

Relatedness and the Resource Curse

Is there a liability of relatedness?

Rune Dahl Fitjar

University of Stavanger

Bram Timmermans

Norwegian School of Economics

Abstract

Literature in evolutionary economic geography has emphasized knowledge spillover benefits of co-location with related industries. We draw on resource curse literature to demonstrate that relatedness also comes with costs in the form of labor market competition. Using a case study of a growth period in the Norwegian petroleum industry, we show that this had positive as well as negative implications for related industries. Industries related to petroleum grew faster than unrelated industries over the period. However, they also suffered from high labor costs and loss of human capital. Related industries had to pay higher wages than unrelated industries, even after controlling for worker characteristics. Furthermore, several of their employees, in particular the most productive ones, left for the petroleum industry. The relationship between petroleum and related industries is asymmetric insofar as workers tend to leave related industries for petroleum at higher rates than vice versa. Furthermore, the petroleum industry recruits the most productive workers from related industries and returns its least productive workers. Overall, this could potentially lead to deskilling in related industries which could more than outweigh any potential knowledge spillover benefits from their relatedness to the petroleum industry. Consequently, we argue that relatedness is not an even playing field: There may be losers, as well as winners, from relatedness.

Keywords: Relatedness, resource curse, petroleum, labour mobility, Norway

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INTRODUCTION

The question of how industries within a region affect each other is central in evolutionary economic geography, especially in the relatedness literature. Regional industries may benefit from cross-industry knowledge spillovers, particularly when they build on related skills. Such knowledge spillovers may be more important than intra-industry spillovers, as cross-fertilization of ideas across industries may stimulate Schumpeterian new combinations and innovation, provided they can communicate effectively (Nooteboom 2000). This in turn gives rise to regional branching, as new industries emerge from existing capabilities in areas technologically related to the region's existing strengths (Boschma and Frenken 2009).

The near-consensus on the positive contributions of relatedness to regional economic growth (Frenken et al 2007), resilience (Diodato and Weterings 2015), and the performance of individual firms (Eriksson 2011; Timmermans and Boschma 2014) has made this perspective central in regional economic policies (McCann and Ortega-Argilés 2015). However, relatedness between industries is often identified from the application of similar resources and technologies, e.g. flows of resources or co-occurrence of technologies between industries (Neffke and Henning 2013; Essletzbichler 2015). This implies that related industries also compete on factor markets. Such competition, however, has not received much attention within evolutionary economic geography. While relatedness might facilitate inter-industry knowledge spillovers, it might also entail inter-industry competition which makes it harder for related industries to access important inputs. This is particularly a risk when there are large power asymmetries between industries (for example if dominant industries divert resources away from smaller ones). This can potentially lead to a decline in the related industries by decreasing regional diversification and subsequently lowering inter-industry knowledge spillovers.

How dominant industries, specifically natural resource industries, affect other industries in an economy is a core issue within the resource curse literature. This literature paints a bleaker picture of this relationship by highlighting the negative effects of dominant resource industries on other tradable sectors. These negative effects are related to macro-economic and political-institutional dynamics, and to labor-market competition due to the higher wages in natural resource industries (Venables 2016). Rather than regional branching, this typically leads to de-branching and increasing specialization in resource economies, making them vulnerable to sudden shifts in natural resource market prices.

This paper integrates these two bodies of literature to examine how the growth of a dominant resource-based industry affects other industries. In doing so, it aims to contribute to both the relatedness and the resource curse literatures. The former has tended to overlook the potential liabilities of being related to growing industries, e.g. in terms of labor-market competition. The latter has not considered whether negative effects might play out differently for industries which are skill-related or unrelated to the resource industry. If competition for skilled labor is an issue, this should be more severe for industries relying on related skills than for those that rely on unrelated skills.

We examine the Norwegian petroleum industry in 2004-2011, a period of significant growth in the industry. Norway has largely managed to escape the macro-economic and political-institutional dynamics of the resource curse (Larsen 2006; Mehlum et al. 2012). This allows us to isolate the labor-market implications of resource extraction as much as possible. We conduct the study at the national scale and within the main petroleum hub, Stavanger, in order to examine impacts of co-location. We focus on a period of rising oil prices in an already oil-intensive national and regional economy. This enables an analysis of what happens to other industries as

the petroleum industry expands. We identify industries related to the oil industry based on labor mobility patterns, using linked employer-employee data from Norwegian registers. Subsequently, we examine employment levels and mobility patterns between the petroleum industry and other industries, distinguishing between petroleum-related and petroleum-unrelated tradable industries, as well as non-tradable industries.

The analysis shows that industries related to petroleum grew more than unrelated industries during the period. This suggests that they benefited overall from being related to a growing industry. However, relatedness also came with costs in the form of rising salaries and deskilling. Related industries had significantly higher labor costs than unrelated industries, even when controlling for worker characteristics. Furthermore, related industries lost workers to the petroleum industry at a much higher rate than unrelated industries, and more workers moved from related industries into petroleum than vice versa. The petroleum industry also tended to selectively poach the most productive workers from related industries, while its least productive workers moved the other way.

In the following section, we present an overview of the literature regarding relatedness and the resource curse. Subsequently, we bring the two literatures together by exploring positive and negative implications of relatedness to resource industries. Next, we present our empirical research strategy by describing the available data, our relatedness measure and the Norwegian petroleum industry. In Section 4, we examine labor mobility patterns between petroleum and other industries, followed by a regression analysis of the characteristics of workers moving between industries in Section 5. Section 6 concludes the study.

THEORY

Relatedness and regional economic development

Within a relatively short time-span, the concepts of related variety and relatedness have achieved a central position in evolutionary economic geography. The concepts combine features of Marshall-Arrow-Romer (MAR) and Jacobian externalities (Frenken et al 2007), while simultaneously being heavily inspired by the work of Nooteboom (2000) and Boschma (2005) on the role of (cognitive) proximity in supporting interactive learning. Studies investigating the effects of related variety on regional economic performance have focused on various regions within Europe (Frenken et al 2007; Boschma & Iammarino 2009; Boschma et al 2012; Hartog et al 2012; Bishop & Gripaos 2010; Boschma et al 2014; Van Oort et al., 2015) and the United States (Essletzbichler 2015) and have covered nearly all industries. The overall conclusion is that, despite some industry variation, related variety tends to positively affect employment growth.

The concept of relatedness has also been applied to describing, understanding, and predicting changes in the regional industrial composition (Frenken & Boschma, 2007; Neffke et al., 2011; Boschma & Gianelle, 2013). The underlying process is regional branching, where the existing industry composition creates opportunities for the entry of new related sectors (Boschma & Frenken 2009). The existing industrial structure consists of a set of competences, which can form fertile ground for the establishment of new industries (Neffke et al., 2011; Boschma et al., 2013). Given these properties, the concept of relatedness has increasing policy relevance, notably in smart specialization (McCann & Ortega-Argiles 2015).

More recently, studies of industry decline (Holm et al 2017; Eriksson et al 2016) have used relatedness to explain why some areas cope better with economic shocks than others (Diodato & Weterings 2015; Holm & Østergaard 2015). Holm et al (2017) investigate how the presence of related industries in the region affects job re-allocation and skill destruction. They demonstrate

that related industries positively affect the likelihood of displaced workers finding new employment and mitigate skill destruction, as wage levels are hardly affected. Eriksson et al (2016) show similar patterns. Diodato & Weterings (2015) further demonstrate that Dutch regions with high levels of related variety recover faster from economic shocks. These regions absorb laid off workers faster due the demand for similar skills by related industries. However, the effect does not seem to hold universally (Holm & Østergaard 2015).

Notwithstanding these positive externalities of being located in the proximity of related industries, negative externalities might also exist. After all, there are rarely any free lunches in economics, and the costs and benefits of relatedness may be unequally distributed across industries. Strong interdependencies among related industries could cause labor market frictions. Related industries, due to their overlap in products and technologies, rely on employees with similar skills. Consequently, to the same extent that displaced workers can find new employment in related industries when an industry is declining, there will be rivalry for (skilled) labor between related industries when an industry is growing. This is particularly the case for co-located industries, as social forces limit employees' willingness to move to a job somewhere else (Dahl & Sorenson 2010).

Such frictions are not uncommon, especially when an industry is dominant or booming. Moreover, these frictions might influence not only related industries, but also the development of new economic activities. For example, Sørensen (2004) demonstrates that nascent entrepreneurs in booming industries have difficulties mobilizing labor, as all available labor in the region is already allocated to the incumbent firms within the industry.

The resource curse

Indeed, frictions between industries are central in the resource curse literature. An important claim is that economies dominated by a resource-intensive industry will experience reduced competitiveness in other tradable industries (Harding and Venables 2016). This is partly due to macro-economic effects. Resource exports will lead to currency overvaluation, making the products of other tradable industries more expensive on the world market (Sachs and Warner 2001; van der Ploeg 2011). It is also because of political and institutional effects, as natural resources may breed conflict and delay institutional development (Karl 1997; Collier and Hoeffler 2004). However, a third aspect of the resource curse hypothesis, and one that is particularly relevant in this context, is that factors of production are drawn into resource extraction. They are also drawn to non-tradable sectors, which tend to expand in response to increased domestic spending due to activities in the resource sector (Corden and Neary 1982; Black et al. 2005). This makes it more difficult for other tradable industries to access capital and labor. These effects are more severe when employment levels are high (Venables 2016). More generally, the resource curse literature is the story of how the prosperity of one sector damages other sectors in the economy. Due to increasing revenues, the dominant (or booming) industry is able to attract capital and labor at the expense of other sectors (Corden 1984).

While the resource curse literature highlights an aspect of industrial dynamics that the relatedness literature largely overlooks, it retains blind spots of its own. For instance, the central element in relatedness, namely knowledge spillovers between different industries, has until recently not been considered (Bjørnland and Thorsrud 2016; Cust et al. 2017). Relatedness between industries has also largely not been analysed, as the literature has focused on the implications of resource extraction for other tradable industries in general. However, industries which are related to resource-based industries would, based on the insights from the relatedness literature, be

expected to be more strongly affected than unrelated industries. They could expect more positive externalities from knowledge spillovers, but also more negative externalities from resource competition, as they depend on more similar inputs, for example employees with related skills. Similar issues have been taken up in recent research. Allcott and Keniston (2018) analyse differences between manufacturing industries with and without supply-chain linkages to oil and gas, finding that industries with such linkages tend to grow during petroleum booms, while unlinked tradables decline. Similarly, Bahar and Santos (2018) find that natural resources tend to drive more specialization also in the non-resource part of a country's export portfolio. They ascribe this mostly to the upwards pressure on wages, reducing competitiveness in labor-intensive sectors.

The resource curse literature has also mainly examined dynamics at a national level, although there is a growing literature on regional dynamics. While the macro-economic implications of resource extraction, as well as political-institutional effects¹, play out mainly at the national level, this is not the case for resource competition. Competition for labor has a strong regional dimension when geographical mobility is limited. The economic geography literature would thus predict stronger effects for related industries which are co-located with the petroleum industry, while geographical distance would imply that industries in less petroleum-specialised regions are partly shielded from this impact. In line with this, research on US counties have found that wages in manufacturing industries are higher in petroleum regions, in particular during petroleum booms (Michaels 2011; Kuralbayeva and Stefanski 2013; Allcott and Keniston 2018). However, several studies have linked this to lower growth and per capita incomes in petroleum regions in

¹ Although on political and institutional implications of oil extraction at the regional level, see e.g. Caselli and Michaels (2013), Dube and Vargas (2013), and Fitjar (2010; 2013).

the long term, e.g. due to crowding out of other tradable industries (Papyrakis and Gerlagh 2007; James and Aadland 2011; Haggerty et al. 2014; Jacobsen and Parker 2016). Some studies in other country contexts (Domenech 2008; Aragón and Rud 2013) – as well as some from the US (Michaels 2011; Allcott and Keniston 2018) – have found more positive effects.

Integrating the perspectives: A curse of relatedness?

Bringing the two perspectives together, we can expect petroleum industries to have positive and negative impacts on related industries. The positive effects derive mainly from the knowledge spillover and agglomeration effects emphasized in the relatedness and broader economic geography literatures. The negative effects arise from the resource competition and crowding out dynamics highlighted in the resource curse literature. Hence, the overall impact on related industries will depend on the relevance of each of these factors for the industry in question. In the following paragraphs, we highlight these in turn to provide an integrated story of some potential economic implications of relatedness to a growing resource extraction industry.

Most obviously, the entry of petroleum industries is associated with an increase in demand, which will benefit both local non-tradable industries and tradable industries which supply some of their output to the local market. Industries which can enter the supply-chain of the petroleum industries will benefit from this, while industries without supply linkages will not be affected (Allcott and Keniston 2018). The increase in demand will also entail growth in the local labour market, which produces agglomeration effects that could increase productivity in the economy as a whole (Michaels 2011).

The petroleum industry could also play a role in human capital accumulation in the regional economy. High wages and good employment opportunities in the industry will create incentives

for workers to obtain relevant education and training, and also promote migration of skilled workers to the region. This implies that industries depending on related skills will have access to a larger local pool of qualified workers. Related industries could expect to benefit more from knowledge spillovers from the petroleum industry. Such knowledge spillovers tend to be bounded in geographical and knowledge space, meaning that industries which are geographically and cognitively close to the petroleum industry would benefit more. Mobility of workers between petroleum and related industries would further facilitate these processes.

On the negative side, natural resource sectors pull resources from other sectors to fuel their growth. The attractiveness of these resources will, as the relatedness literature suggests, not be uniformly distributed over an economy. The petroleum industry demands workers with a particular set of skills and industry experience, which are more often to be found in skill-related industries. These industries will therefore face challenges in retaining workers, as these possess skills which are in demand in the oil industry. They will also struggle to recruit new workers, as they are looking for workers with similar characteristics as those in demand in the oil industry. This will drive up salaries in related industries more than in industries which do not demand the same types of skills.

However, related industries will not be able to match the salaries in the petroleum industry itself, where resource rents allow firms to pay premium salaries. Consequently, the petroleum industry would be able to poach more productive workers, while related industries cannot attract the best workers from the oil companies. Over time, this could lead to deskilling in related industries, as their productive workers are constantly leaving and being replaced by either less productive workers arriving from the oil industry or new entrants to the regional labor market. Combined with the mechanisms discussed above, this would imply that they have to pay higher salaries for

less productive employees. These dynamics will be stronger for industries which are co-located with the petroleum industry.

At the regional scale, this implies that the presence of resource industries can be both a blessing and a curse. By increasing local demand and replacing less productive industries, petroleum industries will drive up local incomes, economic growth and welfare. Through agglomeration and knowledge spillover effects, this will also enhance productivity in other industries. Since the knowledge spillover and demand effects are more important for related industries, this could also promote related diversification, thereby securing a more diversified industry portfolio and enhancing resilience.

However, the same processes can easily also turn in the opposite direction, in particular in the longer term². Resource industries can drive up the cost of labor, resulting in deskilling of related industries. This reduces competitiveness in these industries, especially for those which do not supply products or services to the resource industry. Rather than regional branching, this could lead to what we might call regional pruning. This entails more path dependent regional development and long-term vulnerabilities. If the related industries that do survive are dependent on the resource industry as a customer, the related variety produced by these would not be associated with more resilience.

² Consistent with this story, Jacobsen and Parker (2016) identify a boom-and-bust cycle where petroleum regions have more positive employment and income growth in the short term, but weaker long-term growth.

RELATEDNESS AND THE NORWEGIAN PETROLEUM INDUSTRY

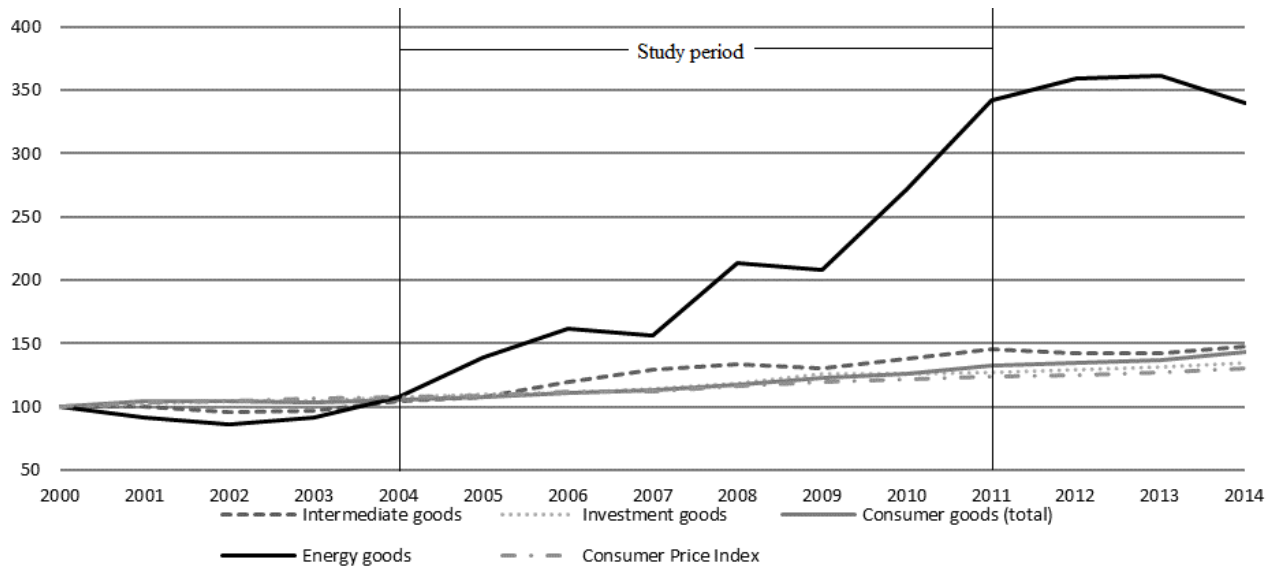
To investigate this issue and demonstrate some of the mechanisms, we present a case study of the petroleum industry in Norway during the period 2004 to 2011.³ We examine the dynamics in the country as a whole, as well as in the main agglomeration of the oil industry, Stavanger. This is a useful example for illustrating the above mechanisms due to the presence of several key characteristics: First, petroleum is a dominant industry in Norway. In 2012, it accounted for more than half of exports and 23 percent of GDP (Norwegian Petroleum Directorate (NPD) 2013), up from 47 percent of exports and 21 percent of GDP in 2004 (NPD 2005). In 2011, Norway was the world's seventh largest exporter of oil and third largest exporter of gas (NPD 2013), a position similar to 2004 (NPD 2005). Thus, over our period of observation, the petroleum industry has further strengthened its position as a dominant industry in Norway. The industry is concentrated in Stavanger, with a location quotient of 5.15 in 2004 and 4.49 in 2011.

Second, the petroleum industry is a tough competitor in the labor market due to resource rents that allow it to pay premium prices for labor. Norway had a remarkably low level of unemployment throughout this period and there was thus high competition for labor among employers. From 2004 to 2011, the unemployment rate declined from 3.9 to 2.7 percent, bottoming out at 1.7 percent in 2008. In Rogaland County, where Stavanger is located, the unemployment rate dropped from 3.7 percent in 2004 to 1.1 percent in 2007, before increasing to 2.0 percent in 2011. Third, investments and hence labor demand in the petroleum industry is heavily affected by oil prices, which grew rapidly from 2004 to 2011 (see Figure 1).

³ We selected this period because of data availability restrictions; however, as Figure 1 illustrates this period closely overlaps a period of strong growth in petroleum prices and hence in the Norwegian petroleum industry.

Consequently, demand for labor increased during this period and the petroleum industry enhanced its already dominant position

Figure 1: Commodity and Consumer Price Index 2000-2014



Source: Statistics Norway

To examine the developments in the petroleum industry and in related industries, we rely on linked employer-employee data for all private sector employees in Norway for the period 2004-2011. This dataset provides complete data on employment in Norwegian industries and regions, as well as on labor mobility across industries. It furthermore provides information concerning salaries and educational attainment, enabling us to examine employees' characteristics. We restrict the analysis to private sector employees⁴ aged 18-65 who work more than 20 hours per week. This leaves a population of 9.7 million worker-year observations, or between 1.15 and 1.30 million per year. The analysis for Stavanger focuses on the labor-market region around

⁴ We exclude employees in NACE rev.1.1 codes 75-91 (public administration, education, health and social services) and NACE 74.50 (recruitment agencies).

Stavanger, including the official statistical regions of Stavanger/Sandnes and Jæren, with around 600.000 observations.

We first identify industries whose core activities are oil and gas exploration and exploitation. This includes industries directly involved in oil and gas extraction, as classified by Statistics Norway (Ekeland 2014; Prestmo et al. 2015): extraction of crude petroleum and natural gas (NACE 11.100), service activities incidental to oil and gas extraction (NACE 11.200), and transport via pipelines (NACE 60.300). In addition, we include industries in which all firms supply goods and services targeted at the petroleum industry, following the broader classification of the Norwegian petroleum industry by Blomgren et al. (2013). This extended definition includes manufacturing of refined petroleum products (NACE 23.200), building and repair of oil platforms and rigs (NACE 35.114 and 35.115), providers of tugboats and supply vessels (NACE 61.106) and offshore supply terminals (NACE 63.224)⁵. We classify all these industries as petroleum industries.

Next, we distinguish between tradable and non-tradable industries following Mano and Castillo (2015). They classify primary industries, mining, manufacturing, wholesale, transport, finance, and business services as tradable industries. Utilities, construction, retail, food and accommodation services, communication services, and real estate are non-tradable industries.

Finally, we identify industries which are related to the petroleum industries. To measure relatedness, we rely on the method of skill relatedness based on labor mobility flows, as introduced by Neffke and Henning (2013). We apply this to Norwegian data by following the approach in Fitjar and Timmermans (2017), but develop the measure using labor mobility flows

⁵ Ekeland (2014) uses a similar definition, although omitting manufacturing of refined petroleum products, and tugboats and supply vessels. We follow Blomgren et al. (2013) in including these as petroleum industries.

for the period 2001-2004. Consequently, the period in which we calculate relatedness is exogenous⁶ from the period of our analysis (2004-2011).

In total, 537 different industries are identified based on 4-digit NACE rev 1.1 codes, giving 287,832 potential industry pairs. We observe actual labor mobility between 48,060 industry pairs during the period. We identify industries as related if the standardised skill-relatedness score is higher than or equal to 0.25. To counter the impact of temporary fluctuation, we impose the additional criterion that standardised skill-relatedness must be higher than or equal to 0 for at least two of the three years of measurement. Applying this measure, 6,185 of the industry pairs are related.

Figure 2 shows industries which are related to any of the petroleum industries⁷. The petroleum industries included in Statistics Norway's narrower definition are highlighted with solid squares, while those additionally included in Blomgren et al.'s (2013) broader definition are highlighted with triangles.

⁶ An alternative approach which is used to obtain an exogenous relatedness matrix is to calculate relatedness using labor mobility in a comparable country. This turns out not to be a viable strategy in this case due to the uniqueness of the Norwegian petroleum industry. Other comparable countries either do not have a petroleum industry (e.g. Sweden and Germany) or have an industry with different skill requirements (e.g. Denmark). Thus, using data from a period preceding that of the analysis is the best option for obtaining an exogenous measure of relatedness. As we measure labor mobility on the basis of yearly changes, the last period used to calculate the relatedness matrix is 2003-04, while the first period used in the study is 2004-05. Hence, there is no overlap between the periods.

⁷ The relatedness matrix is a directed network. However, in the analysis, we include industries with high outbound and/or inbound relatedness to petroleum in our definition of petroleum-related industries. In effect, we therefore transform the matrix into an undirected network. Therefore, Figure 2 also shows undirected edges in the network graph.

CROSS-INDUSTRY LABOR MOBILITY PATTERNS

We classify industries into four sectors: petroleum industries, petroleum-related tradables (all industries in black in Figure 2), petroleum-unrelated tradables (all tradable industries not included in Figure 2), and non-tradables. Aggregating employment over these categories, Table 1 shows their employment trends during the period 2004-2011 at the national level and in the Stavanger region. As there is a structural break in the dataset from 2007 to 2008, due to the transition to NACE rev. 2, we show trends separately for the 2004-07 and 2008-11 periods.⁸

Table 1: Growth of Industries 2004-2007 (2004=100) and 2008-2011 (2008=100)

	2004*	2005	2006	2007	2008*	2009	2010	2011
Norway								
Non-Tradables	100	100	104	106	100	99	98	102
Unrelated Tradables	100	99	101	101	100	97	94	95
Petroleum Related Tradables	100	98	102	106	100	97	94	98
Petroleum	100	110	124	131	100	101	104	108
Total	100	100	103	105	100	98	97	99
Stavanger								
Non-Tradables	100	102	108	113	100	99	101	106
Unrelated Tradables	100	100	105	108	100	99	98	98
Petroleum Related Tradables	100	103	106	115	100	99	95	104
Petroleum	100	97	120	130	100	102	108	122
Total	100	100	110	116	100	99	101	107

*The values in 2004 for Norway as a whole are 449,836, 464,620, 195,732 and 49,390 for respectively non-tradables, unrelated tradables, petroleum-related tradables, and petroleum firms, and 559,259, 430,135, 218,517, and 64,590 in 2008. For the Stavanger region, the equivalent figures are 20,770, 20,370, 11,423, and 14,762 in 2004, and 28,795, 20,072, 14,972, and 17,930 in 2008.

⁸ In the transition from NACE rev. 1.1 to NACE rev. 2, the majority of industries are reassigned new industry codes. However, some industries are split in more detailed industry classes, and a few change sectors, e.g. from manufacturing to services (such as publishing). We therefore see some growth in non-tradables (and corresponding decline in tradables) between 2007 and 2008. This pertains mainly to unrelated tradables, while the vast majority of petroleum-related tradables translate well between the systems and employment numbers are consistent. In making the transition from NACE rev. 1.1 to NACE rev. 2, we rely on the correspondence table provided by RAMON (http://ec.europa.eu/eurostat/ramon/index.cfm?TargetUrl=DSP_PUB_WELC).

Similar to Ekeland (2014), we find an overall increase in petroleum employment. The number of employees in petroleum grew throughout our period of observation, corresponding to the rise of oil prices. The petroleum industry grew faster than other industries, adding a third of all new jobs between 2004 and 2007, compared to a job growth of only 5 percent in the economy as a whole. From 2008 to 2011, it grew by 8 percent, while the economy as a whole lost 1 percent of jobs. As predicted in the resource curse literature, non-tradables grew faster than tradables during the period, expanding by 6 percent from 2004 to 2007, and by 2 percent from 2008 to 2011. Among tradables, however, related industries appeared to benefit. While employment in unrelated tradables grew by only 1 percent from 2004 to 2007, related tradables grew by 6 percent. From 2008 to 2011, unrelated tradables lost 5 percent of jobs, compared to only 2 percent for related tradables. This confirms previous studies highlighting that tradables are hit differently by the presence of a dominant industry and that some tradable industries might benefit from agglomeration effects (Allcott and Keniston 2018).

Stavanger exhibited much stronger employment growth than Norway as a whole, adding 16 percent new jobs from 2004 to 2007, and 7 percent from 2008 to 2011. Stavanger had somewhat similar growth in the petroleum industry from 2004 to 2007 as the national economy, but much stronger from 2008 to 2011. During the latter period, the region's petroleum industry grew by 22 percent. Overall, Stavanger's growth was more balanced, with stronger growth in all other categories than the national economy, even if petroleum was still the largest growth sector. Petroleum-related tradables notably grew by 15 percent from 2004 to 2007, compared to 8 percent for unrelated tradables, suggesting that processes of regional branching were at play. Stavanger's non-tradable sector also expanded by more than the national level, adding 13 percent

more jobs from 2004 to 2007. Developments between 2008 and 2011 follow the same pattern, with non-tradables growing faster than tradables. Among tradables, petroleum-related industries grew by 4 percent in this period, while non-related tradables declined by 2 percent.

The patterns of development in the Norwegian economy thus seem to follow the branching logic of the relatedness literature, growing more strongly in industries which are related to petroleum than in unrelated industries. This is particularly the case at the regional level. Nonetheless, the dominant petroleum industry still grew more strongly than other tradables, even related ones, making the economy even more specialised over the period observed.

The large growth in the petroleum industry also begs the question of where firms recruit the additional labor needed from. To address this, Table 2 examines entries and exits to and from the petroleum industry. Non-petroleum industries tend to have more outflow to petroleum than inflow from this sector. Over the period as a whole, exits to petroleum outnumber entries from petroleum by a ratio of around 1.9 for non-tradables and petroleum-related tradables, and by about 2.2 for unrelated tradables. Furthermore, between 50 and 64 percent of workers who move from non-petroleum industries to petroleum arrive from petroleum-related industries. This demonstrates that workers from petroleum-related industries fuel much of the employment growth in this sector. The pattern is similar in Stavanger, as nearly 2,300 workers left related industries for petroleum over the period, while only 1,600 moved the other way – a ratio of 1.4. However, entries to the oil industry in Stavanger from petroleum firms in other regions also outnumbered exits by more than 400 workers over the period, meeting some of the region's increased labor demand.

Table 2: Annual entries into petroleum and exits from petroleum, number of workers

Norway						
Exits to petroleum	2004	2005	2006*	2008	2009	2010
All non-tradables	476	1,128	1,136	630	636	1,041
Petroleum-unrelated tradables	533	1,220	1,121	550	525	889
Petroleum-related tradables	1,751	2,578	2,678	1,410	1,530	1,953
Petroleum	2,010	3,539	4,613	1,939	2,128	4,055
Total exits to petroleum	4,770	8,465	9,548	4,529	4,819	7,938
Entries from petroleum	2005	2006	2007*	2009	2010	2011
All non-tradables	229	324	453	649	395	575
Petroleum-unrelated tradables	252	399	441	346	466	343
Petroleum-related tradables	670	1,134	1,393	1,048	835	1,237
Petroleum	2,010	3,539	4,613	1,939	2,128	4,055
Total entries from petroleum	3,161	5,396	6,900	3,982	3,824	6,210
Stavanger						
Exits to petroleum	2004	2005	2006*	2008	2009	2010
All non-tradables	75	199	179	110	106	209
Petroleum-unrelated tradables	135	285	321	157	160	288
Petroleum-related tradables	248	541	370	290	338	477
Petroleum	357	990	894	598	494	1,268
Total exits to petroleum	815	2,015	1,764	1,155	1,098	2,242
Entries from petroleum	2005	2006	2007*	2009	2010	2011
All non-tradables	47	68	75	74	90	210
Petroleum-unrelated tradables	71	106	117	97	149	103
Petroleum-related tradables	198	254	297	221	251	370
Petroleum	340	997	1,067	706	495	1,431
Total entries from petroleum	656	1,425	1,556	1,098	985	2,114

* Due to the above-mentioned structural break in industry codes we do not investigate the characteristics of exit in 2007 and characteristics of entry in 2008.

That many workers move to petroleum is not surprising. These industries pay considerably higher wages than other industries.⁹ Figure 3 shows the mean wages in each industry category.

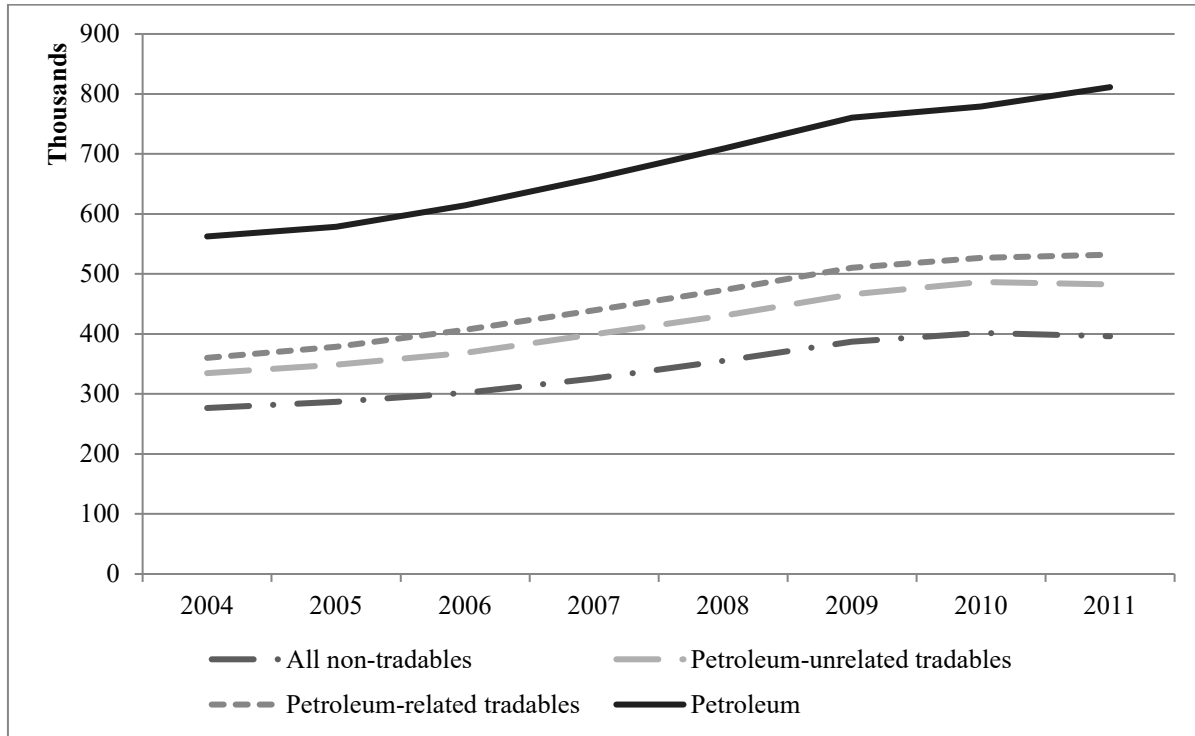
⁹ Admittedly, wages are not the only reason for moving into petroleum. Factors such as opportunities for development and training, the possibility to work with state-of-the-art technology, opportunities for job-related travel, the on- and off-duty work schedule while working offshore, and the expected job security that coincides with periods of growth might all contribute to making the sector attractive. However, research has repeatedly demonstrated wages are the most important factor in accepting a job offer (Rynes et al 2004). Since wage differences are so substantial, this is surely also a large driver of the observed mobility into petroleum.

Throughout the period, the average wage in the petroleum sector¹⁰ was around 50 percent higher than in petroleum-related tradables, two-thirds higher than in petroleum-unrelated tradables and around double the average in non-tradables. The petroleum industry in Stavanger paid higher wages still, around 2.2 times the average of non-tradable wages and three-quarters more than unrelated tradables. Wages in petroleum-related tradables are notably higher than in unrelated ones. This is especially the case in the Stavanger region, where the difference is NOK 105,000 (USD 19,000) in 2011 compared to NOK 50,000 (USD 9000) at the national level. Petroleum-related tradables in Stavanger paid wages above the national average for these industries by between 12 and 15 percent, while the wages in unrelated tradables were only between 1 and 7 percent above the national average. This suggests that petroleum-related industries have to pay premium wages above other tradables due to stronger labor competition from the petroleum industry. Geographical proximity to the industry further increases this wage premium for firms located in the largest oil agglomeration.

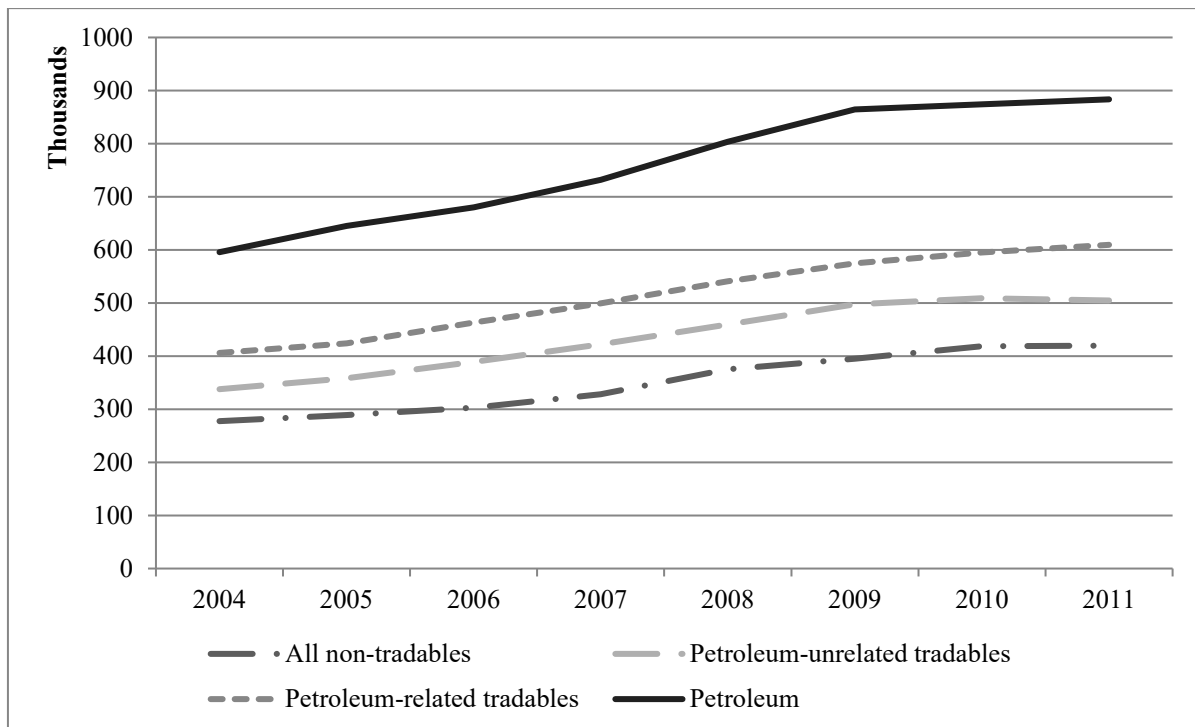
¹⁰ The differences within the petroleum industry are also substantial, in particular between oil and gas extraction firms and other sub-categories. The average wage in oil and gas extraction was NOK 1,037,112 (USD 184,954) in 2011, while other petroleum industries varied from NOK 586,950 (USD 104,674) to NOK 925,800 (USD 165,103).

Figure 3: Mean income levels, by industry types. NOK.
 (NOK 500,000 \approx USD 90,000 at 2011 prices and USD 75,000 at 2004 prices)

Norway



Stavanger



To examine whether this is related to observable differences in the types of workers employed by these industries, Table 3 shows the results of regressing individual salaries on the four industry categories, controlling for other worker characteristics. The analysis reveals that even after controlling for education and demographic characteristics, petroleum-related tradables pay around NOK 28,000 (around USD 5,000 at 2011 prices) higher annual salaries than unrelated tradables. In Stavanger, the difference is NOK 61,000 (around USD 11,000). These differences are still dwarfed by the petroleum industry, which pays around NOK 180,000 (USD 32,000) above the average wage in petroleum-related tradables. In Stavanger, the petroleum industry on average pays annual salaries of more than NOK 200,000 (USD 36,000) above the salaries of equivalent workers in petroleum-related tradables.

Table 3: Regression of annual wages (in 100,000 NOK) on industries, controlling for demographic characteristics

	Norway			Stavanger		
	Coef.	***	Std.	Coef.	***	Std.
Non-tradables (baseline)						
Unrelated tradables	0.363	***	0.002	0.298	***	0.014
Petroleum-related tradables	0.643	***	0.003	0.911	***	0.016
Petroleum	2.472	***	0.005	2.978	***	0.015
Female	-1.016	***	0.002	-1.465	***	0.012
Age	0.023	***	0.000	0.042	***	0.001
Years since graduation	0.015	***	0.000	0.023	***	0.001
College (non-STEM)	1.347	***	0.003	1.694	***	0.016
College (STEM)	1.856	***	0.003	2.384	***	0.017
Constant	1.309	***	0.014	0.826	***	0.029
Year dummies	Yes			Yes		
Region dummies	Yes			No		
R ²	0.21			0.22		
N	9,457,618			601,675		

Significance levels: ***< 0.001; **<0.01; *0.05

WHICH WORKERS MOVE?

The above analyses provide insights into the volume of labor mobility flows across different types of industries and the average salaries within these industries. Besides the number of people that move between industries, we are interested in the characteristics of these workers. Therefore, we use a multinomial logit regression analysis to estimate the likelihood of a worker moving into a sector, depending on their previous sector of employment and their individual characteristics.

The analysis takes on the following form:

$$\text{Logit} [\text{Pr}(\text{Industry}_{i,t} = j)] = \alpha_j + \beta_{1j} \text{Industry}_{i,t-1} + \beta_{2j} \text{Income}_{i,t-1} + \beta_{3j} \text{Gender}_i + \beta_{4j} \text{Age}_{i,t-1} + \beta_{5j} \text{Years since graduation}_{i,t-1} + \beta_{6j} \text{STEM education}_{i,t-1} + \beta_{7j} \text{Other college education}_{i,t-1} + \beta_{8j} \text{County}_{i,t-1} + \beta_{9j} t$$

This model predicts the likelihood that individual i is employed in the j th industry at time t depending on the industry in which i works at time $t-1$ as well as i 's income, education (in terms of degree, discipline and recency), age and gender, all measured at time $t-1$. Industry can take one of four values j : Non-tradable, petroleum-unrelated tradable, petroleum-related tradable, or petroleum. Income is measured as taxable employment income in 100.000 NOKs (equivalent to USD 18,000 at 2011 prices). Education is a dummy variable that takes the value 1 if i has completed a university degree at any level. We include separate dummy variables for educational background in the STEM subjects (Science, Technology, Engineering and Mathematics) and in other subjects. Gender is a dummy variable that takes the value 1 for females and 0 for males. County is a vector of dummy variables for the counties of Norway, reclassified to merge counties

forming part of the same labor market¹¹. We also include dummy variables for each year t of observation.

Table 4 presents the results of the analyses¹². In all industry categories, workers are most likely to move within the same category, which is expected as this also includes within-industry mobility. Unsurprisingly, there is a positive coefficient for the likelihood of moving between petroleum and petroleum-related industries. This is also expected as relatedness is defined on the basis of observed mobility between these industries in the preceding period (2001-2004). However, it does indicate that the higher mobility between these industries is a consistent feature over time. Formally, it also confirms the hypothesis that workers in petroleum-related industries are more likely to move to the petroleum industry than workers in unrelated industries.

More importantly, the effect is far from symmetric. Employees in petroleum-related industries have 4.8 times higher odds¹³ of moving into petroleum industries than those working in non-tradables. For employees in petroleum industries, the odds of moving into petroleum-related industries are only 1.6 times higher than for those working in non-tradables. Employees in petroleum industries are also the least likely to move into unrelated tradables or non-tradables among all sectors. The trend is similar in Stavanger, where petroleum workers are even less likely to move to petroleum-related industries compared to the national pattern.

There are also differences in the mobility of individuals with different wage levels between these industries. For non-tradables, there is a negative relationship between income and the likelihood

¹¹ The counties merged are Oslo and Akershus, Hedmark and Oppland, Aust-Agder and Vest-Agder, and Sør-Trøndelag and Nord-Trøndelag.

¹² Appendix Table A.3 shows the results for analyses conducted separately for the 2004-07 and 2008-11 period, corresponding to before and after the transition to NACE rev. 2. The results are highly consistent across both periods, indicating that the change in the NACE classification does not have a major impact on the results. Separate analyses for the other regression models are available from the authors upon request.

¹³ This is calculated by exponentiating the coefficients.

of moving, meaning that high incomes reduce the likelihood of moving to jobs in these sectors compared to staying within the same job. For petroleum and tradables, the relationship is positive. This means that workers with higher income are more likely to change to jobs in these industries. If we assume that higher wages are linked to more productive individuals, there appears to be a skill-bias in mobility towards these industries. The coefficient is largest for moving into the petroleum industries.

STEM education also significantly increases the likelihood of moving into the petroleum industry over staying in the same job. It also increases the likelihood of moving into unrelated tradables and to petroleum-related tradables, although the coefficients are somewhat lower. Conversely, non-STEM education has no impact on the likelihood of moving into the petroleum industry, but a positive effect on moving into other (related and unrelated) tradable industries. In the Stavanger region, both STEM and non-STEM education are positively correlated with moving into petroleum and to unrelated tradables, but not to petroleum-related tradables.

Table 4: Multinomial logit on exit from related industry type (Benchmark: Stayers)

Norway	Move to non-tradable			Move to unrelated tradable			Move to petroleum-related tradable			Move to petroleum		
	Coef.		Std.	Coef.		Std.	Coef.		Std.	Coef.		Std.
Non-tradable (baseline)												
Unrelated tradable	-1.28	***	0.01	1.32	***	0.01	0.28	***	0.01	0.11	***	0.02
Petroleum-related	-1.36	***	0.01	0.08	***	0.01	1.98	***	0.01	1.56	***	0.02
Petroleum	-2.29	***	0.02	-1.15	***	0.02	0.50	***	0.02	2.64	***	0.02
Income	-0.02	***	0.00	0.01	***	0.00	0.00	***	0.00	0.02	***	0.00
Female	-0.06	***	0.00	-0.15	***	0.00	-0.35	***	0.01	-0.58	***	0.02
Age	-0.04	***	0.00	-0.03	***	0.00	-0.03	***	0.00	-0.02	***	0.00
Years since graduation	-0.01	***	0.00	-0.00	***	0.00	-0.01	***	0.00	-0.02	***	0.00
College (STEM)	-0.31	***	0.01	0.13	***	0.01	0.13	***	0.01	0.23	***	0.01
College (non-STEM)	-0.10	***	0.01	0.21	***	0.01	0.05	***	0.01	0.00		0.02
Constant	-0.84	***	0.01	-2.61	***	0.01	-3.61	***	0.02	-6.57	***	0.07
Year dummies		yes			yes			yes			yes	
County dummies		yes			yes			yes			yes	
N= 6,267,473												
Pseudo R2= 0.10												
log L=-2866460												
Stavanger	Coef.		Std.	Coef.		Std.	Coef.		Std.	Coef.		Std.
Non-tradable (baseline)												
Unrelated tradable	-1.25	***	0.02	1.43	***	0.02	0.29	***	0.04	0.68	***	0.04
Petroleum-related	-1.45	***	0.03	0.07	*	0.03	1.91	***	0.03	1.54	***	0.04
Petroleum	-2.36	***	0.04	-1.23	***	0.05	0.28	***	0.04	1.84	***	0.04
Income	-0.04	***	0.00	0.00		0.00	0.01	***	0.00	0.02	***	0.00
Female	-0.09	***	0.02	-0.12	***	0.02	-0.34	***	0.03	-0.38	***	0.03
Age	-0.03	***	0.00	-0.03	***	0.00	-0.02	***	0.00	-0.02	***	0.00
Years since graduation	-0.01	***	0.00	0.00		0.00	-0.01	***	0.00	-0.02	***	0.00
College (STEM)	-0.57	***	0.04	0.26	***	0.03	0.06		0.03	0.20	***	0.03
College (non-STEM)	-0.15	***	0.03	0.24	***	0.02	-0.11	***	0.03	0.06	*	0.03
Constant	-0.83	***	0.04	-2.71	***	0.04	-3.39	***	0.06	-4.18	***	0.07
Year dummies		yes			yes			yes			yes	
N= 399,644												
Pseudo R2= 0.10												
log L=-194128.22												

Significance levels: ***< 0.001; **<0.01; *0.05

While the analyses in Table 4 show the types of workers moving into different industries, they do not provide details on the types of workers moving out of the same sectors. For this reason, we reran the analysis on the sub-samples of individuals working in each of the four industry types in year t-1. This allows us to examine the characteristics of workers moving between each pair of industries. We are particularly interested in the characteristics of workers who move between petroleum and related industries. The hypothesis is that more productive workers tend to leave related industries for the petroleum industry, while less productive workers move the other way.

In this case, we fit the following regression model:

$$\text{Logit} [\text{Pr}(\text{Industry}_{i,t} = j)] = \alpha_j + \beta_{1j} \text{Income}_{i,t-1} + \beta_{2j} \text{Gender}_i + \beta_{3j} \text{Age}_{i,t-1} + \beta_{4j} \text{Years since graduation}_{i,t-1} + \beta_{5j} \text{STEM education}_{i,t-1} + \beta_{6j} \text{Other college education}_{i,t-1} + \beta_{7j} \text{County}_{i,t-1} + \beta_{8j} t$$

The full results of these analyses are shown in Appendix Tables A.1 and A.2. We want to focus on the relationship between income, as a proxy for productivity, and mobility between different types of industries. Table 5 shows a matrix of the coefficients for income in these analyses.

Table 5: Multinomial logit on exit from related industry type, by prior industry. Coefficients for income

	Move to non-tradable		Move to unrelated tradable		Move to petroleum-related tradable		Move to petroleum	
	Coef.	Std.	Coef.	Std.	Coef.	Std.	Coef.	Std.
Norway								
From non-tradable	-0.00	0.00	-0.01 ***	0.00	-0.00	0.00	0.02 ***	0.00
From unrelated tradable	-0.07 ***	0.00	0.02 ***	0.00	0.01 ***	0.00	0.03 ***	0.00
From petroleum-related	-0.07 ***	0.00	-0.02 ***	0.00	0.01 ***	0.00	0.04 ***	0.00
From petroleum	-0.13 ***	0.01	-0.04 ***	0.01	-0.05 ***	0.01	0.01 ***	0.00
Stavanger								
From non-tradable	-0.02 ***	0.01	-0.03 **	0.01	0.01	0.00	0.01 ***	0.00
From unrelated tradable	-0.10 ***	0.01	0.02 ***	0.00	0.02 **	0.01	0.04 ***	0.00
From petroleum-related	-0.11 ***	0.02	-0.00	0.01	0.02 ***	0.01	0.06 ***	0.01
From petroleum	0.01	0.01	-0.03 **	0.01	0.01 ***	0.00	0.01 ***	0.00

Significance levels: ***< 0.001; **<0.01; *0.05

Starting with the petroleum industry, there is a positive relationship between income and moving into the petroleum industry from all other sectors. Meanwhile, there is a negative relationship between income and leaving the petroleum industry for all other sectors. This means that the petroleum industry systematically attracts the highest paid workers from other sectors, while its lower salaried workers are leaving. For mobility within the petroleum industry, there is a slight positive effect of income on the likelihood of moving.

Secondly, the effect of income on moving into the petroleum industry is stronger for petroleum-related industries than for unrelated tradables, meaning that related industries are somewhat more susceptible than unrelated industries to losing high-salaried workers to the petroleum industry. In addition, the negative effect of income on moving in the opposite direction is also stronger, meaning that related industries get even lower paid workers in return. In line with Kuralbayeva and Stefanski (2013), we also find skill-biased mobility between the tradable and non-tradable sectors. The non-tradable sectors are expanding mostly by hiring less productive workers from tradable sectors.

The patterns are similar in Stavanger, with the exception of mobility from petroleum to petroleum-related industries. Overall, the positive coefficients for moving into the petroleum industry from tradable industries are somewhat stronger in Stavanger, while the negative effects are weaker. For mobility from petroleum to petroleum-related industries, there is actually a positive coefficient, although the coefficient is lower than for mobility in the opposite direction. Overall, this implies that mobility is somewhat less skill-biased in the most petroleum-specialised region than for the national economy as a whole.

DISCUSSION AND CONCLUSION

This paper has examined the relationship between the petroleum industry and other industries, focusing in particular on labor-market competition. Departing from the literatures on relatedness and on the resource curse, we analysed labor mobility between the petroleum industry and other related and unrelated industries at the national and regional level during a period of rising oil prices. Overall, we find patterns in support of the relatedness literature: As the petroleum industry grew over this period, its related industries also grew, and at a higher rate than the growth of unrelated industries. This was particularly the case in Stavanger, which is the main hub of the Norwegian petroleum industry. Overall, this is indicative of a process of regional branching, with expansion in related industries. However, the strongest growth remained in the petroleum industry itself, signifying increasing specialization of the regional economy in response to rising oil prices. In line with the resource curse literature, we also found stronger growth in non-tradables than in other tradables. Overall, this makes the economy more vulnerable to downturns in the global petroleum market. Indeed, the fall in oil prices from 2014 resulted in rapidly increased unemployment and a contraction of the non-tradable sector, in particular in the Stavanger region.

A more diversified industrial structure would certainly have reduced the impact of these global trends on the national and regional economies. However, the analysis of labor mobility between petroleum and other industries shows how difficult it is to escape path dependent development processes when resource industries are growing. The petroleum industry paid wages which were far higher than any other industry during this period. Even allowing for income, education and other worker characteristics, average wages in the petroleum industry were around NOK 180,000 (USD 32,000) higher than in petroleum-related industries. As a result, high-salaried (and

presumably more productive) workers in petroleum-related industries were more likely to leave these industries and move to the petroleum industry. Meanwhile, low-salaried workers in the petroleum industry moved the other way. Overall, this suggests a pattern where the best human capital consistently tends to enter the petroleum industry, while related industries get second dibs on workers.

The literature on relatedness has largely overlooked resource competition of this sort. The analyses provided here show that relatedness is not an equal playing field. Skill relatedness dynamics tend to play out much more in favour of the petroleum industry than its related industries. Related industries provide the petroleum industry with workers possessing relevant skills, and it is able to recruit the best among these due to its ability to pay well above market wages. For related industries, labor-market relatedness is mainly a drawback. Petroleum-related industries pay higher wages than other tradables for comparable human capital, and nonetheless lose a much higher share of their workers to the petroleum industry. The silver lining is that many of these related industries are also linked to the petroleum industry through supplier relations, resulting in overall growth. This input-output relationship can most likely partly account for their more positive overall growth, in line with previous findings in the relatedness (Diodato and Weterings 2015) and resource curse (Allcott and Keniston 2018) literatures. However, for the regional and national economy, it remains a concern that the most productive human capital tends to accumulate in the petroleum industry.

This paper has studied these dynamics in the case of Norway and the Stavanger region, which is arguably an exceptional case. In particular, the extremely low unemployment rate during the study period would have further exacerbated the labor competition dynamics analysed in this paper. However, other characteristics of the Norwegian case make it less susceptible to resource

course dynamics, as previous literature has argued (e.g. Mehlum et al. 2012). It has strong institutions and a history of successful resource management, as well as a well-educated population and a compressed wage structure. While labor in general was in short supply in Norway during this period, talent is always scarce and could be more costly in less egalitarian societies. Hence, the mechanisms identified here could be at least as important in other regional and national contexts.

To what extent are such patterns limited to the case of petroleum or other resource industries? Certainly, resource industries have some characteristics that set them apart, as the resource curse literature has amply highlighted. They are often characterised by sudden windfalls and highly dependent on global resource prices, leading to sudden shifts in demand. Their access to resource rents further increases their potential to distort local labor markets more than other industries. However, the broader idea that the benefits of relatedness may be asymmetrically distributed, and that there may also be costs associated with relatedness, could also hold outside the resource sector. Competition for labor is a general phenomenon and the growth of an industry that demands skilled labor could have negative knock-on effects for industries with related skill requirements also in other contexts.

The observation that relatedness to a dominant industry can have both positive and negative effects, places policy-makers in a precarious situation. On the one hand, they should strengthen relatedness to reap the benefits of externalities in periods of growth. At the same time, they must assure that this relatedness does not lead to dependence between related industries and the booming industry when faced with an economic downturn. This would hamper the ability of related industries to act as a cushion to dampen unemployment, as argued by Diodato and Weterings (2015), since related industries would face similar business cycles as the dominant

industry. Related industries must therefore be encouraged to explore alternative markets for their technologies. A challenge is that the petroleum industry uses resource rents to pay a premium for these technologies, making it less interesting for related industries to diversify into other markets. In addition, policy should focus on diversifying the industrial structure outside the influence sphere of petroleum industry. This means that supporting development in industries unrelated to petroleum deserves more attention in resource regions. This would not mean to turn away from relatedness-based policies altogether and shifting one policy out for another. After all, Stavanger, but also Norway in general, has witnessed growth and development of a strong petroleum industry, partly due to relatedness-based policies. Rather, it would revolve around the simultaneous implementation of policies that support unrelated industries while reaping the benefits from the growth realized by these relatedness-based policies. Such efforts would act as a counterweight that help regions avoid industrial lock-in in times of growth, while also providing a cushion in times of industry decline and stagnation.

Overall, this analysis shows that the literature on relatedness could benefit from interacting with other branches of literature, for example, the resource curse literature. The latter provides insights on resource competition and potential negative aspects of relatedness that have hitherto been overlooked in evolutionary economic geography. Meanwhile, perspectives from the relatedness literature may also contribute to developing other bodies of literature, for example, by showing that the resource curse may have different effects on industries which are related to resource industries than on those which are not.

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Appendix Table A.1: multinomial logit on exit from related industry type (Benchmark are those that stay)

		Move to non-tradable		Move to unrelated tradable		Move to petroleum-related tradable		Move to petroleum						
		Coef.	Std.	Coef.	Std.	Coef.	Std.	Coef.	Std.					
From non-tradable	Income	-0.00	0.00	-0.01	***	0.00	-0.00	0.00	0.02	***	0.00			
	Gender	-0.03	***	0.00	-0.26	***	0.01	-0.69	***	0.02	-1.08	***	0.04	
	Age	-0.03	***	0.00	-0.05	***	0.00	-0.04	***	0.00	-0.01	***	0.00	
	Years since graduation	-0.01	***	0.00	0.01	***	0.00	-0.00	***	0.00	-0.05	***	0.00	
	N= 2,524,115	College (STEM)	-0.09	***	0.01	0.36	***	0.02	0.83	***	0.02	0.76	***	0.05
	Pseudo R2= 0.03	College (non-STEM)	-0.10	***	0.01	0.55	***	0.01	0.16	***	0.02	-0.04	***	0.05
LL=-1158567.4	Constant	-0.98	***	0.01	-2.16	***	0.03	-3.29	***	0.03	-7.13	***	0.17	
From unrelated tradable	Income	-0.07	***	0.00	0.02	***	0.00	0.01	***	0.00	0.03	***	0.00	
	Gender	-0.11	***	0.01	-0.11	***	0.01	-0.50	***	0.02	-0.45	***	0.04	
	Age	-0.05	***	0.00	-0.02	***	0.00	-0.04	***	0.00	-0.04	***	0.00	
	Years since graduation	-0.00	***	0.00	-0.01	***	0.00	-0.01	***	0.00	-0.03	***	0.00	
	N= 2,316,147	College (STEM)	-0.48	***	0.02	0.18	***	0.01	0.56	***	0.02	1.20	***	0.04
	Pseudo R2= 0.03	College (non-STEM)	-0.07	***	0.01	0.12	***	0.01	0.03		0.02	0.48	***	0.04
LL=-1031747.1	Constant	-1.49	***	0.03	-1.50	***	0.01	-2.85	***	0.04	-6.43	***	0.17	
From petroleum-related tradable	Income	-0.07	***	0.00	-0.02	***	0.00	0.01	***	0.00	0.04	***	0.00	
	Gender	-0.26	***	0.02	-0.26	***	0.02	-0.12	***	0.01	-0.49	***	0.03	
	Age	-0.04	***	0.00	-0.04	***	0.00	-0.02	***	0.00	-0.02	***	0.00	
	Years since graduation	-0.01	***	0.00	-0.00		0.00	-0.01	***	0.00	-0.03	***	0.00	
	N= 1,089,984	College (STEM)	-0.62	***	0.02	-0.20	***	0.02	-0.14	***	0.01	0.33	***	0.02
	Pseudo R2= 0.03	College (non-STEM)	-0.20	***	0.02	0.28	***	0.02	-0.02		0.01	-0.08	**	0.03
LL=-537066.92	Constant	-1.87	***	0.05	-1.87	***	0.03	-1.92	***	0.03	-5.20	***	0.13	
From petroleum	Income	-0.13	***	0.01	-0.04	***	0.01	-0.05	***	0.01	0.01	***	0.00	
	Gender	-0.50	***	0.06	-0.09		0.05	-0.49	***	0.04	-0.43	***	0.02	
	Age	-0.03	***	0.00	-0.03	***	0.00	-0.03	***	0.00	-0.01	***	0.00	
	Years since graduation	-0.01	***	0.00	0.01		0.00	-0.00		0.00	-0.01	***	0.00	
	N= 337,227	College (STEM)	-0.80	***	0.07	0.14	*	0.06	0.20	***	0.03	-0.16	***	0.02
	Pseudo R2= 0.04	College (non-STEM)	-0.12		0.07	0.59	***	0.06	0.14	**	0.04	-0.11	***	0.03
LL=-125415.39	Constant	-2.44	***	0.24	-4.36	***	0.46	-2.64	***	0.22	-2.22	***	0.12	
	Year and country dummies		yes		yes				yes		yes			

Significance levels***< 0.001; **<0.01; *0.05

Appendix Table A.2: multinomial logit on exit from related industry type in Stavanger (Benchmark are those that stay)

		Move to non-tradable		Move to unrelated tradable		Move to petroleum-related tradable		Move to petroleum	
		Coef.	Std.	Coef.	Std.	Coef.	Std.	Coef.	Std.
From non-tradable	Income	-0.02 ***	0.01	-0.03 **	0.01	0.01	0.00	0.01 ***	0.00
	Gender	-0.04 ***	0.02	-0.17 ***	0.04	-0.67 ***	0.06	-0.82 ***	0.09
	Age	-0.03 ***	0.00	-0.04 ***	0.00	-0.04 ***	0.00	-0.02 ***	0.01
	Years since graduation	-0.01 ***	0.00	0.01 ***	0.00	0.00	0.00	-0.04 ***	0.01
	College (STEM)	-0.08	0.06	0.17	0.11	0.81 ***	0.10	1.09 ***	0.11
	College (non-STEM)	-0.09 **	0.03	0.52 ***	0.06	0.17 *	0.09	0.24 *	0.11
N= 126,227	Constant	-0.98 ***	0.05	-2.24 ***	0.10	-3.09 ***	0.14	-4.10 ***	0.18
Pseudo R2= 0.03									
LL=-62919.848									
From unrelated tradable	Income	-0.10 ***	0.01	-0.02 ***	0.00	0.02 **	0.01	0.04 ***	0.00
	Gender	-0.16 ***	0.05	-0.10 ***	0.03	-0.53 ***	0.06	-0.03	0.06
	Age	-0.05 ***	0.00	-0.03 ***	0.00	-0.03 ***	0.00	-0.03 ***	0.00
	Years since graduation	-0.00	0.00	-0.00	0.00	-0.01 **	0.00	-0.03 ***	0.00
	College (STEM)	-0.91 ***	0.11	0.41 ***	0.04	0.40 ***	0.07	1.37 ***	0.07
	College (non-STEM)	-0.31 ***	0.06	0.15 ***	0.03	-0.04	0.07	0.77 ***	0.07
N= 107,080	Constant	-1.30 ***	0.11	-1.48 ***	0.06	-3.04 ***	0.13	-3.68 ***	0.16
Pseudo R2= 0.03									
LL=-55626.425									
From petroleum-related tradable	Income	-0.11 ***	0.02	-0.00	0.01	0.02 ***	0.01	0.06 ***	0.01
	Gender	-0.38 ***	0.08	-0.11	0.07	-0.02	0.04	-0.23 ***	0.06
	Age	-0.04 ***	0.01	-0.03 ***	0.00	-0.01 ***	0.00	-0.02 ***	0.00
	Years since graduation	-0.00	0.01	0.00	0.00	-0.01 **	0.00	-0.03 ***	0.00
	College (STEM)	-0.81 ***	0.11	-0.04	0.08	-0.07	0.04	0.40 ***	0.06
	College (non-STEM)	-0.14	0.09	0.30 ***	0.08	-0.14 **	0.05	0.12	0.07
N= 71,277	Constant	-1.95 ***	0.16	-2.37 ***	0.14	-1.85 ***	0.07	-2.85 ***	0.12
Pseudo R2= 0.03									
LL=-41710.311									
From petroleum	Income	0.01	0.01	-0.03 **	0.01	0.01 ***	0.00	0.01 ***	0.00
	Gender	-0.37 ***	0.11	-0.25 *	0.10	-0.66 ***	0.07	-0.39 ***	0.04
	Age	-0.04 ***	0.01	-0.03 ***	0.01	-0.04 ***	0.00	-0.03 ***	0.00
	Years since graduation	-0.01	0.01	0.00	0.01	-0.01	0.00	-0.01 **	0.00
	College (STEM)	-1.41 ***	0.14	0.03	0.10	-0.16 **	0.06	-0.27 ***	0.04
	College (non-STEM)	-0.39 ***	0.12	0.51 ***	0.11	-0.45 ***	0.08	-0.35 ***	0.05
N= 95,060	Constant	-3.03 ***	0.23	-3.79 ***	0.23	-2.26 ***	0.14	-2.28 ***	0.09
Pseudo R2= 0.04									
LL=-32605.946									
	Year dummies	yes		yes		yes		yes	

Significance levels ***< 0.001; **<0.01; *0.05

**Appendix Table A.3: Multinomial logit on exit from related industry type (Benchmark: Stayers).
2004-07 and 2008-11 separately.**

Norway 2004-2007	Move to non-tradable			Move to unrelated tradable			Move to petroleum-related tradable			Move to petroleum		
	Coef.		Std.	Coef.		Std.	Coef.		Std.	Coef.		Std.
Non-tradable (baseline)												
Unrelated tradable	-1.28	***	0.01	1.28	***	0.01	0.32	***	0.01	0.10	***	0.03
Petroleum-related	-1.39	***	0.01	0.13	***	0.01	2.01	***	0.01	1.61	***	0.02
Petroleum	-2.46	***	0.03	-1.25	***	0.03	0.51	***	0.02	2.68	***	0.02
Income	-0.02	***	0.00	0.01	***	0.00	-0.00	***	0.00	0.03	***	0.00
Female	-0.07	***	0.01	-0.13	***	0.01	-0.36	***	0.01	-0.58	***	0.02
Age	-0.04	***	0.00	-0.03	***	0.00	-0.03	***	0.00	-0.02	***	0.00
Years since graduation	-0.01	***	0.00	-0.00	***	0.00	-0.01	***	0.00	-0.02	***	0.00
College (STEM)	-0.27	***	0.01	0.08	***	0.01	0.14	***	0.01	0.23	***	0.02
College (non-STEM)	-0.09	***	0.01	0.23	***	0.01	-0.03	***	0.01	-0.05	*	0.02
Constant	-0.68	***	0.02	-2.41	***	0.02	-3.42	***	0.03	-6.50	***	0.09
Year dummies	yes			yes			yes			yes		
County dummies	yes			yes			yes			yes		
N= 3,106,457												
Pseudo R2= 0.10												
log L=-1497371.1												
Norway 2008-2011	Coef.		Std.	Coef.		Std.	Coef.		Std.	Coef.		Std.
Non-tradable (baseline)												
Unrelated tradable	-1.29	***	0.01	1.36	***	0.01	0.22	***	0.01	0.14	***	0.03
Petroleum-related	-1.33	***	0.01	0.03	*	0.01	1.96	***	0.01	1.48	***	0.03
Petroleum	-2.16	***	0.03	-1.04	***	0.03	0.50	***	0.02	2.59	***	0.03
Income	-0.02	***	0.00	0.01	***	0.00	0.01	***	0.00	0.02	***	0.00
Female	-0.05	***	0.01	-0.19	***	0.01	-0.34	***	0.01	-0.58	***	0.02
Age	-0.03	***	0.00	-0.02	***	0.00	-0.02	***	0.00	-0.02	***	0.00
Years since graduation	-0.01	***	0.00	-0.00	***	0.00	-0.01	***	0.00	-0.02	***	0.00
College (STEM)	-0.34	***	0.01	0.19	***	0.01	0.13	***	0.01	0.23	***	0.02
College (non-STEM)	-0.12	***	0.01	0.19	***	0.01	0.13	***	0.01	0.05	*	0.02
Constant	-0.96	***	0.02	-3.12	***	0.02	-3.93	***	0.03	-6.93	***	0.11
Year dummies	yes			yes			yes			yes		
N= 3,161,016												
Pseudo R2= 0.09												
log L=-1366978.3												

Significance levels: ***< 0.001; **<0.01; *0.05