202	Laboratory work, upper secondary level 3 (Vg3)	Low	52	755
481902	Training for telegraph operators	Low	37	541
455109	Technical aeronautics, upper secondary level 3 (Vg3)	Low	76	1133
457113	Industrial plumbing, upper secondary level 3 (Vg3)	Low	187	2846
555107	Technical vocational school, electronics programme, two-year	Low	40	603
457123	Scaffolding, upper secondary level 3 (Vg3)	Low	71	1108
352204	Chemical processing, upper secondary level 2 (Vg2)	Low	6	96
355208	Machine and mechanic trades, two-year foundation course	Low	24	387
455203	Automation engineering, Advanced Course II	Low	117	1887
555103	Technical vocational school, energy technology programme	Low	13	217

Education code (NUS)	Name Education	Education Level	OG Workers	Not OG Workers
555206	Technical vocational school, welding technology programme	Low	23	390
455101	Avionics, upper secondary level 3 (Vg3)	Low	16	277
581303	Technical vocational school, transport engineering programme	Low	11	192
381399	Maritime navigation, unspecified, upper secondary, basic education	Low	24	425
455121	Service electronics, maritime electronic systems, Advanced Course II	Low	7	125
581304	Technical vocational school, maritime trades with specialization in nautical/fishery subjects	Low	44	801
455202	Construction and production machinery mechanics, upper secondary level 3 (Vg3)	Low	51	1019
544201	Kitchen and restaurant management, one-year	Low	9	180
555102	Technical vocational school, electrical power technology programme	Low	245	4813
581301	Ships master course	Low	70	1386
371101	Fishing and general seamanship, upper secondary level 2 (Vg2)	Low	9	192
381304	Course for deck/engine cadets	Low	16	342
455199	Electrical and electronic subjects, unspecified, upper secondary, final year	Low	146	3184
457112	Industrial painting, upper secondary level 3 (Vg3)	Low	53	1142
455244	Automation engineering, Advanced Course III	Low	35	788
555106	Technical vocational school, electronics programme	Low	195	4303
555203	Technical vocational school, automotive engineering programme	Low	34	763
549911	Business and administration training with data processing	Low	11	251
501102	Preparatory course for college of engineering, county	Low	143	3435
455234	Sheet metal, welding and steel construction trades, upper secondary, final year	Low	285	7027
541199	Business and administration, unspecified, post-secondary non-tertiary education	Low	11	277
581305	Technical vocational school, maritime trades with specialization in nautical/fishery subjects, two-year	Low	28	732
355101	Automation, upper secondary level 2 (Vg2)	Low	41	1104
355102	Electrical trades, foundation course	Low	37	1003
455107	Power-supply operation, upper secondary level 3 (Vg3)	Low	299	8185
471101	Fishing and general seamanship, upper secondary level 3 (Vg3)	Low	13	364
355299	Mechanical subjects, unspecified, upper secondary, basic education	Low	171	5017
358107	Training in cookery, upper secondary, basic education	Low	35	1038
455103	Electrical installation and maintenance, upper secondary level 3 (Vg3)	Low	611	17707
455228	Metal component production, Advanced Course II	Low	99	2891
455239	Welding, upper secondary level 3 (Vg3)	Low	44	1294
469907	Institutional cleaning, upper secondary level 3 (Vg3)	Low	142	4180
355104	Electrical power, upper secondary level 2 (Vg2)	Low	84	2566
357118	Technical drawing, two-year foundation course	Low	6	182
455222	Agricultural machinery mechanics, upper secondary level 3 (Vg3)	Low	83	2489
355199	Electrical and electronic subjects, unspecified, upper secondary, basic education	Low	38	1193
355209	Machine skills, Advanced Course I	Low	127	3970
455233	Sheet metal work, upper secondary level 3 (Vg3)	Low	56	1774
455106	Power-supply fitter, upper secondary level 3 (Vg3)	Low	35	1116
455108	Aircraft mechanic, upper secondary, final year	Low	9	293
457116	Mapping and surveying, Advanced Course II	Low	11	356
359904	Apprentice school	Low	62	2040
358104	Hotel and food processing trades, foundation course	Low	14	487
455125	Service electronics, radio communications systems, Advanced Course II	Low	15	515
455243	Construction and production machinery mechanics, upper secondary level 4 (Vg4)	Low	13	476
343201	Commercial subjects, two-year foundation course	Low	35	1297
355211	Engineering and mechanical trades, foundation course	Low	91	3436
381902	Training for telegraph operators, upper secondary, basic education	Low	32	1198
452203	Metallurgical processes, Advanced Course II	Low	71	2639
455299	Engineering and mechanical trades, unspecified, upper secondary, finishing course	Low	50	1899
558102	Technical vocational school, food processing programme	Low	14	523
455205	Motor vehicle, heavy vehicles, upper secondary level 3 (Vg3)	Low	61	2409
455238	Blacksmithing, upper secondary level 3 (Vg3)	Low	6	234
482199	Military subjects, unspecified, upper secondary, final year	Low	30	1181
543199	Secretarial training, unspecified, post-secondary non-tertiary education	Low	72	2780
543101	Secretarial training, one-year	Low	164	6728
357119	Technical drawing, Advanced Course I	Low	25	1044
355207	Motor vehicles, upper secondary level 2 (Vg2)	Low	85	3709
357115	Technical building trades, foundation course	Low	11	489

Education code (NUS)	Name Education	Education Level	OG Workers	Not OG Workers
381402	Transport services, Advanced Course I	Low	7	307
455105	Electrical repair, upper secondary level 3 (Vg3)	Low	8	364
455204	Motor vehicle, light vehicles, upper secondary level 3 (Vg3)	Low	304	13599
455208	Motor vehicle body repair, upper secondary level 3 (Vg3)	Low	76	3391
359903	Industrial and manufacturing work, upper secondary, basic education	Low	32	1457
455241	Toolmaker, upper secondary level 3 (Vg3)	Low	20	943
355217	Sheet metal, welding and steel construction trades, upper secondary, basic education	Low	9	451
401103	General secondary school education, upper stage	Low	346	17448
441107	Supervisor training for skilled workers	Low	12	615
455138	Computer electronics, upper secondary level 4 (Vg4)	Low	30	1518
501101	Preparatory course for university or college education	Low	107	5570
582199	Military subjects, unspecified, post-secondary non-tertiary education	Low	35	1965
355213	Sheet metal work and welding, Advanced Course I	Low	23	1364
357901	Construction machinery operation, Advanced Course I	Low	9	530
359999	Natural sciences, vocational and technical subjects, other, unspecified, upper secondary, basic education	Low	120	6940
455120	Service electronics, audio and video systems, Advanced Course II	Low	30	1762
658499	Mining and extraction, unspecified, undergraduate level	Medium	21	4
656202	Bachelor degree, resource geology, three-year	Medium	15	5
655206	College degree in engineering, petroleum engineering, three-year	Medium	134	65
655217	Bachelor degree, engineering, petroleum engineering, three-year	Medium	102	71
658403	College of maritime studies, offshore programme for stability and technical managers	Medium	6	5
658402	Maritime college, petroleum programme	Medium	18	26
656299	Geophysics, unspecified, undergraduate level	Medium	49	82
652213	Bachelor degree, oil and gas, three-year	Medium	12	24
659924	Bachelor degree, engineering, unspecified major, three-year	Medium	6	12
652209	Supplementary education for engineers, chemistry	Medium	98	305
656103	Bachelor degree, geology, three-year	Medium	10	36
655204	College degree in engineering, maritime, three-year	Medium	8	29
659912	College degree in engineering, three-year, unspecified subject group	Medium	198	789
655220	College diploma, mechanical engineering, two-year	Medium	31	137
655210	Supplementary education for engineers, mechanical engineering	Medium	103	460
651506	College degree in engineering, aquaculture technology, three-year	Medium	12	55
631908	Bachelor degree, social sciences and personal management, three-year	Medium	30	149
656199	Geology, unspecified, undergraduate level	Medium	8	42
681305	Maritime college, ship administration programme	Medium	8	50
655299	Mechanical subjects, unspecified, undergraduate level	Medium	281	1817
631906	Social studies, two-year course	Medium	51	332
681303	College degree, nautical studies, three-year	Medium	34	235
681304	Maritime college, maritime operations, nautical programme, two-year	Medium	45	312
681399	Maritime navigation, unspecified, undergraduate level	Medium	36	261
681909	Bachelor degree, logistics, three-year	Medium	11	87
652299	Chemistry, unspecified, undergraduate level	Medium	63	527
682901	College degree in engineering, safety, three-year	Medium	22	189
655214	Bachelor degree, technical marine operations, three-year	Medium	7	62
659907	College degree, technical and business programme, three-year	Medium	7	67
651406	College degree, environmental and resource studies, three-year	Medium	27	268
682903	Bachelor degree, engineering, safety and security, three-year	Medium	14	144
641119	College degree in engineering, practical economics and management, three-year	Medium	11	117
655213	Bachelor degree, engineering, machinery, three-year	Medium	95	1030
655205	College degree in engineering, mechanical engineering, three-year	Medium	263	3220
681902	College degree, transport economics and logistics, three-year	Medium	14	176
652211	Bachelor degree, engineering, chemical engineering, three-year	Medium	25	320
682999	Safety and security, other, unspecified, undergraduate level	Medium	7	94
655105	Supplementary education for engineers, electrical engineering	Medium	22	329
655207	Engineering programme, mechanical engineering, two-year	Medium	388	6072
699902	Cand.mag. degree, unspecified	Medium	71	1115
651408	Environmental studies, undergraduate level	Medium	6	99
652205	Engineering programme, chemistry, two-year	Medium	84	1398
656999	Earth sciences, other, unspecified, undergraduate level	Medium	6	101
652204	College degree in engineering, chemistry, three-year	Medium	51	906
655101	Engineering programme, electrical engineering, two-year	Medium	273	5290

Education code (NUS)	Name Education	Education Level	OG Workers	Not OG Workers
659999	Natural sciences, vocational and technical subjects, other, unspecified, undergraduate level	Medium	472	10255
641158	Master of Business Administration (MBA), one-year	Medium	10	227
641131	Business and economics degree, four-year	Medium	566	13234
655102	College degree in engineering, electrical engineering, three-year	Medium	231	5614
641135	Business administration, 3rd year, unspecified	Medium	55	1442
641127	Degree in auditing, higher level, one-year	Medium	51	1366
669913	Supplementary education for the health and social services sector, workplace oriented health care	Medium	6	168
641134	Supplementary education for engineers, business administration	Medium	31	904
654115	Engineering programme, computer science, two-year	Medium	41	1205
681309	Bachelor degree, nautical studies, three-year	Medium	9	274
641115	College degree, business and administration, two-year	Medium	265	8927
637103	Study of law, undergraduate level	Medium	48	1686
641106	Bachelor of Business Administration	Medium	157	5368
631101	Administration and organization theory, undergraduate level	Medium	9	320
654114	College degree in engineering, computer science, three-year	Medium	93	3293
655199	Electrical and electronic subjects, unspecified, undergraduate level	Medium	41	1487
659902	Cand.mag. degree, natural sciences and technology/engineering	Medium	75	2666
682199	Military subjects, unspecified, undergraduate level	Medium	171	6489
641133	Tax auditor programme, part 2	Medium	9	344
657102	College degree, land consolidation, two-year	Medium	6	238
631110	College degree, public administration, two-year	Medium	6	250
641130	Accounting programme, three-year	Medium	59	2501
642202	Bachelor of Marketing, three-year	Medium	18	757
655106	Bachelor degree, engineering, electrical engineering, three-year	Medium	46	1978
661108	Supplementary education in nursing, anaesthesia	Medium	8	358
611101	English, undergraduate level	Medium	24	1201
611115	German, undergraduate level	Medium	8	398
654116	Supplementary education for engineers, information and computer technology	Medium	16	788
657103	College degree in engineering, building, three-year	Medium	58	2811
649999	Business and administration, other, unspecified, undergraduate level	Medium	85	4366
641999	Business and administration, other, unspecified, undergraduate level	Medium	182	9703
689999	Transport and communications, safety and security and other services, other, unspecified, undergraduate level	Medium	35	1965
641141	Bachelor degree, economics and administration, three-year	Medium	78	4396
657104	Engineering programme, building, two-year	Medium	91	5363
699999	First stage of tertiary education, undergraduate level, unspecified field of study	Medium	81	4732
752212	Graduate engineering degree, petroleum engineering	High	413	267
752221	Master degree, technology, petroleum engineering, two-year	High	52	38
756211	Master degree, technology, earth sciences and petroleum engineering, five-year	High	81	67
756103	Cand.scient. degree, geology	High	453	405
756205	Graduate engineering degree, earth sciences and petroleum engineering	High	153	155
752203	Cand.techn. degree, petroleum engineering	High	12	14
852202	Dr.ing. degree, geology and petroleum engineering	High	8	10
756101	Cand.real. degree, geology	High	72	99
758401	Graduate engineering degree, mining programme	High	108	149
752211	Graduate engineering degree, metallurgy	High	354	608
752222	Master degree, petroleum engineering, two-year	High	7	12
752223	Master degree, process engineering, two-year	High	8	16
755206	Master of Science, petroleum engineering, two-year	High	7	14
741114	Graduate engineering degree, petroleum economics	High	26	53
755209	Graduate engineering degree, offshore engineering	High	116	237
756107	Master degree, geology, two-year	High	11	24
756901	Master degree, earth sciences, two-year	High	51	126
756207	Cand.scient. degree, geophysics	High	106	269
759909	Graduate engineering degree, industrial economics and technology management	High	26	71
755223	Master degree, technology, offshore engineering, two-year	High	39	109
755212	Master degree, technology, engineering design, two-year	High	6	21
755215	Master degree, technology, maritime technology, five-year	High	31	110
858401	Dr.ing. degree, mining	High	15	54
731906	Master of Science, social sciences, two-year	High	8	29

Education code (NUS)	Name Education	Education Level	OG Wor-kers	Not OG Wor-kers
759916	Master degree, technology, industrial economics and technology management, two-year	High	38	169
731912	Master degree, social security, two-year	High	9	49
755113	Master degree, technology, electronics, cybernetics and signal treatment, two-year	High	6	33
756206	Cand.real. degree, geophysics	High	23	131
752210	Graduate engineering degree, chemistry	High	365	2118
755207	Graduate engineering degree, mechanical engineering	High	724	4356
755219	Master degree, technology, product development and production, five-year	High	14	89
754108	Graduate engineering degree, information technology	High	64	416
781301	Graduate degree in maritime studies, 2½ year	High	6	39
759917	Master degree, technology, engineering science and ICT, five-year	High	7	46
753102	Cand.scient. degree, applied and industrial mathematics	High	6	42
752109	Graduate engineering degree, physics	High	45	340
741124	Master degree, change management, two-year	High	8	64
781901	Master degree, logistics	High	16	129
759910	Graduate engineering degree, natural sciences and technical subjects, unspecified subject group	High	182	1492
759912	Graduate engineering degree, process engineering	High	22	184
859999	Natural sciences, vocational and technical subjects, other, unspecified, postgraduate education	High	159	1415
759999	Natural sciences, vocational and technical subjects, other, unspecified, graduate level	High	733	7721
753103	Cand.scient. degree, mathematics	High	27	293
855202	Dr.ing. degree, machine skills	High	12	132
741109	Master of Business Administration (MBA), one-year	High	24	272
741115	Graduate engineering degree, business and administration	High	74	884
759911	Graduate engineering degree, process control	High	16	204
741108	Master of Business Administration (MBA), 1½ year	High	27	348
752104	Cand.scient. degree, physics	High	62	803
751404	Graduate engineering degree, industrial environmental engineering	High	9	119
752202	Cand.scient. degree, chemistry	High	80	1066
759908	Graduate engineering degree, physics and mathematics	High	55	727
859902	Dr.ing. degree, natural sciences, vocational and technical subjects	High	100	1330
755210	Graduate engineering degree, engineering design and production technology	High	47	658
735105	Cand.polit. degree, information science	High	10	148
755103	Graduate engineering degree, electric power engineering	High	40	626
755110	Master degree, technology, energy and environment, five-year	High	6	96
741111	Master of Management, two-year	High	87	1448
859904	Dr.scient. degree, natural sciences, vocational and technical subjects	High	122	2016
741107	Graduate studies for business and economics degree graduates, unspecified	High	13	218
859908	Ph.d.-program, natuaral sciences, vocational and technical subjects	High	43	722
734102	Cand.polit. degree, social economics	High	39	688
741118	Auditing exam, postgraduate level, 1½-year	High	30	546
759914	Master degree, technology, physics, informatics and mathematics, five-year	High	6	112
852201	Dr.ing. degree, chemistry	High	6	111
759915	Master degree, technology, industrial economics and technology management, five-year	High	8	154
855102	Dr.ing. degree, electrical engineering	High	9	173
731101	Cand.polit. degree, administration and organization theory	High	24	526
741121	Master degree, economics and administration, two-year	High	11	245
741125	Business and economics graduate/Master degree, economics and administration, two-year	High	54	1234
741199	Business and administration, unspecified, graduate level	High	202	4881
749999	Business and administration, other, unspecified, graduate level	High	66	1662
755101	Graduate engineering degree, technical cybernetics	High	62	1572
756302	Cand.scient. degree, natural geography	High	8	207
739999	Social sciences and law, other, unspecified, graduate level	High	21	558
741104	Cand.merc. degree, business and administration	High	6	161
754112	Master degree, technology, information and communication technology, two-year	High	13	347
757105	Graduate engineering degree, civil and environmental engineering	High	181	4975
752201	Cand.real. degree, chemistry	High	13	368
741112	Master of Science, business administration, two-year	High	11	318
759913	Graduate engineering degree, technical subjects	High	11	326
755102	Graduate engineering degree, electronics	High	114	3457

Education code (NUS)	Name Education	Education Level	OG Workers	Not OG Workers
759902	Cand.scient. degree, natural sciences and technical subjects, unspecified subject group	High	19	643
799999	First stage of tertiary education, graduate level, unspecified field of study	High	35	1165
899999	Postgraduate education, unspecified field of study	High	20	731
734101	Cand.oecon. degree	High	36	1421
859903	Dr.philos. degree, natural sciences, vocational and technical subjects	High	11	452
752102	Cand.real. degree, physics	High	10	454
754106	Graduate engineering degree, computer engineering	High	19	858
734103	Master degree, social economics, two-year	High	6	307
751902	Cand.scient. degree, biology	High	24	1320

*Possibly a data entry error, code 455221: Skilled operator, chemical/technical industry, Advanced Course II seems more fitting