Transferable Know-How: Evidence from the Upstream Oil & Gas Industry*

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Abstract

We investigate the consequences of the adoption of Enhanced Oil Recovery (EOR) on productivity, competition, and further technological adoption in the upstream oil & gas industry in the North Sea. Exploiting geological heterogeneity and a Norwegian Supreme Court decision that reduced policy uncertainty, we show that early EOR adopters increased their productivity and gained shares of the North Sea market through three channels. First, direct productivity gains due to EOR adoption. Second, specialization by transferring the acquired know-how to other EOR-eligible fields. Third, diversification through know-how-driven economies of scope that facilitated investments in non-EOR-eligible fields requiring alternative technologies.

JEL classifications: O33, Q40, D40
Keywords: innovation, technology adoption, know-how, competition, productivity, specialization, diversification, oil & gas industry, enhanced oil recovery, North Sea

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1 Introduction

In a continuous effort to improve productivity and maintain competitiveness, successful firms regularly engage in the adoption and use of innovative technologies (Olley and Pakes, 1996, Collard-Wexler and De Loecker, 2015). Beyond the immediate productivity gains, technology adoption can generate future returns through the accumulation of *transferable know-how*—the knowledge and expertise gained from adopting a technology which can enhance a firm's ability to identify and adopt other technologies in the future (Cohen and Levinthal, 1990). Transferable know-how can take various forms, including process or infrastructure complementarity (Aral *et al.*, 2012), learning-by-doing/using (Colombo and Mosconi, 1995), or, more profoundly, changes in a firm's attitude toward technology (Orlikowski, 1992). Early technology adoption can thus initiate a virtuous cycle of technological progress leading to long-term gains in productivity and competitiveness.

Identifying the drivers and consequences of transferable know-how in technology adoption is crucial to understanding technological progress and the diffusion of innovation, but it presents several empirical challenges. A key difficulty is the self-selection of technology adopters: early technology adopters may differ from non-adopters in several unobservable ways and may in general also be more likely to adopt other technologies later on. This complicates the separate identification of transferable know-how—a form of state dependence—from other, potentially correlated, firm-specific unobservable traits (Zahra and George, 2002). In addition, the measurement of transferable know-how is inherently challenging, as it can take many intangible forms and include factors such as skills, routines, and organizational knowledge, which are in general hard to quantify.

In this paper, we investigate the role of transferable know-how induced by the adoption of Enhanced Oil Recovery (EOR) in the North Sea oil & gas industry during 1975-1995. Our empirical strategy leverages heterogeneity in the geological and technological constraints for EOR adoption across oil & gas (O&G) fields, in combination with an unexpected 1985 ruling by the Norwegian Supreme Court that reduced policy uncertainty in Norway relative to the UK. This unique setting enables us to evaluate firms' decisions regarding production and technology adoption (other than EOR) in a triple-difference framework, offering novel insights into the ways in which transferable know-how shapes technological specialization, diversification, and—ultimately—competition.

EOR improves resource extraction by injecting natural gases (e.g., CO_2) or chemicals into reservoirs. Since the first successful commercial CO_2-based project in 1972 (Scurry County, Texas) (U.S. Department of Energy, 2010), EOR has transformed upstream O&G production.[1] O&G extraction relies on reservoir pressure to force resources to the surface, but as pressure decreases over time, recovery is usually limited to 20-40% (e.g., Sandrea

[1]The earliest recorded EOR attempt was by J.W. Goff in 1901 (Rintoul, 1976), who injected steam and air into Kern River wells, California. Although he achieved some incremental output, low oil prices stalled further progress (Brandt, 2011).

and Sandrea, 2007, IEA, 2008). By restoring pressure, EOR increases recovery to 50-70% (e.g., McGuire *et al.*, 2000, Toole and Grist, 2003, Muggeridge *et al.*, 2014). Importantly, by the 1980s, EOR was an established technology widely available for adoption to all O&G firms globally.

Our analysis leverages unique data from Wood MacKenzie, a data consulting firm, which tracks each field's geology, yearly production, reserves, expenditures, and deployed technologies. We observe annual activities of all firms across all fields in the Southern North Sea basin from 1975 to 1995, which saw extensive EOR use, fostering major energy hubs like Aberdeen, UK (Cumbers, 2000, Alvarado and Manrique, 2010).[2]

Our identification strategy relies on detailed micro-data and the combination of two sources of exogenous variation for EOR adoption. First, not all O&G fields are geologically and technologically eligible for EOR adoption. Our detailed field-level data allow us to determine eligibility based on geological characteristics (e.g., oil acidity, reservoir depth) and technological infrastructure (e.g., platform types) (Al Adasani and Bai, 2011, Nwidee *et al.*, 2016). Crucially, a field's ineligibility for EOR represents an exogenous constraint, independent of firms' characteristics and willingness to adopt. However, eligibility alone may not be enough to address endogeneity: more productive firms may still have self-selected into EOR-eligible fields, anticipating future adoption of EOR or other productivity-enhancing technologies.

We then combine a field's EOR eligibility with an unexpected event that altered the returns to EOR adoption in Norway but not in the UK. Specifically, we rely on a 1985 ruling by the Norwegian Supreme Court that reduced the legal risks associated with capital investment in Norwegian fields relative to those in Britain (a reduction in policy uncertainty as in Gowrisankaran *et al.*, 2022). We combine these sources of exogenous variation by estimating triple-difference regressions at the field and at the firm level (Olden and Møen, 2022). First, we compare outcomes before and after 1985 for fields in Norway, using similar UK fields as controls. Second, we compare outcomes before and after 1985 for firms that, before 1985, owned portfolios of fields with slightly different shares of Norwegian EOR-eligible fields.

Our results show that EOR adoption significantly increased in Norway relative to the UK after 1985, and that, as a consequence, relative increases in production followed suit. EOR-eligible fields in Norway saw a 12.6-fold increase in production, with effects occurring through both the intensive margin (five-fold increase for already productive fields) and the extensive margin (44 percentage point higher probability of production). Although higher production required higher operational expenditures, the ratio of production to costs improved, indicating an increase in productivity due to the adoption of EOR.

Firms that adopted EOR experienced a substantial boost in productivity and competitiveness. Firms with portfolios of fields that, before 1985, included more Norwegian

[2]For example, Holt *et al.* (2009) highlight the role of pipelines in delivering CO_2 to fields.

EOR-eligible fields substantially increased their market shares after the Supreme Court decision. A 10 percentage point higher share of Norwegian EOR-eligible fields in a firm's pre-1985 portfolio was associated with a 39% increase in market share post-1985. This growth occurred primarily through portfolio expansions both at the intensive and at the extensive margin. At the intensive margin, these firms increased their stronghold of EOR-eligible fields, whose ownership structure became more concentrated. At the extensive margin, these firms entered approximately one additional field for each 10 percentage point increase in their pre-1985 share of Norwegian EOR-eligible fields.

Crucially, we document that operational know-how in the adoption and implementation of EOR—rather than the mere direct financial returns of the investment—drove these patterns. Although all firms possessing ownership shares of EOR-eligible fields benefited financially from EOR adoption, those that *operated* at least one such field—bearing responsibility for capital and operational expenses—experienced post-1985 increases in market shares on a different and much larger scale (a 108% increase compared to just 9% for firms without such an operational know-how). This stark contrast underscores the competitive advantage of direct technological expertise.

The adoption of EOR also had consequences for firms' subsequent decisions to specialize or diversify across technologies. Firms with EOR-specific know-how both specialized (acquiring more EOR-eligible fields) and diversified into higher risk ventures, such as deep well fields or those with heavy or sour oil. Notably, 28.5% of their new field acquisitions were EOR eligible, while the remaining 71.5% required completely different technologies—suggesting that early successes with EOR adoption also fostered experimentation with higher risk assets.

This portfolio diversification was accompanied by technological diversification. After 1985, firms with pre-1985 EOR-specific know-how also significantly expanded the range of technologies adopted in exploration, production, and extraction. A 10 percentage point higher share of Norwegian EOR-eligible fields in the pre-1985 portfolio led to a 40% increase in technological diversification within each technological class. This effect was particularly pronounced among non-state-owned firms, underlying the importance of the private sector in pushing technological progress in the North Sea O&G industry.

Our findings reveal a novel mechanism linking technology adoption with firm behavior and market composition. Rather than operating primarily through scale economies or market power, we identify a knowledge-based pathway: some of the expertise obtained from adoption and use of one technology may be transferrable, facilitating adoption and experimentation with other technologies. This transfer of expertise reflects *economies of scope in innovation*, where initial technological adoption builds capabilities that reduce the costs of adopting subsequent technologies. As a result, we find that the gap in deployed technologies and risky field development between Norway and the UK narrowed after 1985, highlighting the benefits of transferable know-how.

Our work contributes to various strands of the literature. An important strand to which we contribute has studied the relationship between competition and innovation (e.g., Schumpeter, 1943, Arrow, 1962, Aghion *et al.*, 2005). Due to the endogenous interplay between competition and innovation, the empirical investigation of their relationship is notoriously complex (e.g., Igami, 2017, Igami and Uetake, 2020). Despite the large body of empirical evidence on the effect of competition on innovation (e.g., Nickell, 1996, Blundell *et al.*, 1999, Bloom *et al.*, 2016, Hashmi and Biesebroeck, 2016, Macher *et al.*, 2021, Pöge, 2022), much less is known about the (opposite) effect of innovation on competition (e.g., Collard-Wexler and De Loecker, 2015, Olmstead-Rumsey, 2020, Horn *et al.*, 2021). Exploiting exogenous constraints to adoption and an unexpected policy change, we estimate the causal effect of technology adoption on market shares, documenting new channels through which innovation can mold competition.

Our work also contributes to the literature that investigates how a firm's history of technology adoption influences its future technology adoption (e.g., Geroski, 2000, Cohen, 2010). Many studies in this strand suggest that early adopters build capabilities (e.g., technical skills, data, routines) that make them more likely to adopt later technologies, pointing to mechanisms similar to what we call *transferable know-how*, such as learning-by-doing/using (e.g., Colombo and Mosconi, 1995), absorptive capacity (e.g., Cohen and Levinthal, 1990, Griffith *et al.*, 2003), and complementary know-how (e.g., Stoneman and Kwon, 1994, Battisti and Stoneman, 2005, Aral *et al.*, 2012). Our identification strategy and detailed data on firm-level deployment of technologies enable us to overcome the basic challenge of empirically separating true state dependence from endogenous self-selection in technology adoption. This allows us to document how transferable know-how can both give rise to specialization into similar technologies and also, perhaps less intuitively, to technological diversification through economies of scope.

We also contribute to an extensive literature studying several aspects of the O&G industry. Seminal papers in this strand include Porter (1995), who studied bidding for exploratory licenses. Related work extended the empirical framework to correlation in fimrs' valuations (Hendricks *et al.*, 2003, Compiani *et al.*, 2020, Kong *et al.*, 2022), to sequential bidding (Kong, 2021) and to auction design (Covert and Sweeney, 2019, Bhattacharya *et al.*, 2022). More recently, a series of articles investigated the mismatches between adopted technologies and O&G field characteristics (Vreugdenhil, 2023) and how cost heterogeneity across fields can be exploited to estimate welfare losses due to misallocations (Asker *et al.*, 2019) and the OPEC cartel (Asker *et al.*, 2021). Additional insights come from Hodgson (2024) on optimal exploration under information externalities in the UK O&G industry, and Asker *et al.* (2024) and De Cannière (2024) on the complex relationship between market power in the O&G industry and environmental outcomes. Bornstein *et al.* (2023) study the macroeconomic impact of technological changes such as fracking, which are transforming the global dynamics of the O&G industry.

Our paper focuses on Enhanced Oil Recovery (EOR), a technology that uses large amounts of carbon dioxide (CO_2). Coupling EOR with carbon capture technologies may help decarbonize the energy sector and benefit oil-exporting nations (Azzolina *et al.*, 2016). Such CO_2-EOR projects are being considered globally, with promising pilots in India and China (Shackley and Verma, 2008, Hill *et al.*, 2020) and large financial incentives put forward by the Biden administration with the Inflation Reduction Act (e.g., IEA, 2016, 2022a). Recent studies also highlight the potential for CO_2-EOR in the North Sea, where shared pipelines could facilitate deployment (Holt *et al.*, 2009, Kemp and Kasim, 2013).[3] However, our research suggests that, to achieve net-zero carbon emissions through CO_2-EOR projects, policy makers must account for the endogenous responses of firms, which may be inadvertently driven to invest in riskier and dirtier fields, thus offsetting the environmental benefit of carbon capture (Masnadi *et al.*, 2018, 2021, Coulomb *et al.*, 2021).

The paper is organized as follows. Section 2 describes the North Sea O&G sector, EOR technology, and the 1985 Norwegian Supreme Court Decision. Section 3 presents the data. Section 4 outlines the empirical strategy, with results on productivity in Section 5 and market shares in Section 6. Section 7 examines the role of know-how and state ownership in shaping market shares and firms' portfolio composition. Section 8 finds know-how as a driver of technological diversification and discusses its macro implications for advancing the North Sea's technology frontier. Section 9 concludes.

2 The Upstream Oil & Gas Sector in the North Sea

In the North Sea, natural gas was first discovered commercially in the Groningen region in the Netherlands in 1959, and similar geological characteristics led geologists to believe that comparable opportunities could also exist in the offshore region surrounding the UK (Odell, 1996; Yergin, 2011). Early attempts at searching for oil & gas in the UK sector of the North Sea had limited success in the early 1960s, but larger discoveries in the latter half of the decade then led to significant investments in the region's offshore energy industry. The discovery of the giant Ekofisk oil field in Norwegian waters in 1969, followed by the discoveries of the Montrose and Forties oil fields in the UK during the same year, brought the region into the spotlight (Shepherd, 2015).[4] This section discusses the similarities and differences of the oil & gas industries in the UK and Norway.[5]

[3]For instance, in 2021 Norway started an "absolutely necessary" CO_2-EOR project capable to stock up to 1.25 billion tonnes of CO_2 under the North Sea (Fairs, 2021). Other countries have also considered or implemented carbon capture programs for CO_2-EOR projects (e.g., McMahon, 2018, Hodgson, 2022).

[4]Denmark also joined this emerging North Sea oil & gas market with the discovery of the Kraka field in 1966, although its stake remained considerably smaller than that of the UK or Norway.

[5]For a general discussion of the early history of Norwegian and British regulation see Hanisch and Nerheim (1992) and Gordon (2011), respectively. Details of early licensing and the first Norwegian licensing round in 1965 are described in Bull (1981).

Licenses. Both systems have similar conditions with respect to license granting, bidding processes, fiscal regimes, and dispute settlements (Kardel, 2019). The allocation of oil & gas exploration and production rights in Norway and the UK follows similar principles, since both countries retain ownership of subsea petroleum resources and require government approval for industrial activities (Gordon, 2011, Brøvig *et al.*, 2018).

In Norway, three types of license govern these operations: exploration licenses, production licenses, and licenses to install and operate facilities. These are awarded through annual bidding rounds in mature areas and biennial rounds in frontier regions. Similarly, the UK employs a licensing system in which firms must bid for exploration rights or acquire stakes in existing licenses (Mace *et al.*, 2017). Until the establishment of the Oil & Gas Authority under the 1998 Petroleum Act, the Department of Energy and Climate Change managed the allocation process through competitive bidding rounds (UK Parliament, 1998).

Despite nominally competitive bidding, not all blocks are awarded in a given round. If applications do not meet undisclosed minimum criteria—potentially including technical capability, financial stability, or domestic industry development objectives—the blocks remain unallocated (Kardel, 2019). For example, the Minister can unilaterally reject any application, and potential applicants are explicitly invited to discuss their operational plans (Kemp, 2013).

Ownership. Ownership structures in oil & gas fields vary, with multiple stakeholders holding equity shares that dictate revenue and cost distributions. Costs include operational expenses (e.g., maintenance, personnel) and capital expenditures (e.g., rigs, platforms). The operator, unlike other shareholders, oversees day-to-day production and strategic decisions, such as technology adoption. Major international oil companies, like Shell and Exxon, operated in the North Sea alongside state-owned or semi-public enterprises.

Both the UK and Norway established national oil companies in the 1970s to develop domestic expertise and secure energy independence. While both countries emphasize competition, Norway historically ensured substantial state participation. The UK's British National Oil Corporation (BNOC), created under the Petroleum & Submarine Pipelines Act 1975, was partially privatized in the early 1980s when its upstream assets were rebranded as Britoil, which was later fully privatized and acquired by BP in 1988. BP itself was privatized in stages, with the final government stake sold in 1987. In Norway, Statoil, founded by the Storting (i.e., the Parliament), evolved into a fully integrated oil firm, with the government retaining over 80% of the ownership after its partial privatization in 2001. Between the 1970s and early 1990s, the Norwegian government maintained a direct stake of at least 50% in key offshore licenses via Statoil (now Equinor), shaping industrial and technological development (Norwegian Ministry of Petroleum and Energy,

2023). In contrast, the UK placed greater emphasis on financial and technical merit in awarding licenses, although it initially engaged in state participation through BNOC and Britoil until privatization in the 1980s (Williams, 1981).

Fiscal policies. Both countries initially imposed royalty-based revenue sharing mechanisms (Hunter *et al.*, 2020). Beyond these statutory royalties, supplementary levies and direct state ownership were used to secure revenues while offering relief measures for marginal fields and enhanced recovery projects (Kemp and Crichton, 1978, Lund, 2014). The UK introduced a 12.5% royalty rate in the 1970s, but revenue collection increasingly relied on the Petroleum Revenue Tax (50% in 1975) (Revenue & Customs, 2016, HM Revenue & Customs, 2016a) and the 1983 Supplementary Petroleum Tax (UK Parliament, 1983). In the early 1990s, the UK reduced overall taxation to attract investment, shifting reliance from royalties to corporate and supplementary taxes (HM Revenue & Customs, 2016b). Norway followed a different path, supplementing its 16.67% royalty with a 50% Special Petroleum Tax and a 22% corporate tax, resulting in a total government take of nearly 78% (Norwegian Parliament, 1975, Australian Financial Review, 2010, Norwegian Ministry of Petroleum, 2024). The taxation, coupled with direct participation via Statoil, contributed to Norway's more centralized offshore resource management.[6]

2.1 A Critical Technology: Enhanced Oil Recovery

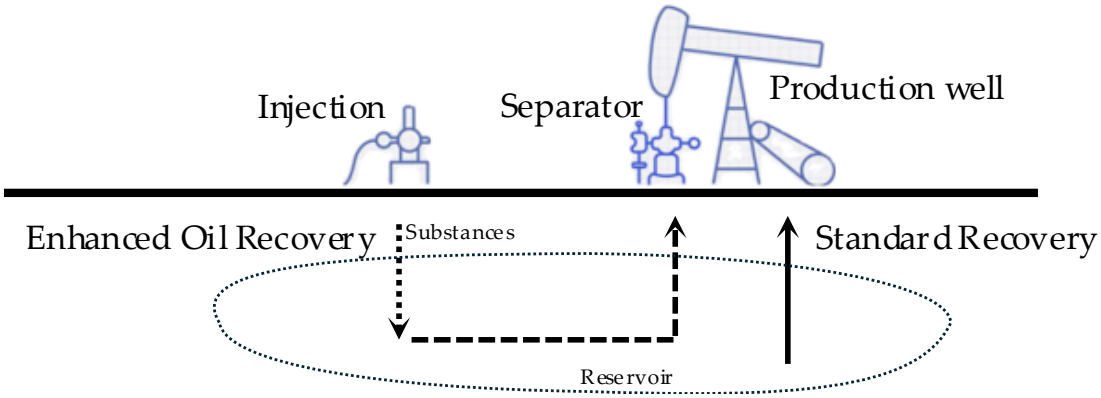
The lifecycle of offshore oil & gas fields comprises five phases: exploration, appraisal, development, production, and decommissioning (Darko, 2014). In the early stages of oil & gas production, natural reservoir pressure drives hydrocarbon extraction. However, as pressure declines, companies employ various techniques to maintain flow rates. Initially, this can involve the injection of water or natural gas, but when these are not sufficient, Enhanced Oil Recovery (EOR) becomes an option.

EOR modifies the chemical composition of hydrocarbons to facilitate extraction by injecting substances into reservoirs as shown in Figure 1. Standard EOR methods include CO_2 injection, chemical flooding, nanofluid injection, thermal methods, and hybrid approaches. The injected substances then mix with the fluids in the reservoirs, easing their flow through the rocks (Alvarado and Manrique, 2010, Tarybakhsh *et al.*, 2019, Wei *et al.*, 2021).

Although effective, EOR is costly and complex, and is typically used only after simpler methods become ineffective. Offshore operators must either dispose of pipes to receive the substances from the inland or build a tank for storing the substances to be injected and arrange shipments. An injection well is also needed. Then a separator must be

[6] Ahlvik and Harding (2024) discuss changes in tax deduction rules and the significant impact on investments in the Norwegian oil & gas sector, illustrating how policy changes can directly affect corporate finance and investment strategies in the energy sector.

Figure 1: An Enhanced Oil Recovery (EOR) operation



Notes: The figure illustrates a standard EOR operation. First, the injected substances are transported to the platform via pipeline or, if unavailable, by ship. On the platform, chemicals are stored in tanks and injected into the reservoir at the optimal pressure and density through rigs strategically placed by outsourced engineering firms. As the chemicals move through rock pore spaces, they mix with crude oil droplets, forming concentrated oil banks that are swept toward production wells. Oil is then separated from water at the well. Injection patterns and substances are optimized via computer simulations. This process, depicted on the right of the figure, applies to oil fields, which dominate North Sea production.

installed in the production well to separate the injected substance, the oil, and the gas. Thus, adopting EOR implies higher operating and capital expenditures.

Despite its higher costs, EOR can extend the life of an oil & gas field. While standard recovery yields only 20-40% of a reservoir's resources, EOR ensures recovery up to 50-70% (Toole and Grist, 2003). However, given its high initial investment and long payback period, the adoption of EOR has historically depended on public support. Over 80% of global EOR production benefits from government incentives or is prioritized by national oil companies (IEA, 2022b). Although the cost of EOR has declined over time, competing technologies, such as shale and offshore developments, have become even cheaper, limiting the adoption of EOR. Since 1959, more than 600 EOR projects have been implemented globally, with the first North Sea application in the mid-1970s (Gbadamosi *et al.*, 2018).

Eligibility. A crucial feature of EOR that we exploit in our identification strategy is that not all fields are eligible for the use of this technology. The eligibility of a field for the adoption of EOR largely depends on the geological and technological properties of the field, such as the size and depth of the reservoir; the sulfur content, porosity, permeability, and density of the crude oil; but also the type of platform and drive mechanisms installed for extraction in the early phases of development of the site (Al Adasani and Bai, 2011; Nwidee *et al.*, 2016). Fields that do not possess the necessary geological and technological characteristics cannot adopt EOR even if the operators wishes to do so.

Conditional on a field being geologically and technologically eligible for EOR, the decision of adoption is then typically made on the basis of forecasts by engineering and economic models. Oil & gas companies typically have in-house reservoir engineers who

create forward-looking models of the reservoirs they are managing. When reservoir models predict a drop in pressure deemed to cause problems with production—such as drops below the "bubble point," which result in some of the liquid hydrocarbons transforming into the gaseous phase—then EOR is considered. The reservoir engineers then work with the company's petroleum economists to forecast future scenarios to determine whether the considerable expense of deploying EOR will result in a net financial benefit in terms of increased production throughout the remaining life of the field.[7]

2.2 1985 Norwegian Supreme Court Decision

Both Norway and the UK place oil and gas licenses within an administrative framework, unlike the private law framework in the United States and Canada (Hunter *et al.*, 2020). This allows either government to unilaterally review licensing conditions based on public interest. A key feature of our identification strategy is the comparison of Norwegian and UK oil and gas fields around a landmark Norwegian Supreme Court decision, which introduced a significant distinction in the rule of law governing production licenses in the two countries (Mestad, 1987, Gordon, 2011).

In Norway, royalties could be paid either in-kind or in cash. Cash payments were governed by the Petroleum Regulation of 1965, which required semi-annual payments. The 1972 Petroleum Regulation introduced quarterly payments without adjusting royalty rates, increasing the financial burden on companies due to the loss of interest from more frequent payments (Decree, 1972). However, the retroactive application of this policy to licenses granted before 1972, such as the Ekofisk license held by Phillips (now ConocoPhillips) since 1969, was unclear. The financial impact of the policy prompted Phillips to challenge its retroactive application in court.

The legal dispute reached the Norwegian Supreme Court in 1985, which ruled that the retroactive clauses in the 1972 regulation were unconstitutional. The Court condemned the state to reimburse Phillips for $32 million (equivalent to $85 million in 2022 dollars) for the interests paid by Phillips and established that, in the future, the government could not retroactively alter the terms of existing licenses without compensation (Retstidende, 1985, Ulfbeck *et al.*, 2016).[8] Following this ruling, other oil & gas companies in Norway filed lawsuits and successfully obtained similar compensation.

The UK, in contrast, continued to implement similar retroactive amendments to production licenses. During a period of just over a decade, the UK government made three unilateral amendments to existing licenses (The Petroleum and Submarine Pipelines Act

[7] Although the adoption decision is made by the field's operator, implementation is typically handled by service companies (e.g., Baker Hughes, Halliburton, Schlumberger, and Weatherford), whose services are widely available globally.

[8] Quoting the Court, "it must be rather clear that the state could not for example change [unilaterally] the time limit for a petroleum license without compensation [...]" (Hunter *et al.*, 2020, page 183).

1975, The Oil and Gas Enterprise Act 1982, and The Petroleum Act 1987), all of which were enforced despite significant opposition from the oil & gas industry. According to Mestad (1987), these amendments were legally permissible under the "parliamentary sovereignty" of the British legal system, which allows retroactive modification of administrative licenses through legislation.[9]

3 Data

Our dataset comes from Wood McKenzie, a consulting firm specializing in resource extraction data. We construct a field-level dataset to analyze field-specific developments and a firm-level dataset that aggregates field-level data based on ownership shares.

3.1 Technology Adoption: Field-level Data

We use data from the portions of the North Sea under the jurisdiction of the UK and Norway, as shown in Figure 2. Blue dots represent UK fields, while red triangles indicate Norwegian fields. Most fields are located on the continental shelf between the two countries, though the UK jurisdiction extends further south, whereas Norwegian fields are concentrated further north. The UK hosts a larger number of fields, reflecting its earlier industry development relative to Norway.

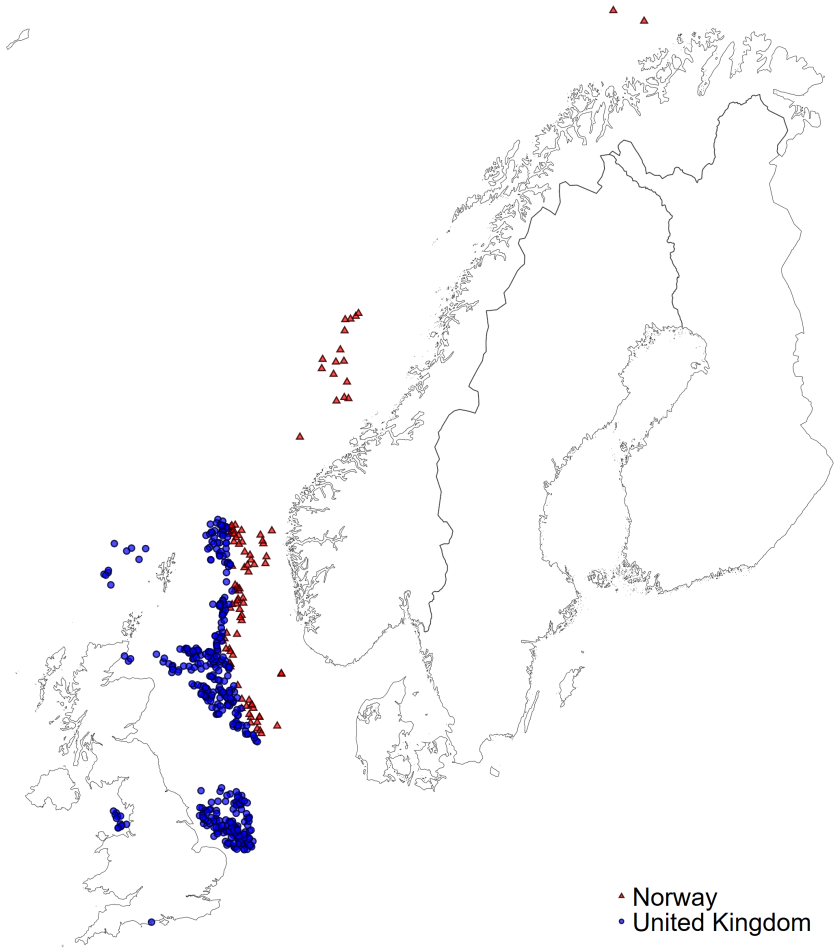
British and Norwegian oil & gas fields are highly comparable in most dimensions such as geology, oil quality, technology use, and operational practices. Table 1 provides a detailed breakdown. Columns 3 and 6 present statistics for the full sample, while the other columns differentiate between fields that began production before or after 1985—the year of the Norwegian Supreme Court decision.

Examining the full sample (columns 3 and 6), the two countries exhibit similar oil compositions, with an oil share of 0.60 in the UK and 0.74 in Norway. API gravity is nearly identical, averaging 40.64° in the UK and 40.30° in Norway, implying that heavy oil fields are rare in both regions. While most fields are in shallow waters, reservoir depths vary. The share of fields classified as deep or ultradeep (exceeding 3,000m) is similar, at 23% in the UK and 37% in Norway. Permeability and porosity are also comparable, with a higher porosity enhancing storage capacity and a higher permeability facilitating hydrocarbon flow and extraction.

The patterns of technology adoption are similar in both countries, with comparable extraction techniques employed. The dataset provides granular information on field-level technological choices and expenditures, enabling us to assess Enhanced Oil Recovery (EOR) eligibility based on established engineering criteria (Al Adasani and Bai, 2011,

[9]The British legal system permits retroactive laws since Parliament of Great Britain (1793)—see Gobbi (2010) for details on commencement rules. However, retroactive criminal laws are prohibited under the European Convention of Human Rights.

Figure 2: British and Norwegian oil & gas fields in the North Sea



Notes: The figure displays oil & gas fields in our sample under UK (blue dots) and Norwegian (red dots) jurisdiction in the southern North Sea.

Nwidee *et al.*, 2016), which we detail in Appendix Table B1. As shown in Panel (d) of Table 1, the share of EOR-eligible fields is nearly identical: 35% in the UK and 40% in Norway. An alternative definition accounting for permeability and porosity yields similar shares of 34% in the UK and 25% in Norway. As we demonstrate throughout the paper, our findings are consistent using both measures of eligibility.

As a preview of our identification strategy, we document that before 1985, EOR adoption was more prevalent in the UK, with 10% of fields employing the technology compared to 6% in Norway. Before 1985, The British oil & gas industry was more developed than the Norwegian and hosted nearly four times as many firms and twice as many operators (Panel a). Firms in the UK had greater expertise in various technologies, including EOR, leading to higher adoption rates and a larger share of EOR-eligible fields (52% in the UK versus 28% in Norway).

However, following the 1985 Supreme Court decision, these trends reversed. The share of EOR-eligible fields and adoption in Norway rose to 45% and 16%, respectively,

Table 1: Descriptive statistics at field-level

	UK			Norway		
	Pre-1985 (1)	Post-1985 (2)	Total (3)	Pre-1985 (4)	Post-1985 (5)	Total (6)
Panel (a): Average number of						
Active per year (exploration/production)	40.45	129.67	106.38	11.26	33.05	27.15
Producing fields per year	30.13	101.72	84.61	6.97	21.95	18.62
firms per year	66.69	81.16	77.38	18.52	27.30	24.93
operators per year	12.90	24.33	21.50	6.30	8.94	8.21
Panel (b): Field Characteristics types						
Average initial oil in place (MMboe)	589.7	272.6	355.4	1366.4	1235.1	1270.6
% fields Large	0.84	0.53	0.61	0.57	0.72	0.68
% fields Moderate	0.15	0.38	0.32	0.43	0.25	0.30
% fields Small	0.02	0.09	0.07	0.00	0.02	0.02
Porosity (%)	19.34	18.92	19.06	29.85	27.78	28.52
Permeability (Millidarcy)	1005.56	750.62	828.34	965.30	1602.79	1415.70
% shallow and moderate fields (<3000m)	0.82	0.75	0.77	0.50	0.67	0.63
% deep and ultradeep fields (>3000m)	0.18	0.25	0.23	0.50	0.33	0.37
Reservoir depth (meters)	2564	2630	2613	2645	2619	2626
Overburden (meters)	2465	2542	2522	2541	2476	2493
Panel (c): Resource types						
API Gravity (Fahrenheit)	40.42	40.73	40.64	41.67	39.81	40.30
% of heavy oil fields	0.00	0.02	0.01	0.00	0.00	0.00
% of oil (as opposed to gas)	0.69	0.57	0.60	0.76	0.72	0.73
Sulfur content (unit measure)	0.48	0.49	0.48	0.23	0.22	0.22
Panel (d): Technologies						
Share of active EOR-eligible fields	0.52	0.30	0.35	0.28	0.45	0.40
Share of active EOR-eligible fields (robust definition)	0.49	0.29	0.34	0.20	0.40	0.35
Share of fields adopting EOR	0.10	0.05	0.06	0.06	0.16	0.13
Share of fixed platform	0.86	0.72	0.76	1.00	0.74	0.81
Share of fixed subsea	0.09	0.24	0.20	0.00	0.20	0.15
Share of tension leg platform	0.01	0.01	0.01	0.00	0.05	0.04
Panel (e): Operations						
Average yearly production (MMboe/year)	20.95	9.75	12.68	27.04	27.59	27.44
Average yearly capital expenditure (CAPEX in $m)	431.80	98.89	185.80	520.70	294.36	355.61
Average yearly operative expenditure (OPEX in $m)	144.49	74.82	93.01	303.96	271.03	279.94
Average CAPEX per MMboe	20.61	10.14	12.87	19.26	10.67	13.00
Average OPEX per MMboe	6.90	7.67	7.47	11.24	9.83	10.21

Notes: Summary statistics for fields located in UK (columns 1 to 3) and Norway (columns 4 to 6). Columns 1 and 4 (2 and 5) present average values across the active fields—i.e., exploration or production phases—before (after) 1985, whereas columns 3 and 6 do so for the active fields in our sample ranging 1975-1995.

while both declined in the UK to 30% and 5%. These trends are mirrored by the patterns of production: average production per field remained stable or increased slightly in Norway—indicating that not only were more fields brought upstream, but the lifespan of mature fields was extended—while production declined sharply in the UK. Similar patterns emerge in capital and operational expenditures. Our empirical analysis will disentangle these effects, accounting for potential confounding factors.

The production of the region grew until the early 2000s, but has since matured and is unlikely to return to its peak levels (Craig *et al.*, 2018). Although the combined oil & gas production from the North Sea once accounted for approximately 8% of the global worldwide, in 2020 the region produced approximately 4% (BP, 2021).

Table 2: Descriptive statistics at firm-level

Firms with EOR eligible fields before 1985 in Norway	Yes			No		
	Pre-1985 (1)	Post-1985 (2)	Total (3)	Pre-1985 (4)	Post-1985 (5)	Total (6)
Panel (a): Firms						
Average number of firms per year	13.57	16.00	14.84	57.02	73.21	65.82
Average number of state-owned firms per year	2.64	3.00	2.83	1.00	1.00	1.00
Share of firms acting as operators	0.26	0.23	0.25	0.08	0.08	0.08
Average market share	0.04	0.05	0.04	0.01	0.00	0.01
Panel (b): Fields per firm						
Average number of fields per firm	7.84	20.52	14.45	1.83	4.30	3.17
Average number of producing fields per firm	5.38	14.91	10.60	1.72	3.62	2.84
Panel (c): Enhanced Oil Recovery						
Share of EOR eligible fields (Norway & UK)	0.46	0.50	0.48	0.65	0.44	0.53
Share of fields adopting EOR (Norway & UK)	0.10	0.18	0.14	0.03	0.05	0.04
Share of EOR eligible fields in Norway (Share EOR Norway)	0.27	0.38	0.33	–	–	–

Notes: Columns 1 to 3 (columns 4 to 6) present summary statistics for firms that had (did not have) EOR-eligible fields in Norway before 1985. Columns 1 and 4 (2 and 5) present yearly average values for the period before (after) 1985, whereas columns 3 and 6 do so for the whole ranging 1975-1995.

3.2 Portfolio Composition: Firm-level Data

Table 2 examines differences across firms based on whether they owned shares in EOR-eligible fields in Norway before 1985, the year of the Supreme Court decision. Our empirical analysis will take advantage of this variation to identify key drivers of productivity, competitiveness, and technology adoption.

Panel (a) shows that, on average, 14.84 firms per year in our sample (1975-1995) held a share in at least one EOR-eligible field in Norway before 1985. This figure varies slightly between columns 1 and 2, reflecting cases where firms acquired shares or were awarded licenses in Norwegian EOR-eligible fields only towards the end of the pre-period (1975-1985). Some of these firms were state-owned (such as Statoil and, until 1987, BP) and acted as operators in roughly 25% of their fields, with little variation over the sample period. In contrast, the number of firms that did not own any share of Norwegian EOR-eligible fields before 1985 grew sharply, increasing from 57.02 in column 4 to 73.21 in column 5. The share of operatorship among these firms was considerably lower, at just 8%. Importantly, the so-called "oil majors," oil firms with a global footprint (e.g., Amoco, Chevron, Conoco, Eni, Exxon, Gulf Oil, Mobil, Phillips, Shell, Texaco, and Total) were already present both in the UK and in Norway.

Panel (b) highlights differences in the portfolios of fields owned by firms. Firms with Norwegian EOR-eligible fields in their pre-1985 portfolios tended to own more fields. This reflects both Statoil's large and expanding portfolio of Norwegian oil & gas fields and the fact that early EOR developments, such as Phillips' efforts at Ekofisk, were driven by major oil firms that held multiple North Sea fields. Notably, the patterns of "number of fields per firm" and of "number of producing fields per firm" are similar across columns,

indicating that the firms that did not own Norwegian EOR-eligible fields prior to 1985 were not only engaged in exploration, but were already actively involved in production.

Panel (c) focuses on EOR adoption. Interestingly, firms that did not own Norwegian EOR-eligible fields before 1985 had a larger share of EOR-eligible fields overall (column 4 vs. column 1). This suggests that the differences in the above panels do not simply reflect self-selection into EOR-eligible fields. EOR adoption rates, however, were significantly lower than eligibility rates. While adoption increased by 66.7% among the firms that did not own Norwegian EOR-eligible fields before 1985 (columns 4 and 5), it increased by 80% among the firms with Norwegian EOR-eligible fields before 1985. This difference reflects both an intensive margin—firms that owned Norwegian EOR fields before 1985 were more likely to adopt EOR post-1985—and an extensive margin, as these firms also expanded into additional EOR-eligible fields in the North Sea. Their average share of EOR-eligible fields increased from 0.46 (column 1) to 0.50 (column 2), while it decreased from 0.65 (column 4) to 0.44 (column 5) among the other firms.

These descriptive statistics already point in the direction of some of our results: firms that owned Norwegian EOR-eligible fields before 1985 grew more than comparable firms that did not own such fields. As shown in the last row of Panel (a), their average market share of North Sea production increased from 4% to 5%, while the market share of firms that did not own Norwegian EOR-eligible fields prior to 1985 declined.

4 Empirical Strategy

This section describes our identification strategy and specifies the regressions we estimate to evaluate the effects of EOR adoption on production, costs, and firms' portfolios of assets and technologies.

4.1 Identification: EOR Eligibility and Supreme Court Decision

The adoption of EOR by firms operating in a field is not random, and a comparison of outcomes before and after the adoption of EOR within a field or across the fields that adopt and those that do not would likely lead to biased estimates. In order to account for potential correlation between EOR adoption and unobservable firm characteristics, such as the risk preferences of managers, we combine two sources of exogenous variation.

First, as discussed in Section 2.1, not all oil & gas fields are geologically and technologically eligible for EOR adoption. As described in Section 3, our detailed field-level data allow us to determine whether each field is eligible for adoption on the basis of geological characteristics such as API gravity, reservoir depth, and the availability of suitable technological infrastructures such as fixed platforms or drilling developments located on the seafloor. The lack of EOR eligibility of a field prevents adoption, irrespective of

unobserved firms' characteristics or managerial willingness to do so. However, the EOR eligibility of a field would not be sufficient to address our endogeneity concerns, in that more productive firms could still self-select into EOR-eligible fields based on their willingness to adopt EOR at a later stage. To overcome this challenge, we combine EOR eligibility of a field with an unforeseen shock that affected the expected returns from EOR adoption for fields in Norway but not in the UK.

In particular, this second source of exogeneous variation is the 1985 Norwegian Supreme Court decision, discussed in Section 2.2. We define as treated the Norwegian fields that were active before 1985 and the firms that were operating in Norway prior to 1985. Importantly, none of the motivations behind the 1985 decision makes any reference to EOR adoption; selection into treatment only indirectly affected EOR adoption.

More broadly, the Supreme Court decision represented an incentive to invest in Norwegian fields in terms of a reduction in *policy uncertainty* in the oil & gas sector in Norway relative to the UK.[10] Since EOR requires large capital investments, we expect the Supreme Court decision to have increased EOR adoption and production in Norway relative to the UK, where the threat of retroactive changes to oil & gas licenses may have discouraged firms to adopt EOR. Therefore, the Supreme Court decision represented an exogenous shock that increased the expected returns of EOR adoption in Norway after 1985, but not in the UK.

To illustrate the impact of the Supreme Court decision in our context, Figure 3 depicts the evolution of EOR adoption and oil production over time in the two countries. Panel (a) shows that the share of EOR fields in Norway (red triangles) increased substantially between 1985 and 1995 and continued to rise, reaching approximately 20% of available fields. In contrast, the corresponding share in the UK (blue circles) declined, following a downward trend already evident in the period 1980–1985, prior to the Supreme Court decision. Panel (b) similarly illustrates a divergence from the UK trend in the average cumulative production of Norwegian EOR-eligible fields (hollow red triangles).

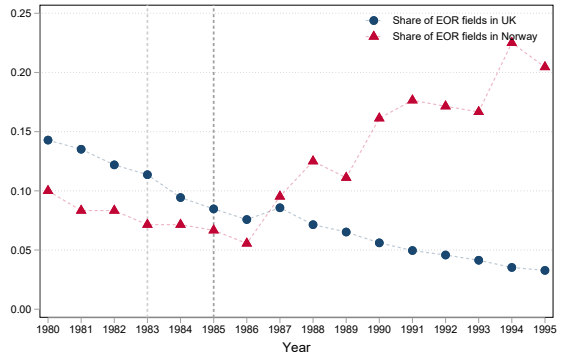
4.2 Field-level Analysis

We combine the two sources of exogenous variation mentioned above in a triple-difference framework. We rely on the Norwegian Supreme Court decision in 1985 to distinguish between treated (Norwegian) and control (UK) fields, and between a pre-period, from 1975 to 1985, and a post-period of the same length, from 1985 to 1995. Due to various geological and technological constraints, EOR can only be adopted in fields with suitable characteristics. We then introduce a further layer of comparison among oil & gas fields

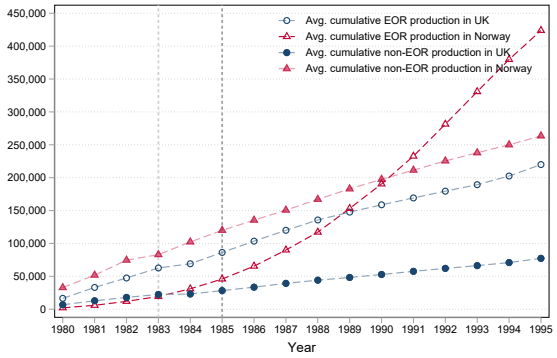
[10] The idea of exploiting a reduction in policy uncertainty as a source of exogenous variation for firms' decisions to adopt expensive technologies builds on the evidence by Gowrisankaran *et al.* (2022), who investigate the effects of uncertainty regarding the enforcement of the "Mercury and Air Toxics Standard" on technology adoption and exit in the market for coal-fired electricity generators.

Figure 3: EOR adoption and production in Norway and in the United Kingdom

(a) Share of EOR fields



(b) Average cumulative production (mboe)



Notes: Panel (a) plots the yearly share of fields adopting EOR by country. For each year, Panel (b) plots the cumulative production of EOR and non-EOR fields by country averaged across EOR-eligible and non-EOR-eligible fields in the country. Vertical dotted lines show the years of Phillips's lawsuit (1983) and of the Norwegian Supreme Court decision (1985).

by exploiting heterogeneity in their EOR eligibility in the period prior to 1985.[11] In particular, for each outcome y_{ft} (e.g., production) measured at the level of field f, country $c(f)$, and year t, we estimate the following triple-difference regression:

$$y_{ft} = \beta_{\text{treat}} \, \text{Norway}_{c(f)} \times \text{EOR}_f \times \text{Post}_t + \beta_1 \, \text{EOR}_f \times \text{Post}_t + \tau_f + \iota_{c(f)t} + \epsilon_{ft}, \qquad (1)$$

where the indicator $\text{Norway}_{c(f)}$ equals 1 for fields in Norway and 0 in the UK, the indicator Post_t equals 1 for the years after 1985, and the indicator EOR_f equals 1 if field f is geologically and technologically eligible for EOR as of 1985 (see Section 2.1). Finally, τ_f and $\iota_{c(f)t}$ are field and country-year fixed effects. In this field-level regression, β_{treat} measures the effect of EOR eligibility in Norway compared to EOR eligibility in the UK after 1985, controlling for field and country-year specific fixed effects. The indicator EOR_f captures an intention-to-treat rather than the more direct, but endogenous, treatment represented by EOR adoption. As a consequence, β_{treat} can be interpreted as a conservative measure of the effect of EOR adoption, in that several eligible fields in Norway and the UK were ultimately not observed to adopt EOR in the time horizon of our sample.

A notable feature of the triple-difference regression is that it relaxes the parallel-trend assumption required for the identification of standard difference-in-differences (DiD) regressions (Olden and Møen, 2022). Specifically, it does not require parallel trends to hold separately for the DiD comparison between EOR-eligible and non-EOR-eligible fields within Norway and the corresponding DiD comparison within the UK. Instead, identifi-

[11] While many geological and technological characteristics of a field remain constant over its life, some key factors influencing EOR adoption evolve over time. For instance, reservoir pressure naturally declines as oil and gas are extracted. To mitigate endogeneity concerns, we measure a field's eligibility for EOR adoption based on its characteristics prior to the Norwegian Supreme Court decision in 1985, rather than at each point during its life cycle.

cation of the triple-difference regression only requires that, in the absence of treatment (the Norwegian Supreme Court decision), the relative difference in outcomes between EOR and non-EOR-eligible fields in Norway (the treated country) would have evolved similarly to the relative difference in outcomes between EOR and non-EOR-eligible fields in the UK (the control country).

Compared to a standard DiD, regression (1) has at least two advantages. First, any systematic bias affecting both DiD comparisons within Norway and within the UK cancels out by construction. This is stronger than controlling for time fixed effects or any other observable control, as it also accounts for all time-varying unobservables potentially impacting all EOR-eligible or all non-EOR-eligible fields. For instance, discoveries in other parts of the world that require similar technologies as EOR-eligible fields in the North Sea or policies in other countries making firms divert funds from non-EOR-eligible fields in the North Sea would be accounted for. Second, field and country-year fixed effects help to account for any form of time-invariant heterogeneity across fields and, respectively, for any county-specific differential evolution in outcomes over time, making the parallel trend assumption required for identification more credible. In particular, country-year fixed effects are especially important to control for the periodic country-level policy changes this industry is typically subject to (e.g., changes to the royalty schemes as documented by Ahlvik and Harding, 2024), mitigating selection issues (e.g., more productive firms selecting into EOR-eligible fields in Norway after 1985).[12]

4.3 Firm-level Analysis

We also estimate firm-level regressions to evaluate the consequences of EOR adoption on oil & gas firms' outcomes. Each of these firms typically (i) is active in multiple fields, some of which are EOR eligible while others are not, and (ii) operates under both the jurisdictions of Norway and the UK. Aggregating over fields, we define for each firm i the continuous treatment variable "Share EOR Norway$_i$" as the average share of Norwegian EOR-eligible fields in the firm's North Sea portfolio prior to 1985. Specifically, for each year up to 1985, we compute the ratio of Norwegian EOR-eligible fields to the total number of fields in the North Sea included in firm i's portfolio, and then take the average over years.[13] Analogously, we define "Share EOR$_i$" as the average share of EOR-eligible fields (both in Norway and in the UK) included in firm i's portfolio prior to 1985.

We measure these shares using field counts rather than ownership-weighted shares to mitigate potential endogeneity concerns. For instance, more productive firms may have held larger stakes in fields with specific characteristics, such as EOR-eligible fields.

[12] These fixed effects also control for the interaction Norway$_{c(f)} \times$Post$_t$, which would need to be included in a triple-difference regression with coarser fixed effects (i.e., only field-specific and country-specific).

[13] We compute the average share over the years up to 1985 because a firm's portfolio of fields may evolve from year to year.

However, the correlation between the two ways of computing these shares is high—e.g., it is 0.7 for "Share EOR Norway$_i$"—and the results we present in this paper are similar with both definitions.

Analogous to the triple-difference field-level regression (1), we estimate the following firm-level regression:

$$\begin{aligned} y_{it} = \gamma_{\text{treat}} \text{ Share EOR Norway}_i \times \text{Post}_t \\ + \gamma_1 \text{ Share EOR}_i \times \text{Post}_t + \alpha_i + \psi_t + \epsilon_{it}, \end{aligned} \tag{2}$$

where y_{it} is an aggregate outcome for firm i across all fields in which i was active in year t (e.g., production or market share), γ_{treat} captures the effect on y_{it} of a higher pre-1985 involvement in EOR-eligible fields in Norway after the Norwegian Supreme Court decision (γ_1 can be interpreted similarly), while α_i and ψ_t are firm and year fixed effects. These firm fixed effects are essential to control for any time-invariant firm-specific observed or unobserved heterogeneity that may affect a firm's outcomes, such as nationality, scale of operations, extent of operations in the rest of the world, and political connections.

Note that the firm-level analogue of the triple-difference regression (1) would require including the term "Share Norway$_i \times$ Post$_t$," where "Share Norway$_i$" is firm i's average share of Norwegian fields (both EOR eligible and non-EOR eligible) in its portfolio before 1985. However, since "Share EOR Norway$_i$" and "Share Norway$_i$" are highly correlated (0.82), we cannot include "Share Norway$_i$" in these regressions. Nevertheless, we conduct robustness checks by incorporating "Share Norway$_i \times$ Post$_t$" in regression (2) and find that the point estimates remain very similar despite mechanically larger standard errors (due to multicollinearity).[14]

To the best of our knowledge, the properties of triple-difference regressions with continuous treatments, as in (2), have not yet been formally studied in the econometrics literature (e.g., Roth *et al.*, 2023, Caron, 2025). Intuitively, however, because of the firm and time fixed effects we control for, identification relies on comparisons between firms with identical shares of EOR-eligible fields in the North Sea before 1985, where treated firms owned an additional EOR-eligible field in Norway prior to 1985, while control firms instead owned an additional EOR-eligible field in the UK prior to 1985. As in field-level regression (1), since the compared firms are otherwise identical except for the jurisdiction of their "marginal" EOR-eligible field, policy changes affecting treated firms are expected to impact in a similar way also control firms and, so to speak, to "cancel out" in the triple-differencing. Then, the observed difference in post-1985 outcomes between treated (i.e., with the marginal EOR-eligible field in Norway before 1985) and control firms (i.e., with

[14]The Variance Inflation Factor (VIF) measures the contribution to multicollinearity of each independent variable in a regression. As an example using firms' productions as the dependent variable, some VIFs exceed the commonly accepted threshold of 10 when including "Share Norway$_i \times$ Post$_t$" in (2). Removing this term reduces all VIFs below 3.6, suggesting no multicollinearity issue.

the marginal EOR-eligible field in the UK before 1985) identifies γ_{treat}, a conservative measure of the effect of EOR adoption.

5 EOR Adoption, Production, and Costs

In this section, we assess the consequences of EOR eligibility in Norway after 1985 compared to EOR eligibility in the UK after 1985 on: (i) EOR adoption, (ii) production (mmboe), (iii) capital expenditures (capex), (iv) operational expenditures (opex), and (v) the ratio between production and opex. Since capex investments do not occur every year and depend on past capex expenditures for related infrastructures, we focus on cumulative rather than current capital expenditures.

5.1 Field-Level Analysis

Table 3 reports coefficient estimates from field-level regression (1) using EOR adoption and measures of oil production as dependent variables. Column 1 confirms the pattern of Panel (a), Figure 3: after the Supreme Court decision in 1985, EOR-eligible fields in Norway, relative to similar fields in the UK, had a 27.6 percentage point higher probability of adopting EOR during the period 1985-1995. In line with Panel (b) of Figure 3, column 2 shows that the overall effect of EOR on production was large: following the Supreme Court decision in 1985, EOR-eligible fields in Norway, relative to similar fields in the UK, increased production over the next ten years by $\exp(2.610) - 1 = 12.6$ times. However, note that the sample used in this regression includes all fields in the North Sea, including those that had not yet started production by 1985. Consequently, the estimates of column 2 conflate both the intensive margin of production (for the fields already producing before 1985) and the extensive margin of production (for the fields not yet producing by 1985).

Column 3 of Table 3 repeats the analysis in column 2, but restricts the sample to those fields already producing by 1985, thus focusing on the intensive margin of production. This shows that EOR-eligible fields in Norway increased production at the intensive margin by approximately 5 times during the period 1985-1995. Finally, the last column of Table 3 evaluates the effect on the extensive margin of production, using as dependent variable the indicator $\mathbb{1}\{\text{prod}_{ft} > 0\}$. These estimates show that the probability of production for EOR-eligible fields in Norway, relative to similar fields in the UK, increased by 44 percentage points during the period 1985-1995. Considering that $\Pr(\text{prod}_{ft} > 0) = 73\%$ in the estimation sample, these results highlight that a sizable portion of the overall increase in production from column 2 is attributable to the fact that many more EOR-eligible fields in Norway than in the UK started (or did not stop) production after 1985.

Appendix Table B2 replicates the analysis with the indicator "Post_t" equal to one for the years after 1983, when the Phillips's lawsuit started, and finds qualitatively similar

Table 3: Field-level EOR adoption and production: Intensive vs. extensive margin

	EOR Adoption	Production Margins		
Dept. var.	$\mathbb{1}\{\text{Adopted EOR}_{ft}\}$	Intensive and Extensive $\ln(1+\text{prod}_{ft})$	Only Intensive $\ln(1+\text{prod}_{ft})$	Only Extensive $\mathbb{1}\{\text{prod}_{ft}>0\}$
	(1)	(2)	(3)	(4)
Norway × EOR × Post	0.276**	2.610***	1.787***	0.440**
	(0.119)	(0.634)	(0.469)	(0.217)
EOR × Post	0.065*	0.621*	0.905**	0.037
	(0.034)	(0.345)	(0.367)	(0.096)
Field selection	All	All	Prod. < 1985	All
Country-Year FE	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes
Observations	1989	1989	924	1989
R-square	0.84	0.62	0.64	0.45

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (1). The dependent variable in column 1 is an indicator that equals 1 if field f has adopted EOR by year t and 0 otherwise. Columns 2–4 use functions of field-level production as dependent variables. Columns 2 and 3 use the log of production, with column 3 restricting the sample to fields that began production before 1985, isolating variation in the intensive margin (i.e., among fields already producing in 1985). The dependent variable in column 4 is an indicator that equals 1 if the field produces in year t and 0 otherwise, capturing only the extensive margin of production. The indicator variables "Norway," "EOR," and "Post" equal 1 for Norwegian fields, for EOR-eligible fields, and for the years after 1985, and 0 otherwise. Each regression includes country-by-year and field fixed effects. Standard errors are clustered at the field-level.

results despite a smaller sample, making the extensive margin more noisy as several already planned EOR projects started between 1983 and 1985. Appendix Table B3 presents another robustness check in which we consider only fields discovered before 1985, so to exclude the potential effect of the Supreme Court decision on exploration activities. Appendix Table B4 presents estimation results for an alternative definition of EOR eligibility which also considers the permeability and the porosity of a field, as these information are missing for some fields. The estimates of these alternative specifications and samples remain consistent with those reported in Table 3.

Table 4 reports coefficient estimates from field-level regression (1) using measures of costs, such as opex (operative costs) and capex (capital investments), as dependent variables. Column 1 shows that after the Norwegian Supreme Court decision in 1985, Norwegian EOR-eligible fields experienced an increase in operational costs of $\exp(2.405)-1 \approx 10.1$ times, consistent with the need for chemicals as input to implement EOR. These results suggest that the increase in production reported in column 2 of Table 3 was larger than that in opex, implying a reduction in average variable costs. Additionally, column 2 of Table 4 shows that EOR adoption required capital investments and the cost of adopting the technology increased cumulative capex by around 2.4 times.[15] These results illustrate

[15] As mentioned above, we focus on cumulative capital expenditures since the capital expenditures in year t might be influenced by the capital expenditures in previous years.

Table 4: Field-level costs and productivity

Dept. var.	$\ln(1+\text{opex}_{ft})$ (1)	$\ln(1+\text{cum. capex}_{ft})$ (2)	prod_{ft} / opex_{ft} (3)
Norway × EOR × Post	2.405**	1.220*	60.110**
	(0.969)	(0.645)	(29.054)
EOR × Post	1.005**	0.030	23.552
	(0.450)	(0.185)	(26.105)
Country-Year FE	Yes	Yes	Yes
Field FE	Yes	Yes	Yes
Observations	1988	1989	1989
R-square	0.58	0.84	0.56

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (1). The dependent variables are opex and cumulative capex (in logs) in columns 1-2 and the ratio of production to opex in column 3. The indicator variables "Norway," "EOR," and "Post" equal 1 for Norwegian fields, for EOR-eligible fields, and for the years after 1985, and 0 otherwise. Each regression includes country-by-year and field fixed effects. Standard errors are clustered at the field-level.

the intuitive trade-off faced by potential EOR adopters, who must balance lower variable costs in the future with large upfront investments.

Appendix Table B5 shows that the results of Table 4 are robust to defining the indicator "Post_t" to be one for the years after 1983. In addition, Appendix Tables B6 and B7 show that the results in Table 4 are also robust to considering only fields discovered before 1985 and a different definition of EOR eligibility, respectively.

To illustrate the evolution of field-level production and costs over time, we also estimate the following event study regression:

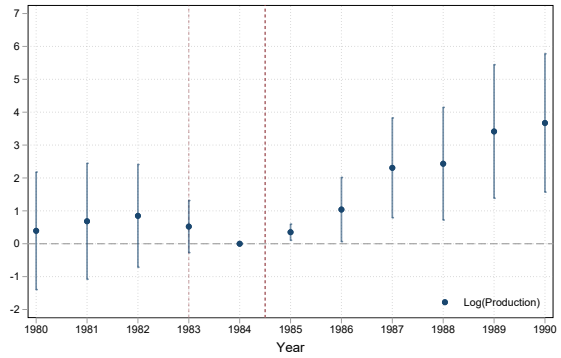
$$\begin{aligned} y_{ft} = &\sum_{d=-4}^{5} \beta_{\text{treat},d}\, \text{Norway}_{c(f)} \times \text{EOR}_f \times \mathbb{1}\{t-1985=d\} \\ &+ \sum_{d=-4}^{5} \beta_{1,d}\, \text{EOR}_f \times \text{Post}_t \times \mathbb{1}\{t-1985=d\} + \tau_f + \iota_{c(f)t} + \epsilon_{ft}, \end{aligned} \tag{3}$$

where $\mathbb{1}\{t-1985=d\}$ is an indicator that equals 1 when year t is d years before or after 1985. As in regression (1), τ_f and $\iota_{c(f)t}$ are field and country-year fixed effects.

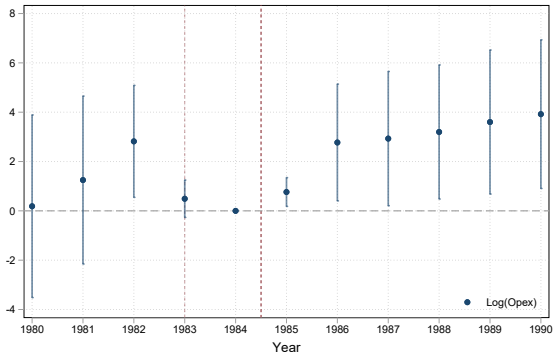
The estimates of $\beta_{\text{treat},d}$ are plotted in Figure 4. Panel (c) shows that cumulative capex increased immediately after the 1985 decision. Panels (a) and (b) instead show that production and opex also increased, but with a delay between one and two years. Despite their conservative nature, these results are consistent with the technical timing needed for the implementation of EOR (e.g., geological survey, installation of tanks and wells). Panel (d) then confirms that production increased proportionally more than opex. We do not observe pre-trends across panels: the trends of EOR-eligible fields were statistically indistinguishable between Norway and the UK before 1985.

Figure 4: Field-level event study of production and costs

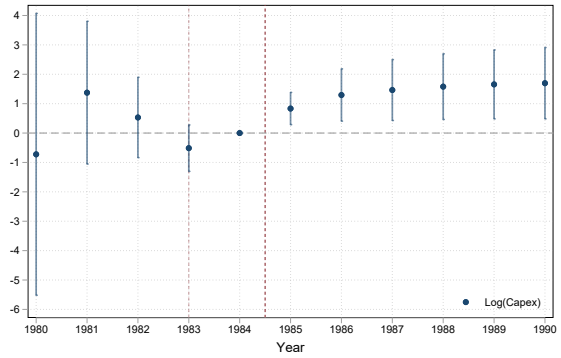
(a) $\ln(1 + \text{prod}_{ft})$



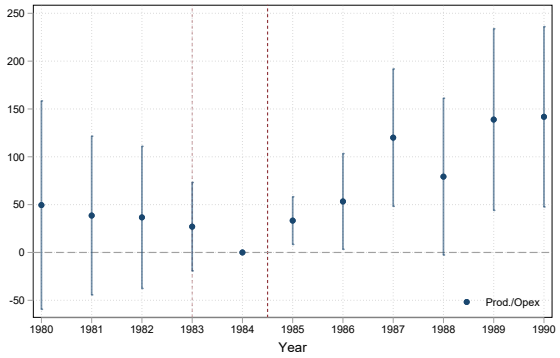
(b) $\ln(1 + \text{opex}_{ft})$



(c) $\ln(1 + \text{cum. capex}_{ft})$



(d) prod_{ft} / opex_{ft}



Notes: Results of the event study regression (3). Each plot reports the coefficients $\hat{\beta}_d$, the impact of EOR eligibility in Norwegian fields d years before or after the Supreme Court decision in 1985. $d = -1$ (i.e., 1984) is the reference year. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the field-level.

5.2 Firm-Level Analysis

Table 5 reports coefficient estimates from the firm-level regression (2) using measures of EOR adoption, production, and costs as dependent variables. Column 1 of Table 5 confirms the field-level findings of column 1, Table 3, and of Panel (a), Figure 3: firms with a pre-1985 portfolio of fields that included 10 percentage points more Norwegian EOR-eligible fields had a 3.5 percentage point larger share of fields in their portfolios that adopted EOR after 1985.[16] In contrast, firms with a pre-1985 portfolio that included British but not Norwegian EOR-eligible fields (with Share $\text{EOR}_i > 0$ and Share EOR $\text{Norway}_i = 0$) were not more likely to adopt EOR after 1985. Considering that the average share of fields that adopted EOR in firms' portfolios was around 4% in the period 1975-1995, these estimates confirm that the Supreme Court decision played a major role in

[16] As reported in Table 2, firms with "Share EOR $\text{Norway}_i > 0$" had pre-1985 portfolios including an average of 7.84 fields. Of these, around $0.27 \times 7.84 = 2.12$ were, on average, Norwegian EOR-eligible fields. A 10 percentage point increase in "Share EOR Norway_i" (from 27% to 37%) implies substituting 0.78 of the other fields in the firm's pre-1985 portfolio with 0.78 Norwegian EOR-eligible fields.

Table 5: Firm-level EOR adoption, production, costs, and productivity

	Adoption	Production and Costs			
Dept. var.	Share EOR	$\ln(1+\text{prod}_{it})$	$\ln(1+\text{opex}_{it})$	$\ln(1+\text{cum. capex}_{it})$	prod_{it} / opex_{it}
	(1)	(2)	(3)	(4)	(5)
Share EOR Norway × Post	0.347***	3.193***	3.059***	2.108***	0.257*
	(0.116)	(0.831)	(0.441)	(0.647)	(0.140)
Share EOR × Post	0.021	-0.402	-0.057	-0.470**	-0.024
	(0.013)	(0.266)	(0.347)	(0.210)	(0.090)
Average dept. var.	0.053	2.562	3.511	6.688	0.328
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	1406	1406	1402	1406	1245
R-squared	0.70	0.86	0.86	0.94	0.43

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (2). The dependent variable "Adoption - Share EOR" in Column 1 is the share of fields that adopted EOR among all the fields in which firm i is active in the North Sea in year t. The remaining columns have as dependent variables production, opex, cumulative capex, and the ratio of production on opex. The variables "Share EOR Norway" ("Share EOR") refers to the share of Norwegian (North Sea) EOR-eligible fields in which a firm was active before 1985. The indicator "Post" equals 1 for the years after 1985, the year of the Supreme Court decision, and 0 otherwise. Each regression includes firm and year fixed effects. Standard errors are clustered at the firm-level.

fostering the diffusion of this technology in Norway. The remaining columns of Table 5 then investigate the consequences of this larger EOR adoption on production and costs.

Column 2 shows that firms with a pre-1985 portfolio of fields that included 10 percentage points more Norwegian EOR-eligible fields had a production of $100 \times (\exp(3.193 \times 0.10) - 1) \approx 38\%$ higher in the period 1985-1995. In line with the field-level evidence from the previous section, firms with a larger pre-1985 share of Norwegian EOR-eligible fields also increased operative costs (column 3), consistently with the need for chemicals to implement EOR, and capital investments (column 4), consistently with higher rates of EOR adoption. Moreover, for these firms, the increase in production was greater than the increase in operational costs, implying a reduction in average variable costs (column 5). Differently, firms with a pre-1985 portfolio that included British but not Norwegian EOR-eligible fields (with Share $\text{EOR}_i > 0$ and Share EOR $\text{Norway}_i = 0$) moved—if at all—in the opposite direction after 1985, slightly *decreasing* production, operational costs, and capital investments.

Appendix Table B8 shows that these results are robust to defining the indicator "Post_t" to be one for the years after 1983. In addition, Appendix Table B9 confirms that these results are also robust to using a different definition of EOR eligibility. As a further robustness, Appendix Table B12 reports estimates of an extension of regression (2) that also controls for "Share $\text{Norway}_i \times \text{Post}_t$," where "Share Norway_i" represents the average share of Norwegian fields included in firm i's portfolio before 1985. This is the firm-level analogue of triple-difference regression (1) and, overall, yields results consistent

with those of regression (2), though with slightly larger standard errors due to the high correlation (0.82) between "Share EOR Norway$_i$" and "Share Norway$_i$."

To illustrate the evolution of firm-level production and costs over time, we also estimate the following event study regression:

$$\begin{aligned} y_{it} = &\sum_{d=-4}^{5} \gamma_{\text{treat},d} \text{ Share EOR Norway}_i \times \mathbb{1}\{t - 1985 = d\} \\ &+ \sum_{d=-4}^{5} \gamma_{1,d} \text{ Share EOR}_i \times \mathbb{1}\{t - 1985 = d\} + \gamma_{2,d} + \alpha_i + \psi_t + \epsilon_{it}, \end{aligned} \tag{4}$$

where $\mathbb{1}\{t - 1985 = d\}$ is an indicator that equals 1 when year t happens to be d years before or after 1985. As in regression (2), α_i and ψ_t are firm and year fixed effects. We report the estimates of $\gamma_{\text{treat},d}$ in Appendix Figure A1, which shows trends similar to those of the field-level event study in Figure 4, with the only difference that the increase in cumulative capex occurs with a few more years of delay, most likely because the cumulative capex at the firm level conflates several other capital investments that do not necessarily relate to the adoption of EOR.[17]

6 Market Shares and Concentration

The results in the previous section show that the Norwegian Supreme Court decision in 1985 encouraged firms to adopt EOR in Norway but not in the UK and, consequently, firms with Norwegian EOR-eligible fields to increase production. However, did this increase in production allow EOR adopters in Noway to acquire larger shares of the oil & gas market in the North Sea?

A firm's market share is calculated as a weighted sum of the production of its fields, with the firm's ownership shares of these fields serving as weights. There are then two channels through which EOR adopters may have increased their market shares. First, these firms could have used the extra-returns of EOR to expand their portfolios at the extensive margin, acquiring ownership shares of fields that were not already in their portfolios. Second, EOR adopters could have also expanded their portfolios at the intensive margin, increasing their ownership shares of fields that were already in their portfolios. Section 6.1 investigates whether the increase in production due to EOR adoption translated into an increase in market shares and whether this was due to portfolio expansions.

Section 6.2 explores whether the changes in market shares documented in Section 6.1 also translated into changes in market concentration in Norway relative to the UK. Finally, Section 6.3 verifies that the changes in market shares documented in Section 6.1

[17] Appendix Figure A2 finds similar results including "Share Norway" in (4), despite larger standard errors due to multicollinearity.

were specific to the owners of Norwegian EOR-eligible fields and did not extend to the owners of other types of Norwegian fields.

6.1 Market Shares and Portfolios of Fields

Extensive margin. We start by estimating firm-level regression (2) using the market share of production in the North Sea as dependent variable. Column 1 of Table 6 shows that firms with a pre-1985 portfolio of fields that included 10 percentage points more Norwegian EOR-eligible fields had a market share of production 0.39 percentage points higher after 1985. Since the average firm-level market share of the North Sea was around $\exp(0.015) \approx 1\%$ during our sample period, this estimate roughly translates into an increase of 39% in the market share of the average firm. The sample used in column 1 includes all firm-year observations, also those corresponding to zero market shares (i.e., for the firms that had not yet started production by 1975 or that had stopped it before 1995). Focusing instead on firm-year observations with only positive production, column 2 shows an increase in market shares of 0.73 percentage points, an estimate almost twice as large as that in column 1 and corresponding to an even larger increase (73%) in the market share of the average "producing" firm. In contrast—and in line with our firm-level results from the previous section—, firms with a pre-1985 portfolio that included British but not Norwegian EOR-eligible fields (with Share EOR$_i > 0$ and Share EOR Norway$_i = 0$) did not experience any relative change in market shares after 1985.

Columns 3-5 of Table 6 investigate whether the increase in market shares documented in columns 1-2 coincided with an expansion of firms' portfolios of fields at the extensive margin, i.e., through the inclusion of new fields in their portfolios. Column 3 shows that firms with a pre-1985 portfolio of fields that included 10 percentage points more Norwegian EOR-eligible fields expanded their portfolios by one additional field after 1985. Columns 4-5 further show that around $100 \times (5.885/10.417) \approx 56\%$ of this expansion was in terms of EOR-eligible fields (column 4), while the remaining 44% was in terms of non-EOR-eligible fields (column 5). Differently, firms with a pre-1985 portfolio that included British but not Norwegian EOR-eligible fields *reduced* their portfolios by around 7.5 fields (24% EOR eligible and 76% non-EOR eligible) after 1985.

Plotting the the estimates of a firm-level event study regression, Appendix Figure A4 illustrates a substantial post-1985 growth in market shares for the firms with Norwegian EOR-eligible fields in their pre-1985 portfolios—a result that holds also excluding state-owned firms. Appendix Table B10 shows that these results are robust to defining the indicator "Post$_t$" to be one for the years after 1983, the year in which Phillips filed its lawsuit. Appendix Table B11 confirms that these results remain qualitatively unchanged using a different definition of EOR eligibility. Finally, the last two columns of Appendix Table B12 illustrate that our estimates are also robust to controlling for "Share Norway$_i$

Table 6: Market shares and portfolio expansions

Dept. var.	Market Share		Number of Fields		
	All	Positive	All Fields	EOR Eligible	Non-EOR Eligible
	(1)	(2)	(3)	(4)	(5)
Share EOR Norway × Post	0.039*	0.073**	10.417**	5.885***	4.532**
	(0.021)	(0.033)	(4.308)	(2.207)	(2.253)
Share EOR × Post	-0.000	0.001	-7.567***	-1.845***	-5.722***
	(0.003)	(0.003)	(1.488)	(0.614)	(1.043)
Average dept. var.	0.015	0.017	5.858	2.410	3.449
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	1406	1232	1406	1406	1406
R-squared	0.83	0.86	0.81	0.80	0.79

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (2). "Market share" is a firm's market share of production in the North Sea. Column 3 uses as dependent variable the total number of fields in which a firm is active in the North Sea. The dependent variables in columns 4-5 decompose the total number of fields in column 3 between the number of EOR-eligible fields (column 4) and the number of non-EOR-eligible fields (column 5) in which a firm is active in the North Sea. The dependent variables are a firm's market share The variables "Share EOR Norway" ("Share EOR North Sea") refers to the share of Norwegian (North Sea) EOR-eligible fields in which a firm was active before 1985. The indicator "Post" equals 1 for the years after 1985, the year of the Supreme Court decision. Each regression includes firm and year fixed effects. Standard errors are clustered at the firm-level.

$\times$ Post$_t$" (despite the larger standard errors due to the multicollinearity between "Share EOR Norway$_i$" and "Share Norway$_i$).

Intensive margin. We now explore whether the increases in market shares documented in columns 1-2 of Table 6 were solely motivated by portfolio expansions at the extensive margin (columns 3-5 of Table 6) or whether they were also driven by portfolio expansions at the intensive margin, i.e., through an increase in the ownership shares of fields already in the portfolio.

To do this, we rely on field-level regression (1) to test whether the level of concentration in the ownership shares of Norwegian EOR-eligible fields changed after the incentives to adopt EOR increased in 1985. Columns 1-3 of Table 7 show that the ownership shares of the top 1, 3, and 5 owners of Norwegian EOR-eligible fields increased substantially after the Supreme Court decision in 1985 compared to those of EOR-eligible fields in the UK (+29.1 percentage points for the top 1 owner, +40.4 for the top 3 owners, and +44 for the top 5 owners). Similarly, columns 4-5 show that, also in terms of HHI indices, the ownership structure of Norwegian EOR-eligible fields became more concentrated after 1985 compared to that of similar fields in the UK.[18]

[18]The normalized HHI index used in column 5 helps comparing concentration across fields in which

Finally, column 6 illustrates that part of the increase in concentration of ownership of Norwegian EOR-eligible fields was due to a substantial decrease in the average number of owners of these fields after 1985. As, on average, each field in the North Sea was owned by 4.33 firms in the period 1975-1995, the estimated decrease of -0.39 corresponds to an almost 10% drop in the average number of owners of Norwegian EOR-eligible fields after 1985. Appendix Table B13 shows that these results remain qualitatively unchanged defining the indicator "Post$_t$" to equal one for the years after 1983.

Table 7: Concentration in field ownership

	Share of			HHI		Number of
Dept. var.	Top 1	Top 3	Top 5	Standard	Normalized	Firms
	(1)	(2)	(3)	(4)	(5)	(6)
Norway × EOR × Post	0.291**	0.404**	0.440**	0.204*	0.249*	-0.390**
	(0.147)	(0.196)	(0.213)	(0.115)	(0.141)	(0.196)
EOR × Post	-0.020	0.021	0.034	-0.019	0.023	0.208
	(0.054)	(0.089)	(0.095)	(0.048)	(0.067)	(0.167)
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1988	1988	1988	1988	1781	1988
R-square	0.59	0.47	0.46	0.64	0.52	0.96

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Results from regression (1) based on field-level variation. Columns 1-3 use the (combined) share of the largest, three largest, five largest firms by ownership share in a field as dependent variable. Columns 4-5 employ the Herfindahl-Hirschman concentration index (HHI) computed in terms of asset interest shares at the field-level. "Normalized HHI" in column 5 is computed as $\frac{\text{HHI}-1/N}{1-1/N}$ and helps comparing the HHI across fields in which the number of active firms N vary. "Number of Firms" in column 6 is the number of partnering firms in a specific field. The indicator variables "Norway," "EOR," and "Post" equal 1 for Norwegian fields, for EOR-eligible fields, and for the years after 1985. Each regression includes country-by-year and field fixed effects. Standard errors are clustered at the field-level.

6.2 Market Concentration and Firm Entry

The results in the previous section highlight that the Norwegian Supreme Court decision led the owners of EOR-eligible fields in Norway to increase their market shares through expansions of their portfolios. We now explore to what extent this *relative* increase translated into an increase in market concentration in Norway relative to the UK.[19]

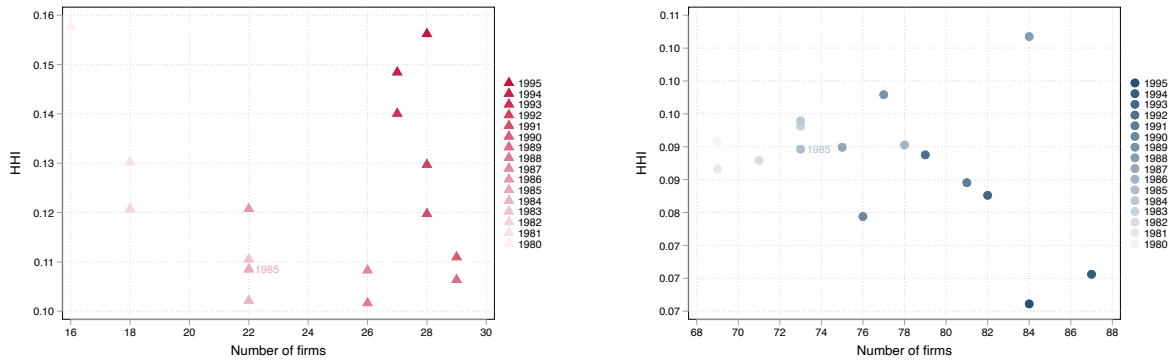
the number of active firms vary. The normalized HHI index is calculated as $\widetilde{\text{HHI}} = \frac{\text{HHI}-1/N}{1-1/N}$, where N is the number of active firms in the field.

[19]The results of regression (2) in columns 1-2 of Table 6 can only inform about *relative* changes in market shares between firms that had pre-1985 portfolios that included different shares of EOR-eligible fields in Norway or in the UK. As a consequence, an estimated relative increase in these market shares does not imply that they increased in absolute terms; indeed, market shares could simply have decreased *less* after the Supreme Court decision and the question of market concentration requires further investigation.

Figure 5 plots the yearly HHI index (y-axis) against the number of firms (x-axis), separately for Norway (Panel (a)) and for the UK (Panel (b)). Shaded points represent observations from older years, while darker points indicate observations from more recent years. Observations from the year of the Norwegian Supreme Court decision (1985), are labeled in each Panel. Panel (a) shows that in Norway, despite substantial entry of new firms—the number of firms nearly doubled in the period 1975-1995—market concentration increased significantly. This suggests that the incumbents were those who managed to expand most aggressively their market presence in Norway after 1985. In contrast, Panel (b) shows that in the UK, where firm entry was more modest (about 10%), market concentration steadily declined, indicating a relative reallocation of production from the incumbents to new entrants.

Figure 5: Concentration increases in Norway despite large entry while it drops in UK

(a) Norway (b) United Kingdom



Notes: Each plot presents the relationship between HHI and the number of firms by market over time. Panel (a) focuses on Norway (red triangles) and Panel (b) on the UK (blue dots). More recent years are in darker shades according to the legend.

6.3 Other Types of Norwegian Fields

As discussed in Section 4.1, the Supreme Court decision in 1985 represented an incentive to invest in Norwegian fields due to a reduction in policy uncertainty in the oil & gas sector in Norway relative to the UK (see also Gowrisankaran *et al.*, 2022). Although we have formulated the discussion in terms of EOR-eligible fields, one may wonder if our findings are specific to this type of fields or whether, more broadly, the Supreme Court decision encouraged firms to simply invest more in *all* types of Norwegian fields relative to UK fields. We now illustrate that this was not the case and that owners of other types of Norwegian fields did not experience relative increases in production, costs, and market shares as those documented in Tables 5 and 6 for owners of EOR-eligible fields.

Table 8 presents estimates of the firm-level regression (2) using the same dependent variables as in Tables 5 and 6, but replacing the pre-1985 ownership treatments "Share EOR Norway" and "Share EOR" with the corresponding shares of other field types that

are non-EOR eligible. Panel (a) considers the shares of deep well fields (reservoir depth greater than 2,000 meters and non-EOR eligible).[20] Panel (b) examines the shares of sour oil fields (presence of sulfide in the well and non-EOR eligible).[21] Panel (c) considers the shares of other non-deep, non-sour, non-EOR-eligible fields, while Panel (d) instead investigates the overall shares of a firm's non-EOR-eligible fields (the total of the shares from Panels (a)-(c)).

The findings indicate that, overall, firms with pre-1985 portfolios that included more Norwegian non-EOR-eligible fields did not experience substantial changes in operations or in market shares. Although incentivizing investments in EOR-eligible fields was not among the explicit objectives of the Norwegian Supreme Court decision in 1985, these results suggest that firms' responses to the ruling primarily went in that direction.

7 Know-How and State Ownership

Norway's path to becoming an oil-producing nation was initially uncertain. In 1958, the Norwegian Geological Survey dismissed the possibility of hydrocarbons on the Norwegian Continental Shelf. Combined with low oil prices, this skepticism led to limited interest from international companies, and the first concession round in 1965 offered liberal terms. However, after the discovery of the Ekofisk field in 1969, the Norwegian government adopted stricter regulations, prioritizing national control over Norway's natural resources. This shift led to the establishment of Statoil (now Equinor) in 1972, which was granted ownership shares of key fields despite a lack of experience. Favorable policies, such as the principles of *carried interest* and of *gliding scale*,[22] supported Statoil's early growth, allowing it to expand its role in the oil & gas industry until these benefits were phased out in the early 1990s (Austvik, 2014).[23]

Although Statoil played an important role in the success of Norway's oil & gas policy, the presence of international firms was also incentivized for the provision of expertise and capital. Foreign companies were invited as minority partners to facilitate the transfer of technology and expertise to state companies, with Norwegian firms gradually assimilating

[20] Significant R&D efforts focus on deep oil, as the discovery of deep and ultra-deep well fields has established the ultra-deep frontier as the next phase of extraction in the North Sea basin (Doornenbal *et al.*, 2022).

[21] The presence of sulfide in oil & gas wells poses major challenges for the industry, causing production losses, corrosion, and environmental risks. For instance, ExxonMobil's LaBarge field in Wyoming, discovered in 1963, faced decades of delay due to its sulfide content. Since then, new technologies have been developed to control and reduce sulfide levels, improving field viability (Burgers *et al.*, 2011).

[22] The "carried interest"principle implied that Statoil did not have to sustain the expenses accumulated during the exploration phase, which were instead covered by the other licenses of the field. The "gliding scale" principle from 1974 instead implied that Statoil could increase its share of a license up to 60-80% when production started. These principles were abolished only in 1992-93.

[23] Note that, as explained in Section 4.3, these and other changes in country-specific industrial policies do not represent a threat for our triple-difference empirical strategy.

Table 8: Firm-level production, costs, and market shares: Other types of fields

	Production and Costs				Market Share	
Dept. var.	$\ln(1+\text{prod}_{it})$ (1)	$\ln(1+\text{opex}_{it})$ (2)	$\ln(1+\text{cum. capex}_{it})$ (3)	prod_{it} / opex_{it} (4)	All (5)	Positive (6)
Panel (a): Non-EOR, Deep Well Fields (Deep)						
Share Deep Norway × Post	0.789	0.118	0.403	0.157	0.013	0.008
	(0.841)	(0.791)	(0.561)	(0.140)	(0.018)	(0.023)
Share Deep × Post	-0.050	-0.321	0.097	-0.176	0.001	0.005*
	(0.304)	(0.431)	(0.237)	(0.130)	(0.003)	(0.003)
Observations	1406	1402	1406	1406	1406	1232
R-squared	0.84	0.84	0.93	0.41	0.82	0.84
Panel (b): Non-EOR, Sour Oil Fields (Sour)						
Share Sour Norway × Post	0.482	-1.094	-0.854	0.075	0.051	0.060
	(1.313)	(1.200)	(0.544)	(0.231)	(0.045)	(0.046)
Share Sour × Post	-0.291	-0.363	-0.127	-0.205	-0.007	-0.004
	(0.338)	(0.418)	(0.246)	(0.156)	(0.005)	(0.005)
Observations	1406	1402	1406	1406	1406	1232
R-squared	0.84	0.84	0.93	0.42	0.82	0.85
Panel (c): Non-EOR, Non-Deep, Non-Sour Oil Fields (Other)						
Share Other Norway × Post	0.773	0.018	0.570	0.035	0.009	0.003
	(1.039)	(1.065)	(0.835)	(0.112)	(0.022)	(0.032)
Share Other × Post	0.214	-0.188	0.677*	0.079	-0.001	0.000
	(0.343)	(0.509)	(0.405)	(0.077)	(0.002)	(0.002)
Observations	1406	1402	1406	1406	1406	1232
R-squared	0.85	0.84	0.93	0.41	0.82	0.84
Panel (d): Non-EOR Fields						
Share non-EOR Norway × Post	0.773	0.018	0.570	0.035	0.009	0.003
	(1.039)	(1.065)	(0.835)	(0.112)	(0.022)	(0.032)
Share non-EOR × Post	0.214	-0.188	0.677*	0.079	-0.001	0.000
	(0.343)	(0.509)	(0.405)	(0.077)	(0.002)	(0.002)
Observations	1406	1402	1406	1406	1406	1232
R-squared	0.84	0.84	0.93	0.40	0.82	0.84
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (2). The table consists of three Panels. The three Panels vary by treatment definition. In Panel (a), the treatment is defined as the share of deep, non-EOR-eligible fields, that a firm is active in before 1985 either in Norway (first row of each Panel) or in the North Sea (second row). Panel (b) focuses on sour, non-EOR-eligible fields. Panel (c) on the remaining (other) non-EOR-eligible fields. Panel (d) on all the non-EOR fields. The indicator "Post" equals 1 for the years after 1985, the year of the Supreme Court decision, and 0 otherwise. The first four columns use operation variables such as production, opex, cumulative capex, and production over opex as dependent variables, whereas columns 5 and 6 use market shares, with column 6 subsetting to observations of firms having positive market shares. Each regression includes firm and year fixed effects. Standard errors are clustered at the firm-level.

know-how and obtaining control of the operations. For instance, Mobil operated the Statfjord field until Statoil took over in 1987. However, concerns over Statoil's growing

political influence led to government efforts to limit its power, including redistributing its ownership shares to a state-controlled investment vehicle in the 1980s (Norway State DFI). This dual approach—leveraging state ownership while relying on foreign expertise—raises the question of whether Norway's market share expansion, as documented in the previous section, stemmed primarily from Statoil's protected learning-by-doing process or from broader industry-wide learning and reinvestment (Thurber and Istad, 2010). This section investigates these mechanisms by analyzing the separate roles of know-how and of state ownership in shaping the evolution of firms' market shares and portfolios of fields.

7.1 Empirical Strategy

To isolate the importance of know-how, we augment the continuous treatment in firm-level regression (2) with a further interaction:

$$\begin{aligned} y_{it} = {} & \theta_{\text{treat}} \text{ K-H}_i \times \text{Share EOR Norway}_i \times \text{Post}_t \\ & + \theta_1 \text{ Share EOR Norway}_i \times \text{Post}_t + \theta_2 \text{ Share EOR}_i \times \text{Post}_t \\ & + \alpha_i + \psi_t + \epsilon_{it}, \end{aligned} \tag{5}$$

where "K-H$_i$" is an indicator variable equal to one if firm i was the operator of at least one field in the North Sea which adopted EOR before 1985, or zero otherwise. This definition of "K-H$_i$" ensures an active role played by firm i in the adoption and management of EOR prior to the Norwegian Supreme Court decision, rather than only a potentially passive ownership of a share of an EOR-eligible field. As in regression (2), θ_1 captures the effect on y_{it} of a higher pre-1985 involvement in EOR-eligible fields in Norway after the Norwegian Supreme Court decision. Differently, θ_{treat} captures the additional effect that the Supreme Court decision may have had on firms with direct expertise on EOR adoption and management prior to 1985, isolating any return beyond the financial benefits shared by all pre-1985 owners of Norwegian EOR-eligible fields.

Consistent with the previous analyses, we exclude "Share Norway" from (2) in the main text due to multicollinearity. However, Appendix Table B14 shows that the results in Sections 7.2, 7.3, and 8 remain robust when including this variable. Therefore, as in regression (2) of Section 4.3, θ_{treat} is identified by comparing two otherwise equivalent firms—thanks to the triple-difference setup and firm and time fixed effects (α_i and ψ_t)—that differ only in whether they operated in an EOR-eligible field. This ensures that the effect of time-and unit-varying factors (e.g., policy) cancels out by construction.[24]

To assess the potentially different role played by state-owned firms, we estimate a regression similar to (5) but that replaces the indicator variable "K-H$_i$" with the indicator variable "S-O$_i$," which equals one if firm i was state-owned before 1985.[25] Importantly,

[24] Appendix results confirm robustness when including "Share Norway" in (5) as a regressor.
[25] Appendix Table B15 lists the state owned firms operating in the North Sea between 1975 and 1995.

because some state-owned firms also had know-how (in the sense of "K-H$_i$ = 1"), we also estimate a version of regression (5) in which we categorize firms into three mutually exclusive groups: firms that prior to 1985 had know-how but were not state-owned, such as Conoco (denoted by "K-H Only$_i$"), firms that prior to 1985 were state-owned and had know-how, such as Statoil and BP (denoted by "K-H & S-O$_i$"), and other firms.[26] With this specification, we estimate the potentially heterogeneous effects of the Norwegian Supreme Court decision for each category of firms and separately identify the effect of know-how from that of state ownership.[27]

7.2 Market Shares

Know-how. Panel (a) of Table 9 presents the estimates of firm-level regression (5) using the market share of production in the North Sea as dependent variable. Column 1 shows that firms with a pre-1985 portfolio of fields that included 10 percentage points more Norwegian EOR-eligible fields *and* that, prior to 1985, were operators in fields that adopted EOR had a market share of production 1.08 percentage points higher after 1985. As the average firm-level market share of the North Sea was around 1% during our sample period, this roughly translates into an increase of 108% in the market share of the average firm. In addition, the estimated θ_1 is 12 times smaller than the estimated θ_{treat}. These results suggest that the expansion in market shares documented in Section 6.1 was primarily driven by the operators' expertise in adopting and efficiently managing EOR during its life cycle, rather than by the financial gains deriving from the mere—and potentially passive—ownership of shares of EOR-eligible fields.

This observation is also supported by the estimates in columns 3-5 of Table 9. These indicate that know-how is the main force behind the portfolio expansions at the extensive margin documented in Table 6. Column 3 shows that firms with a pre-1985 portfolio of fields that included 10 percentage points more Norwegian EOR-eligible fields expanded their portfolios by (a statistically insignificant) 0.51 additional fields after 1985. Differently, firms with similar pre-1985 portfolios of fields and that, prior to 1985, were operators in fields that adopted EOR expanded their portfolios by 3.4 additional fields after 1985. Notably, only 0.96 of these additional fields (column 4), or $9.655/33.812 \approx 28.5\%$, were EOR eligible, while the remaining 2.4 (71.5%) were not (column 5). This suggests

[26] In this specification, we exclude two firms that were state-owned but essentially did not have any EOR-eligible field in their portfolios before 1985. These are Norway State FDI, which was endowed with shares of Statoil's EOR-eligible fields only in 1984, and Britoil, which was purchased by BP in 1988. Including these two firms in the estimation sample does not affect our results in this or the following sections (see Appendix Tables B16, B18, and B20).

[27] The decision to drill in a field is known to depend on the drilling decisions at nearby fields due to spatial correlation of well outcomes (Hodgson, 2024). Similarly, the decision to adopt EOR could also be influenced by EOR adoption decisions in nearby fields. However, as shown in Appendix C, it was operators' know-how—rather than proximity to fields that adopted EOR—that primarily drove EOR adoption. Therefore, we do not further explore the role of geographic proximity.

Table 9: Know-how, market shares, and portfolio expansions

Dept. var.	Market Share	Number of Fields		
		All Fields	EOR Eligible	Non-EOR Eligible
	(1)	(2)	(3)	(4)
Panel (a): Know-How (K-H)				
K-H × Share EOR Norway × Post	0.108***	33.812***	9.655***	24.157***
	(0.035)	(10.635)	(2.966)	(8.820)
Share EOR Norway × Post	0.009**	5.148	4.059*	1.089
	(0.004)	(3.248)	(2.135)	(1.327)
Observations	1377	1377	1377	1377
R-squared	0.88	0.83	0.81	0.81
Panel (b): State-Owned (S-O)				
S-O × Share EOR Norway × Post	0.129***	25.463**	8.690***	16.773**
	(0.025)	(9.968)	(2.757)	(7.910)
Share EOR Norway × Post	0.011**	7.127*	4.482**	2.645
	(0.005)	(3.981)	(2.192)	(2.045)
Observations	1377	1377	1377	1377
R-squared	0.88	0.82	0.81	0.80
Panel (c): Know-How (K-H) & State-Owned (S-O)				
K-H & S-O × Share EOR Norway × Post	0.132***	28.155***	9.287***	18.868**
	(0.025)	(9.825)	(2.799)	(7.804)
K-H Only × Share EOR Norway × Post	0.050**	47.503***	10.545**	36.958***
	(0.023)	(10.474)	(4.858)	(6.249)
Share EOR Norway × Post	0.010**	-1.787	2.375	-4.162**
	(0.005)	(3.452)	(2.135)	(1.680)
Observations	1377	1377	1377	1377
R-square	0.89	0.85	0.82	0.84
Share EOR × Post	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Average dependent variable	0.012	5.216	2.116	3.100

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (5). The dependent variables are firm i's market share (column 1), and the number of fields (2), number of EOR-eligible fields (3), and number of non-EOR-eligible fields (4) in i's portfolio in year t. The table consists of three Panels, which vary based on the definition of the heterogeneity investigated. Panel (a) interacts "Share EOR Norway × Post," which is the share of firm i's fields that are eligible for EOR before 1985 times an indicator that is 1 for the years after 1985, with "K-H," an indicator that is 1 if firm i was an operator in a field that adopted EOR before 1985, and zero otherwise, which we define as know-how. Panel (b) interacts "Share EOR Norway" with "S-O" (sate ownership) an indicataor that is 1 if firm i was state owned during 1975-1995. Since some firms have both know-how and are state-owned, we decompose the effect of "K-O" and "S-O" in Panel (c) by creating the variable "K-H & S-O," an indicator for a state-owned firm with know-how, and "K-H Only," an indicator for a non-state-owned firm with know-how. All regression control for the "Share EOR × Post," which is firm i's share of EOR-eligible fields in the North Sea before 1985 times the post-1985 indicator, and firm and year fixed-effects. Firms that are state-owned and have no know-how are excluded from all the analyses. Standard errors are clustered at the firm-level.

a broader shift in investment strategy, as firms with EOR-specific know-how exhibited a renewed interest in fields with different characteristics that could have been suitable for alternative technologies beyond EOR. Once again, the effect of merely owning shares of EOR-eligible fields is instead estimated to be negligible.

Know-how versus state ownership. Panel (b) reports estimates of firm-level regression (5), replacing the indicator variable "K-H$_i$" with "S-O$_i$," an indicator variable equal to one if firm i was state-owned before 1985. These results closely resemble those in Panel (a), potentially reflecting the aforementioned Norwegian policies in support of Statoil.[28] Because some of the operators in fields that adopted EOR prior to 1985 were also state-owned (e.g., Statoil), it is unclear from Panels (a) and (b) whether know-how or state ownership was the main driver behind these findings.

We overcome this challenge by further separating the firms with know-how ("K-H$_i$ = 1") into two groups, those that were also state-owned ("K-H & S-O$_i$ = 1") and those that were not ("K-H Only$_i$ = 1"). We present the estimation results of this version of firm-level regression (5) in Panel (c) of Table 9. Column 1 shows that "K-H & S-O" firms with a pre-1985 portfolio of fields that included 10 percentage points more Norwegian EOR-eligible fields experienced an increase in market shares of 1.29 percentage points after 1985. As these firms had an average market share of 0.95% in the period 1975-1985, this corresponded to a 136% increase in the average market share. Firms with know-how that were not state-owned ("K-H Only") also gained market shares, albeit to a lesser extent, with an increase of 0.5 percentage points. As their average market share was around 0.5% in the period 1975-1985, this corresponded to a 100% increase in the average market share.

With respect to portfolio expansions at the extensive margin, the estimated effect for "K-H Only" firms in the second row of Panel (c) is instead substantially larger than that for "K-H & S-O" firms in the first row. "K-O Only" firms with a pre-1985 portfolio of fields that included 10 percentage points more Norwegian EOR-eligible fields expanded their portfolio by about 4.7 new fields (column 3), with 78% of these being non-EOR eligible (column 5). Differently, the portfolios of "K-H & S-O" firms expanded by about 2.8 fields, with 67% of these being non-EOR eligible.

Oil Majors. Some firms may have acquired EOR expertise outside the North Sea and applied it in Norway after the 1985 Supreme Court decision. Sheng (2013) documents major EOR adoptions by the "Seven Sisters" (BP, Chevron, Exxon, Gulf Oil, Mobil, Shell,

[28] According to Thurber and Istad (2010), Statoil's development relied heavily on "learning by doing," with government support playing a crucial role in accelerating the company's technical competence, albeit at the cost of higher expenses. For example, in 1978, the government granted Statoil a "golden block" for the Gullfaks field, despite objections from international oil companies. This led to Statoil assuming its first production operatorship in 1981. Another significant form of support came in 1987, when the government transferred operatorship of Statfjord from Mobil to Statoil, a move that was likely made earlier than would have been justified under purely competitive conditions (PESD Interviews).

Texaco) and other global players (Amoco, Conoco, Eni, Phillips, Total). We modify (5) by replacing the know-how indicator with an "Oil Major$_i$" indicator, set to one for these firms. Appendix Table B17 shows that a marginal increase in pre-1985 exposure to EOR-eligible fields in Norway led to a drop in market share and in the number of EOR-eligible fields, confirming that the results in Table 9 are not driven by oil majors.[29]

Discussion. These results highlight how these different types of firms employed different portfolio expansion strategies after the Norwegian Supreme Court decision. First, firms with know-how (both "K-H & SO" and "K-H Only") expanded their portfolios toward EOR-eligible fields in a proportion similar to their availability (24% of the fields in the North Sea are EOR eligible, see Table 1). Second, while the estimated market share increase of "K-H Only" firms in column 1 is smaller than that estimated for "K-H & S-O" firms, their more aggressive entry into new fields (columns 3-5) suggests that the expected returns—also in terms of market shares—may have materialized over a longer horizon, as not all newly acquired licenses immediately translate into extraction sites. Not all oil & gas fields are alike, and some require more expensive and advanced technologies for extraction (e.g., sour oil and deep wells), whose adoption can delay production relative to other "less risky" fields. In what follows, we shed some light on these mechanisms by exploring in greater detail portfolio diversification strategies (Section 7.3) and their consequences in terms of *further* technology adoption beyond EOR (Section 8).

7.3 Portfolio Diversification

In this section, we investigate further the portfolio diversification strategies of different types of firms in relation to fields' geological characteristics and their implied levels of risk. Table 10 reports estimates of the same versions of firm-level regression (5) as in Table 9 but using as dependent variables the number of EOR-eligible fields (columns 1-4) and of non-EOR-eligible fields (columns 5-8) of different geological types. The dependent variables in columns 1-3 and 5-7 count for each firm and year the number of fields included in the portfolio that contain heavy oil, sour oil, or have a deep well, commonly considered to be high-risk.[30] Columns 4 and 8, instead, count the number of remaining fields that do not belong to these categories and that are commonly considered to be lower risk.

Know how. The results in Panel (a) of Table 10 complement those in Panel (a) of Table 9, clarifying that the aggressive portfolio expansion of "K-H" firms took place primarily in high-risk fields. "K-H" firms with a pre-1985 portfolio of fields that included 10 percentage points more Norwegian EOR-eligible fields expanded their portfolio by around

[29] As discussed in Section 4.3, we do not include "Share Norway × Post" in (5) because of its high correlation with "Share EOR Norway × Post." However, its inclusion does not affect the results qualitatively, as shown in Panel (a) of Appendix Table B17.

[30] Column 1 of Table 10 is empty as the geological characteristics of EOR-eligible fields are incompatible with heavy oil. Fields containing heavy oil can only be non-EOR eligible.

Table 10: Know-how and portfolio diversification

Dept. var.	Number of EOR Eligible Fields:				Number of Non-EOR Eligible Fields:			
	Heavy Oil	Sour Oil	Deep Well	Other (Lower Risk)	Heavy Oil	Sour Oil	Deep Well	Other (Lower Risk)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel (a): Know-How (K-H)								
K-H × Share EOR Norway × Post	–	1.385	8.878***	0.825*	0.848***	16.071	18.932**	2.292**
	–	(0.868)	(2.770)	(0.419)	(0.242)	(9.988)	(8.296)	(0.939)
Share EOR Norway × Post	–	-0.022	3.937*	0.118	-0.150**	-0.348	0.239	0.330
	–	(0.296)	(2.056)	(0.130)	(0.062)	(0.773)	(1.023)	(0.258)
Observations	–	1377	1377	1377	1377	1377	1377	1377
R-squared	–	0.77	0.81	0.78	0.33	0.76	0.76	0.70
Panel (b): State-Owned (S-O)								
S-O × Share EOR Norway × Post	–	0.544	7.587***	1.137*	0.809***	6.123	12.750	1.642***
	–	(0.563)	(2.457)	(0.579)	(0.105)	(6.506)	(7.869)	(0.515)
Share EOR Norway × Post	–	0.109	4.366**	0.115	-0.117	1.191	1.498	0.473
	–	(0.332)	(2.121)	(0.125)	(0.078)	(1.499)	(1.615)	(0.307)
Observations	–	1377	1377	1377	1377	1377	1377	1377
R-squared	–	0.76	0.80	0.78	0.32	0.75	0.75	0.68
Panel (c): Know-How (K-H) & State-Owned (S-O)								
K-H & S-O × Share EOR Norway × Post	–	0.714	8.185***	1.140*	0.856***	8.124	14.439*	1.835***
	–	(0.561)	(2.496)	(0.578)	(0.093)	(6.391)	(7.801)	(0.488)
K-H Only × Share EOR Norway × Post	–	3.009***	10.555**	0.061	0.828	35.306***	29.809***	3.398
	–	(0.786)	(4.350)	(0.634)	(0.781)	(5.706)	(6.851)	(2.296)
Share EOR Norway × Post	–	-0.010	3.949*	0.112	-0.150**	-0.203	0.321	0.339
	–	(0.298)	(2.058)	(0.130)	(0.062)	(0.787)	(1.045)	(0.260)
Observations	–	1377	1377	1377	1377	1377	1377	1377
R-squared	–	0.77	0.81	0.78	0.33	0.78	0.77	0.70
Share EOR × Post	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Average dependent variable	–	0.580	2.015	0.097	0.060	1.864	2.356	0.156

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (5). The dependent variables are the number of fields eligible for EOR (columns 1-4) and non-eligible for EOR (columns 5-8) where in firm i's portfolio in year t. Each column focuses on different field types (heavy, sour, deep well, or other non-heavy, non-sour, non-deep fields). EOR cannot be implemented with heavy oil, and hence, column 1 is empty. The table consists of three Panels, which vary based on the definition of the heterogeneity investigated. Panel (a) interacts "Share EOR Norway × Post," which is the share of firm i's fields that are eligible for EOR before 1985 times an indicator that is 1 for the years after 1985, with "K-H," an indicator that is 1 if firm i was an operator in a field that adopted EOR before 1985, and zero otherwise, which we define as know-how. Panel (b) interacts "Share EOR Norway" with "S-O" (sate ownership) an indicataor that is 1 if firm i was state owned during 1975-1995. Since some firms have both know-how and are state-owned, we decompose the effect of "K-O" and "S-O" in Panel (c) by creating the variable "K-H & S-O," an indicator for a state-owned firm with know-how, and "K-H Only," an indicator for a non-state-owned firm with know-how. All regression control for the "Share EOR × Post," which is firm i's share of EOR-eligible fields in the North Sea before 1985 times the post-1985 indicator, and firm and year fixed-effects. Firms that are state-owned and have no know-how are excluded from all the analyses. Standard errors are clustered at the firm-level.

0.9 additional EOR-eligible fields (column 3). Moreover, "K-H" firms also diversified aggressively into non-EOR-eligible fields, entering into around 0.08 additional heavy oil fields (column 5), 1.6 more sour oil fields (column 6, not significant), 1.9 more deep well fields (column 7), and 0.23 additional lower risk fields (column 8). In contrast, the second row of Panel (a) shows that firms without know-how only expanded their portfolios toward EOR-eligible fields with deep wells while, if anything, exited from non-EOR-eligible fields, in particular from those with heavy oil.

Know-how versus state ownership. Panel (b) of Table 10 shows that the portfolio diversification strategy of state-owned firms was somehow more limited, especially in terms of non-EOR-eligible fields. Panel (c) of Table 10 further clarifies this. Compared to "K-H & S-O" firms, "K-O" Only firms not only specialized more in EOR-eligible fields, but also diversified more their portfolios by entering fields with different geological characteristics, mostly high-risk. In particular, columns 2-3 and 6-7 indicate that "K-H Only" firms with a pre-1985 portfolio of fields that included 10 percentage points more Norwegian EOR-eligible fields expanded their portfolio by around 0.3 EOR-eligible and 3.53 non-EOR-eligible fields with sour oil, and by around 1.05 EOR-eligible and 2.98 non-EOR-eligible fields with deep wells. In contrast, "K-H & S-O" firms with similar pre-1985 portfolios expanded their portfolios moderately in terms of high-risk fields, by around 0.81 non-EOR-eligible fields with sour oil (non significant), and by around 0.81 EOR-eligible and 1.44 non-EOR-eligible fields with deep wells, while they entered more aggressively into fields with a lower risk profile (both EOR-eligible and non-EOR-eligible fields).[31]

Oil Majors. We examine the role of oil majors by replacing the know-how indicator with an "Oil Major$_i$" indicator in (5). Appendix Table B19 shows that the Supreme Court decision did not alter these firms' portfolio composition. We find no evidence of increased entry into specific fields or diversification across multiple fields, confirming that the results in Table 10 are not driven by oil majors.

Discussion. In summary, the results presented in this section underscore the pivotal role that EOR-specific know-how played in driving both market share expansion and portfolio diversification in the Norwegian oil & gas sector. Importantly, while favorable treatment and financial support from state ownership allowed firms to aggressively expand their market shares, technological know-how was the primary driver behind the observed portfolio expansion and diversification that followed the Norwegian Supreme Court decision. In the next section, we investigate whether these firms, having expanded and diversified their portfolios of fields, also adopted a broader range of technologies beyond EOR, further enhancing their competitive positioning and shaping their long-term strategic outcomes.

[31] Panel (b) of Appendix Table B14 show similar results including "Share Norway" as a regressor.

8 "Transferable" Know-How

The 1980s marked a period of significant technological innovation in the oil & gas industry in the North Sea. Several key advancements improved extraction efficiency and addressed the harsh offshore conditions of the region. One major development was the use of *concrete gravity base structures* (condeep)—the world's largest man-made movable object of that time (see Appendix Figure A5)—providing stability for offshore platforms, as for example at Gullfaks (Norway). The introduction of *floating production, storage, and offloading* (FPSO) units enabled production in areas unsuitable for fixed platforms, with Petrojarl 1 deployed at Balder (Norway) as an early example. *Subsea production systems* allowed extraction from remote reservoirs, enhancing operations at Gullfaks South (Norway) and Arbroath (UK), for example. *Tension Leg Platforms* (TLPs) also emerged as a key innovation, with Hutton (UK), operated by Conoco, being the site of the world's first production TLP, installed in 1984.[32] Finally, *horizontal drilling*, which was pioneered in Brynhild (Norway) and later also deployed in Beatrice (UK), improved reservoir drainage.

These innovations illustrate the technological transformation of the North Sea during the 1980s, strengthening its role as a center of offshore engineering advances. In this section, we explore whether the Supreme Court decision encouraged owners of Norwegian EOR-eligible fields to diversify the range of technologies they employed in the oil & gas sector in the North Sea, and in particular whether the successful and early adoption (pre-1985) of a technology such as EOR (what we defined above as "know-how") facilitated the adoption of other, unrelated technologies.

8.1 Definition of Technological Diversification

For the analysis of technological diversification we use firm-level regressions (2) and (5). For each firm i, we define the following measure of technological diversification:

$$1 - \sum_{\tau=1}^{N} \left(\frac{\text{firm } i\text{'s production through technology } \tau \text{ in year } t}{\text{firm } i\text{'s total production in year } t} \right)^2, \tag{6}$$

which is one minus the HHI in terms of firm i's "technological shares." In particular, we consider a range of N mutually exclusive technologies, each of which could have been adopted in a given field in a specific year. Then, for each technology $\tau = 1, ..., N$, we

[32] Norway also saw the deployment of TLPs in deeper fields than the Hutton field (150m), such as in Snorre (310m) and Heidrun (350m), with installations in 1992 and 1995, respectively, both operated by Statoil. In the 1980s, several non-Statoil operators in Norway deployed innovative technologies in the North Sea. For example, Aukra (Norway) saw the installation of the Sea Eagle FPSO in 1990 operated by Shell—a firm with "Know-How$_i$"=1. In Oseberg (Norway), the Oseberg A condeep was deployed in 1988 by Mobil, which also had know-how. Additionally, Frigg (Norway) deployed subsea production systems and a floating production unit in 1986, operated by BP and Total. These deployments highlight the variety of cutting-edge solutions employed by non-Statoil operators during the period.

compute the share of firm i's production in year t obtained through τ, relative to firm's total production in that year (obtained through any technology). When we compute a firm's production from technology τ, we weigh the production of each field in firm i's portfolio by firm i's ownership shares in year t over these fields. Finally, we use (6) as a dependent variable (rather than HHI directly) to interpret the measure as an indicator of dispersion rather than of concentration in firm i's technological portfolio.

Technologies. We classify technologies into two distinct groups and provide detailed descriptions of each in Appendix D.

The first group is *Exploration & Production Technologies*, which includes the infrastructures required for exploration and production. For instance, a *fixed platform* is a stationary platform that supports drilling and production activities in shallow waters. A *production semi-submersible platform* is an offshore platform anchored to the seabed for deepwater drilling. A *subsea system* involves wells connected to a platform for remote deep oil and gas extraction.

The second group is *Extraction & Reservoir Drive Technologies*, which consists of extraction technologies designed to increase recovery rates or enhance production by maintaining or improving reservoir pressure. These include primary and secondary recovery methods, which are used at the early stages of a field's life cycle. In comparison, *Enhanced Oil Recovery (EOR)* is a tertiary recovery technology, only employed once primary and secondary recovery methods are no longer effective.

Field characteristics. Since the suitability of the technologies a firm may decide to employ in a given field is closely related to the specific type of oil and other geological characteristics of the field, we also assess technological diversification by computing (6), but with respect to the depth of the well (total vertical depth) and the size of the reservoir. As these are continuous variables, we first discretize them into quintiles (over their distribution in the North Sea) and then compute the corresponding diversification measures (6) in terms of the discretized variables. In this case, τ in (6) denotes the quintile of a specific field in terms of well depth or reservoir size.

In this context, larger values of measure (6) indicate that a firm obtained its total production through a relatively more varied portfolio of fields that span the range of possible well depths and reservoir sizes in the North Sea.

Technology-related costs. We also evaluate technology diversification in terms of the *tariff* expenses and *capex* associated to each field. Tariffs are the charges related to the use of specific infrastructures in the oil & gas industry, including production (processing raw oil or gas in a plant), transportation (fees to move oil and gas through pipelines, ships or other networks) and storage (fees to store oil or gas in facilities such as tank farms or underground caverns).[33] Since these variables vary over time, we calculate the

[33]We observe only the total tariff amount for each year and field, without further breakdowns.

cumulative tariff and capex per MMboe for each field over all years. For each of these cumulative variables, we then follow a procedure similar to the one described above and allocate fields to their quintiles, and finally compute the corresponding diversification measure (6), where τ represents again the specific quintile of a field.

In this context, low values of measure (6) indicate that a firm obtained its total production through a relatively specialized portfolio of fields that required similar levels of services and capital investments for their operations. Importantly, though, low values of measure (6) do not indicate the "type" of field that a firm specialized in (low-tariff or high-capex), only specialization in fields requiring similar levels of tariffs or capex.

8.2 Results

Panel (a) of Table 11 presents estimates of firm-level regression (2) that use as dependent variables the measures of technological diversification discussed in Section 8.1. Firms with a pre-1985 portfolio of fields that included 10 percentage points more Norwegian EOR-eligible fields experienced a modest decrease of about 4 percentage points in diversification in both exploration & production technologies and extraction technologies after 1985 (columns 1 and 2). We observe similar decreases in diversification also in terms of well depth and reservoir sizes (columns 3 and 4), as well as in cost variables such as tariff intensity and capex intensity (columns 5 and 6). Therefore, larger pre-1985 shares of EOR-eligible fields were not sufficient to incentivize firms to diversify their portfolio after the Supreme Court decision.

Know how. Panels (b), (c), and (d) of Table 11 present estimates of firm-level regression (5) using the same dependent variables as in Panel (a), but also controlling for know-how or state ownership. The results in Panel (b) indicate that firms with a pre-1985 portfolio of fields that included 10 percentage points more Norwegian EOR-eligible fields *and* that, prior to 1985, were operators in fields that adopted EOR (i.e., firms with know-how) instead substantially increased diversification of their technological portfolios by at least 8-9 percentage points after 1985 (according to all measures).

A comparison between Panels (a) and (b) reveals a significant difference: while firms with Norwegian EOR-eligible fields in Norway before 1985 did not diversify their portfolios of technologies after 1985 (if anything, they specialized them), those that operated fields that also adopted EOR before 1985 instead substantially diversified their portfolios of technologies after 1985. Comparing the estimated coefficients with the average values of the dependent variables in the last row of the table indicates that a 10 percentage point increase in "Share EOR Norway" led firms with know-how to diversify approximately 40% more (e.g., from column 4: $0.1231/0.318 = 38.7\%$).

The second row of Panel (b) shows the change in diversification for firms without know-

Table 11: Know-how and technological diversification

Dept. var.	Diversification in Technology Portfolio (1 - HHI)					
	Exploration & Prod. Tech. (1)	Extraction Technologies (2)	Well Depth (3)	Reservoir Size (4)	Tariff Intensity (5)	Capex Intensity (6)
Panel (a): Baseline						
Share EOR Norway × Post	-0.404*	-0.338	-0.311	-0.314	-0.446**	-0.338
	(0.229)	(0.218)	(0.246)	(0.230)	(0.192)	(0.232)
Share EOR × Post	-0.258**	-0.146	-0.239**	-0.200*	-0.177*	-0.205**
	(0.106)	(0.098)	(0.101)	(0.105)	(0.101)	(0.102)
Observations	1377	1377	1377	1377	1377	1377
R-squared	0.36	0.31	0.34	0.32	0.33	0.33
Panel (b): Know-How (K-H)						
K-H × Share EOR Norway × Post	0.952***	0.888*	0.951**	1.231***	0.838**	0.898**
	(0.285)	(0.492)	(0.422)	(0.402)	(0.390)	(0.366)
Share EOR Norway × Post	-0.531**	-0.457**	-0.438*	-0.478**	-0.559***	-0.458**
	(0.212)	(0.205)	(0.238)	(0.195)	(0.178)	(0.223)
Observations	1377	1377	1377	1377	1377	1377
R-squared	0.37	0.32	0.35	0.33	0.34	0.33
Panel (c): State-Owned (S-O)						
S-O × Share EOR Norway × Post	0.750***	0.405	0.604*	0.775***	0.453*	0.666**
	(0.240)	(0.314)	(0.311)	(0.243)	(0.256)	(0.318)
Share EOR Norway × Post	-0.479**	-0.378*	-0.371	-0.391*	-0.492**	-0.404*
	(0.221)	(0.227)	(0.251)	(0.220)	(0.196)	(0.232)
Observations	1377	1377	1377	1377	1377	1377
R-squared	0.37	0.31	0.35	0.32	0.34	0.33
Panel (d): Know-How (K-H) & State-Owned (S-O)						
K-H & S-O × Share EOR Norway × Post	0.822***	0.508	0.693**	0.892***	0.542**	0.738**
	(0.242)	(0.308)	(0.310)	(0.230)	(0.252)	(0.320)
K-H Only × Share EOR Norway × Post	1.267***	1.808***	1.575***	2.053***	1.556***	1.283***
	(0.305)	(0.329)	(0.408)	(0.288)	(0.321)	(0.424)
Share EOR Norway × Post	-0.529**	-0.450**	-0.434*	-0.472**	-0.553***	-0.455**
	(0.212)	(0.206)	(0.239)	(0.197)	(0.179)	(0.224)
Observations	1377	1377	1377	1377	1377	1377
R-squared	0.37	0.32	0.35	0.33	0.34	0.34
Share EOR × Post	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Average dependent variable	0.219	0.308	0.337	0.318	0.342	0.338

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Panel (a) presents estimates from (1), whereas the remaining 3 Panels presents estimates from (5), which investigates heterogeneous effects. The dependent variables is computed according to (6) using the categories within each technology type (columns 1-2), field characteristics (columns 3-4), and cost expenditures (column 5-6). In column 5, "tariffs" are costs paid for services needed to the field. Panel (b) interacts "Share EOR Norway × Post," which is the share of firm i's fields that are eligible for EOR before 1985 times an indicator that is 1 for the years after 1985, with "K-H," an indicator that is 1 if firm i was an operator in a field that adopted EOR before 1985, and zero otherwise, which we define as know-how. Panel (c) interacts "Share EOR Norway" with "S-O" (sate ownership) an indicataor that is 1 if firm i was state owned during 1975-1995. Since some firms have both know-how and are state-owned, we decompose the effect of "K-O" and "S-O" in Panel (d) by creating the variable "K-H & S-O," an indicator for a state-owned firm with know-how, and "K-H Only," an indicator for a non-state-owned firm with know-how. All regression control for the "Share EOR North Sea × Post," which is firm i's share of EOR-eligible fields in the North Sea before 1985 times the post-1985 indicator, and firm and year fixed-effects. Firms that are state-owned and have no know-how are excluded from all the analyses. Standard errors are clustered at the firm-level.

how.[34] The coefficients align with those in the first row of Panel (a). All coefficients are negative across all columns, indicating that firms without know-how actually specialized their technological portfolios, if anything. Additionally, these estimates are statistically significant, whereas they were largely insignificant in the first row of Panel (a). By specifically accounting for firms with know-how with another variable, Panel (b) finds a drop in the variance of the estimator for "Share EOR Norway × Post," pointing to the different trends in terms of diversification between these two groups of firms.

State ownership. State-owned firms with Norwegian EOR-eligible fields in their pre-1985 portfolios also engaged in technological diversification after 1985, as shown by the estimates in Panel (c). For instance, column 1 shows that a 10 percentage point increase in "Share EOR Norway" led state-owned firms to further diversify their exploration & production technologies by 7.5 percentage points, implying an increase of about $\frac{0.075}{0.219} = 34.2\%$ compared to the average diversification level in the industry. However, in line with the results in Table 10, these estimates are generally smaller than those obtained when exploring heterogeneity based on know-how.

Know-how versus state ownership. We further disentangle the technological differentiation strategies of firms with know-how from those of state-owned firms in Panel (d). Overall, these results—together with those in Table 10—confirm the central role of know-how in driving technological diversification. In particular, the second row—which refers to firms that operated EOR-eligible fields that adopted EOR in the North Sea before 1985 but were not state-owned—systematically reports the highest increases in technological diversification. The coefficient estimates are an order of magnitude higher for "K-H Only" firms compared to those of "K-H & S-O" firms. For instance, the coefficient estimates for "K-H Only" firms are 2.27 times higher in column 3 (well depth) and 2.87 times higher in column 5 (tariff intensity). Additionally, the standard errors are relatively smaller in the second row compared to the first, indicating that this group of firms behaved more similarly than those in the first row, despite the latter including only two firms, Statoil and BP.

Finally, note that this analysis excludes state-owned firms without know-how (i.e., Britoil and Norway State DFI). We replicate the analysis including these firms in Appendix Table B20. The key difference in that Table is that Panel (c) no longer finds an increase in technological diversification for state-owned firms. The inclusion of state-owned firms that primarily functioned as financial vehicles under government control—particularly Norway State DFI—reveals that these firms did not pursue technological diversification but rather acquired large productive assets to secure a steady cash flow for the government. This is evident in Panel (d), which performs a horse race across mutually exclusive groups of firms: state-owned firms with know-how diversified their

[34] Although not explicitly displayed, this and the following Panels also control for "Share EOR × Post."

technological portfolios, whereas state-owned firms without know-how specialized them.

Oil Majors. The results in Appendix Table B21 exclude the possibility that oil majors drove technological diversification after the Norwegian Supreme Court decision. In particular, we do not find any statistically significant change in our technological diversification measures for those oil majors that owned more Norwegian EOR-eligible fields before 1985.

8.3 Country-level Trends in Technological Diversification

Collectively, our results suggest that firms that owned EOR-eligible fields (rather than any other type of field, Table 8) prior to 1985 expanded their production after the Supreme Court decision both directly through EOR adoption (Table 5), but also indirectly by expanding their portfolios toward other EOR-eligible fields and other non-EOR-eligible fields (Table 6). Firms that already possessed EOR-specific know-how before 1985 were those that experienced the largest increases in production and market shares, and were also those that expanded their portfolios more aggressively after the Supreme Court decision (Table 9). In particular, these firms not only specialized in other EOR-eligible fields, but also diversified their portfolios investing in fields with different characteristics (Table 10) that required alternative technologies (Table 11). Transferable know-how acquired through the implementation of EOR, rather than state ownership or the financial returns of EOR adoption, was the key driver behind the expansion of market shares and the relative increase in market concentration experienced by Norway (Figure 5).

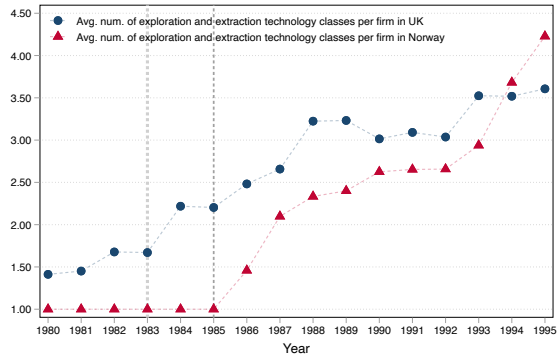
At the aggregate level of the country, Figure 6 shows that, after 1985, Norway started to close the technological gap with the UK, until actually taking up the technological lead in the early 1990s. Importantly, the figure focuses on firms that were simultaneously operating in both countries, ruling out the effects of entry in Norway or of exit from the UK that may have followed the Norwegian Supreme Court decision.

Panel (a) shows country-specific trends in the adoption of exploration & production technologies as those studied in column 1 of Table 11. Before 1985, firms operating in both countries exhibited stable trends: in Norway, firms typically specialized on a single platform technology, while in the UK, firms adopted a wider range of technologies—typically between 1.5 and 2.5—by partnering in fields requiring different technological approaches. In the UK, firms had already begun to diversify their technological portfolios before the Phillips lawsuit, whereas in Norway, firms maintained an average of one technology per firm until 1985. After 1985, the range of exploration & production technologies deployed in Norway started to widen, eventually overtaking the range deployed in the UK.

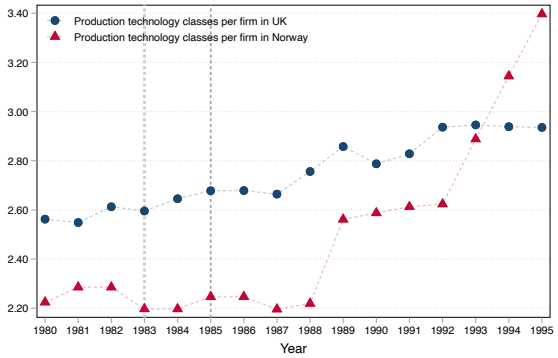
Panel (b) of Figure 6 shows similar patterns to those of Panel (a), but for extraction technologies as those studied in column 2 of Table 11. These include standard extraction methods, artificial lift, injections, drive, and other methods. In the UK, technology de-

Figure 6: Range of technology classes adopted by firms in each country

(a) Exploration & production technologies



(b) Extraction technologies



Notes: Panel (a) plots the average number of exploration and extraction technologies by country (e.g., platform type). Panel (b) plots the average number of production technologies by country (e.g., artificial lift). Vertical dotted lines show the years of Phillips's lawsuit (1983) and of the Norwegian Supreme Court decision (1985).

ployment remained relatively stable throughout the sample period, whereas in Norway, the range of deployed extraction technologies began to rise in 1988. In particular, the diversification in exploration & production technologies documented in Panel (a) preceded the diversification in extraction technologies documented in Panel (b). This makes intuitive sense, as investments in rigs, platforms, and drills for exploration and early production, as those in Panel (a), are typically expected to precede investments in primary and secondary recovery technologies, as those in Panel (b).

State ownership does not appear to be the main driver behind these country-level trends in technology adoption. In fact, as shown in Appendix Figure A6, replicating the analysis by excluding the technologies deployed in fields operated by state-owned firms yields similar patterns. Although the gap between Norway and the UK narrows, the number of exploration & production technologies deployed in Norway still began to increase in 1985 (Panel (a)), followed by a steady growth in the number of extraction technologies from 1988 (Panel (b)).

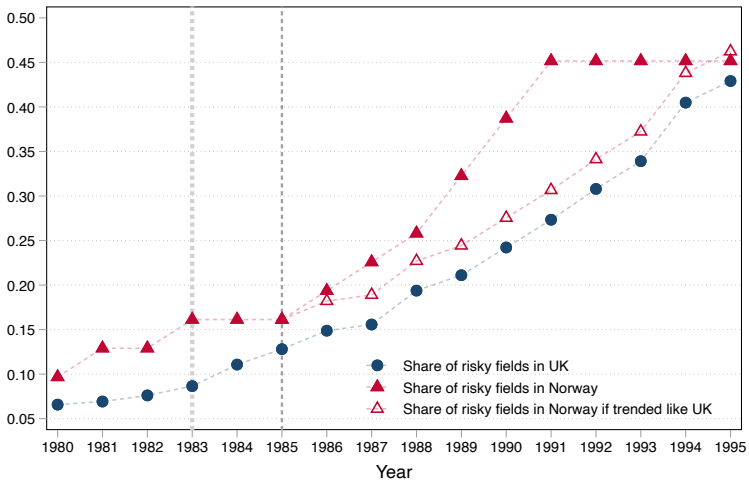
These results highlight the role of technological know-how in shaping industry evolution. Early adopters of EOR leveraged their accumulated know-how to enter new fields, adopt new technologies, and develop more complex extraction strategies, contributing to the growth of Norway's oil & gas sector. This suggests that some of the knowledge acquired from one technological breakthrough can be leveraged by adopters to facilitate diversification into other technologies, driving long-term industry transformation.

As a last piece of country-level evidence, Figure 7 plots trends in the ratios of "active" risky fields in a specific year—whereby "active" we mean fields in exploration or in production—over the total number of risky fields that were active in any year until 2010. As we do not observe the number of fields that were offered but not awarded during each licensing round, using 2010 as a reference ensures that all fields that could have been

offered by 1995 are included in the analysis. In line with our previous definitions, a field is classified as "risky" if it contains heavy oil, sour oil, or if it has a reservoir deeper than 3,500m. The analysis in this figure excludes fields operated by state-owned firms.

The figure shows that the UK (blue dots) experienced a steady growth in the share of active risky fields, rising from 7% in 1980 to 43% in 1995. In contrast, Norway (red triangles) experienced a growth similar to that of the UK only until 1985, while it experienced a steeper increase in the period 1985-1990. The Norwegian share of active risky fields then plateaued at 45%, reflecting our definition of a deep field, as no field deeper than 3,500m was drilled during the period 1990-1995.

Figure 7: Investments in high-risk fields



Notes: The figure depicts the ratio of risky fields developed in a given year to the total number of risky fields developed by 2010 for each country. Since the set of fields offered but not awarded in annual licensing rounds is unknown, using 2010 as the reference year ensures that all fields that could have been offered by 1995 in the UK and Norway are included in the analysis. A field is risky if it contains heavy oil, sour oil, or if its reservoir is deeper than 3,500m. Fields operated by state-owned firms are not considered. Vertical dotted lines mark the years of the Phillips lawsuit (1983) and the Norwegian Supreme Court decision (1985).

9 Conclusion

This paper investigates the effects of technology adoption on firms' strategic choices and performance: whether to specialize in a particular technology or to diversify across multiple technologies, and the consequences of these decisions on productivity and competitiveness. In particular, we study the the consequences of adoption of Enhanced Oil Recovery (EOR) in the North Sea oil & gas industry between 1975 and 1995. The North Sea oil & gas industry offers a compelling setting for this investigation, as it is characterized by intense competition and a rapidly advancing technological frontier, creating strong incentives for technology adoption.

However, technology adoption is often influenced by unobservable firm-specific traits that can also correlate with productivity and competitiveness. To address this identification challenge, we exploit two sources of exogenous variation in the adoption of EOR. First, and independently of firms' willingness to adopt it, not all fields are geologically and technologically suitable for EOR. Second, we interact these constraints to EOR adoption with an unexpected Norwegian Supreme Court decision that reduced policy uncertainty in Norway relative to the UK. Our analysis employs micro-data encompassing detailed information about field geology, production costs, firm operations, and deployed technologies at each phase of production.

Our findings demonstrate that EOR adoption led to gains in productivity and substantial increases in market shares. Early adopters gained market shares through both specialization, transferring their EOR-specific know-how to other EOR-eligible fields, but also diversification, venturing in riskier fields not suitable for EOR and requiring a different range of technologies. Our results suggest that some of the expertise obtained from adoption and use of one technology may be transferrable, facilitating adoption and experimentation with other technologies. This transfer of expertise reflects *economies of scope in innovation*, whereby early technology adoption paves the way for subsequent technology adoption and fuels a virtuous cycle of technological progress.

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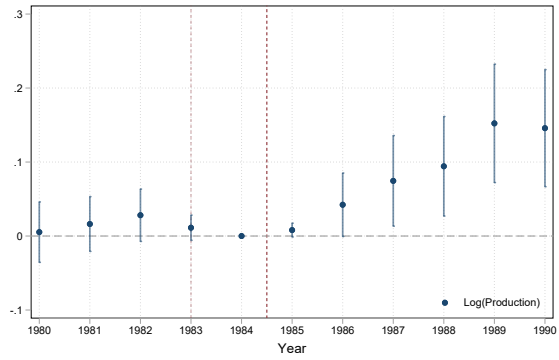
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Online Appendix

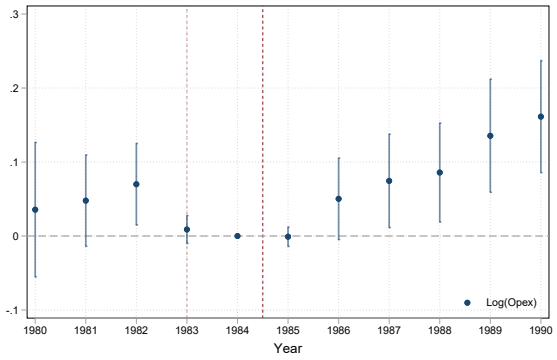
A Additional Figures

Figure A1: Firm-level event study of production and costs

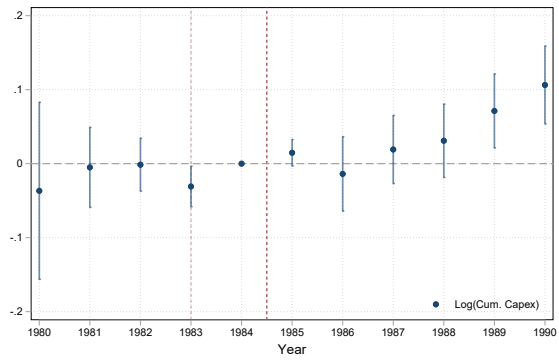
(a) $\ln(1 + \text{prod}_{it})$



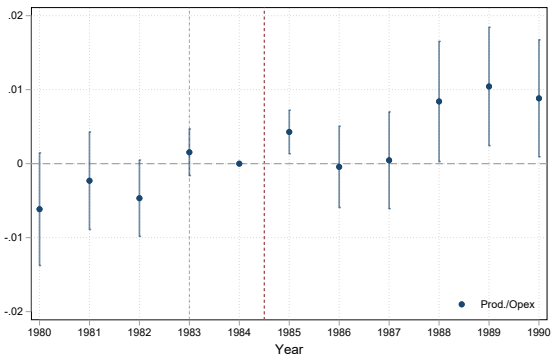
(b) $\ln(1 + \text{opex}_{it})$



(c) $\ln(1 + \text{cum. capex}_{it})$



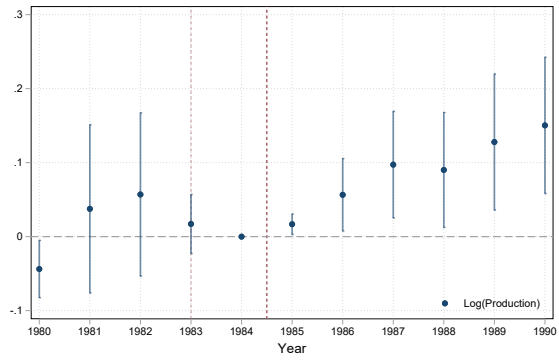
(d) prod_{it} / opex_{it}



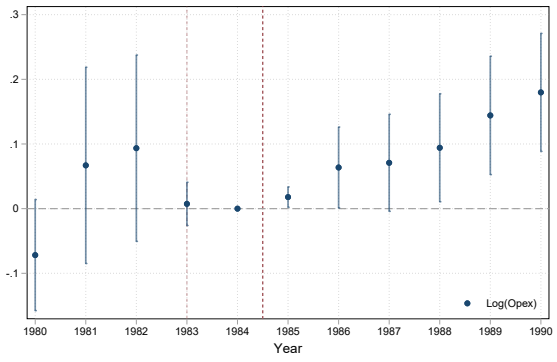
Notes: Results of the event study from regression (4). The Figures show the coefficients $\hat{\beta}_d$, the impact of being eligible for production d periods in Norway before or after the Supreme Court decision in 1985. $d = -1$ is the reference level. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the firm-level. Vertical dotted lines show the years of Phillips's lawsuit (1983) and of the Norwegian Supreme Court decision (1985).

Figure A2: Firm-level event study of production and costs: Including "Share Norway$_i$" as a regressor

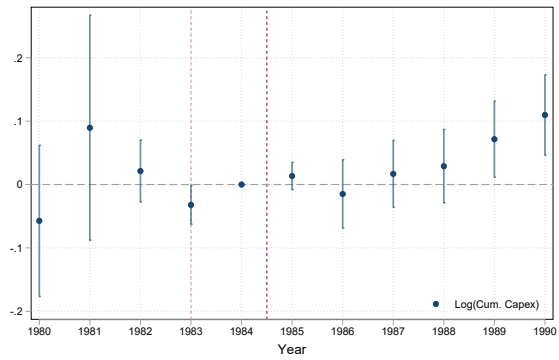
(a) $\ln(1 + \text{prod}_{it})$



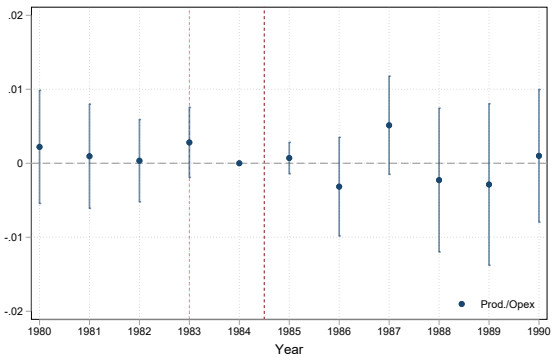
(b) $\ln(1 + \text{opex}_{it})$



(c) $\ln(1 + \text{cum. capex}_{it})$



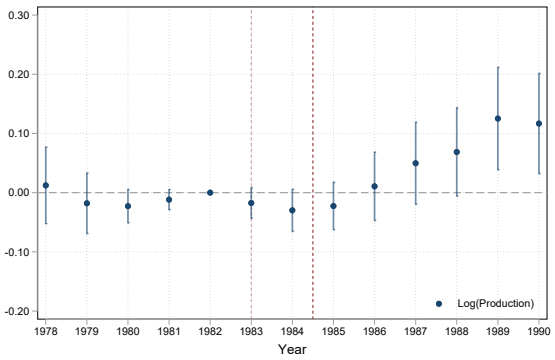
(d) prod_{it} / opex_{it}



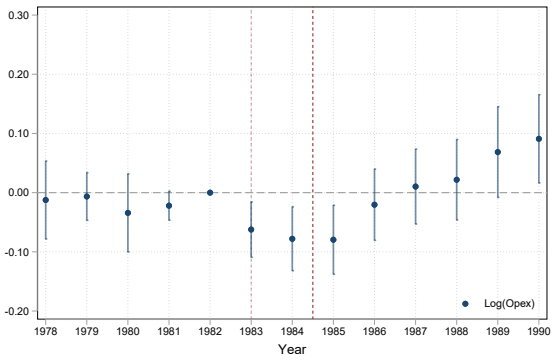
Notes: Results of the event study from a specification of regression (4) in which we also control for "Share Norway." The Figures show the coefficients $\hat{\beta}_d$, the impact of being eligible for production d periods in Norway before or after the Supreme Court decision in 1985. $d = -1$ is the reference level. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the firm-level. Vertical dotted lines show the years of Phillips's lawsuit (1983) and of the Norwegian Supreme Court decision (1985).

Figure A3: Firm-level event study of production and costs (treatment starts in 1983)

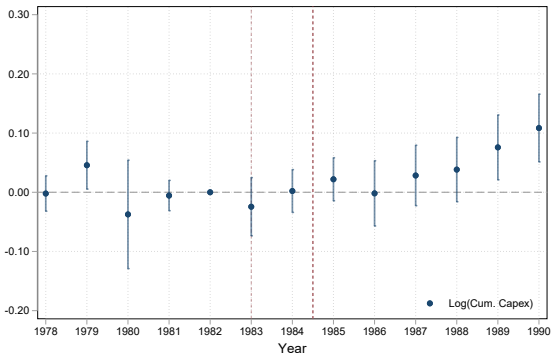
(a) $\ln(1 + \text{prod}_{it})$



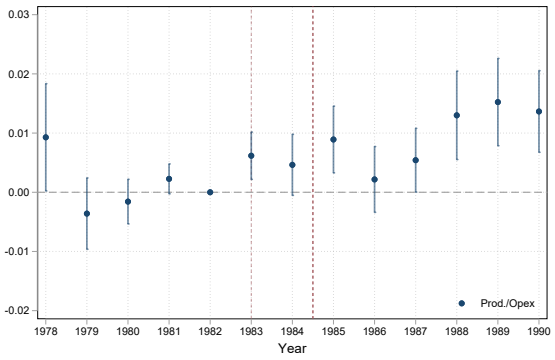
(b) $\ln(1 + \text{opex}_{it})$



(c) $\ln(1 + \text{cum. capex}_{it})$



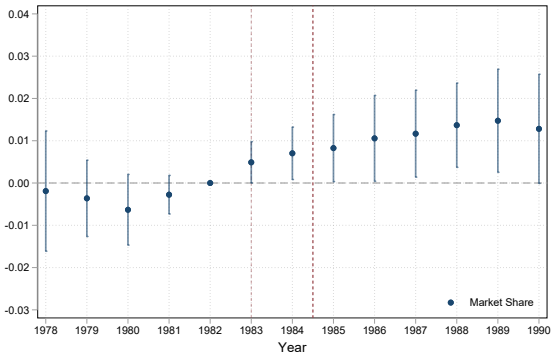
(d) prod_{it} / opex_{it}



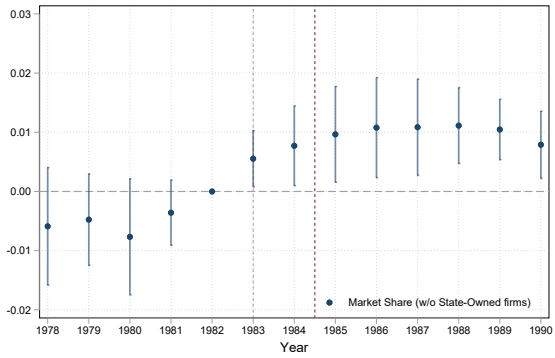
Notes: Results of the event study from regression (4). The Figures show the coefficients $\hat{\beta}_d$, the impact of being eligible for production d periods in Norway before or after the start of the lawsuit in 1983. The red bar indicates the time of Supreme Court decision at the end of 1984. $d = -1$ is the reference level. The vertical bars represent 95% confidence intervals. Standard errors are clustered at the firm-level. Vertical dotted lines show the years of Phillips's lawsuit (1983) and of the Norwegian Supreme Court decision (1985).

Figure A4: Market shares

(a) All firms



(b) Excluding State-Owned Firms



Notes: The event study from Equation 4 using market share. Panel (b) excludes state-owned firms such as BP and Statoil and their subsidiaries. The regression includes country-by-year and firm fixed effects. The vertical bars indicate 95% confidence intervals, calculated with clustered standard errors by firm. Vertical dotted lines show the years of Phillips's lawsuit (1983) and of the Norwegian Supreme Court decision (1985).

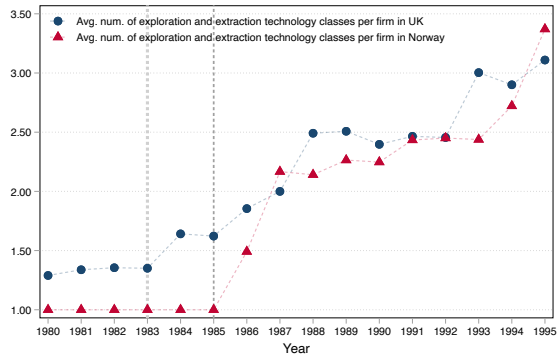
Figure A5: The condeep in Troll field



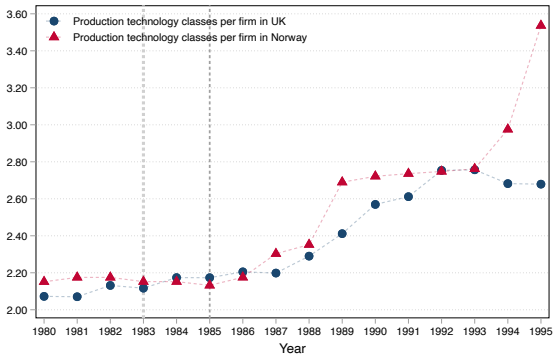
Notes: The Troll A platform, the tallest concrete structure ever built for the oil and gas sector, stands at 472 meters, with a 369-meter subsea base. It remains the largest structure ever moved. Awarded to Norwegian Contractors by Shell Norway in 1991, its construction at Vats, Rogaland, involved 2,000 workers over four years, using over 245,000 m^3 of concrete. It was completed in 1994.

Figure A6: Range of technology classes adopted by firms in each country: Excluding state-owned firms

(a) Exploration & production



(b) Extraction technologies



Notes: Panel (a) plots the average number of exploration and extraction technologies by country (e.g., platform type). Panel (b) plots the average number of production technologies by country (e.g., artificial lift). The analyses include only firms that were not state owned in the sample period. Vertical dotted lines show the years of Phillips's lawsuit (1983) and of the Norwegian Supreme Court decision (1985).

B Additional Tables

Table B1: Criteria for EOR eligibility

Variable	Inclusion Restriction	EOR eligibility	
		Standard	Robust
Hydrocarbon	"Oil" or "Oil & Gas"	✓	✓
Development type	"Fixed platform", "Subsea", "Tension leg platform"	✓	✓
Field size	"Giant", "Grouping", "Large"	✓	✓
Water depth	"Shallow water"	✓	✓
Field primary resource	"Conventional shelf"	✓	✓
API	Between 22.6 and 47.6	✓	✓
Reservoir depth (m)	Between 909.68 and 4,460.23	✓	✓
Porosity (%)	>40 (exclusion)		✓
Permeability (mD)	>4,000 (exclusion)		✓

Notes: This table shows technical and geological features of the 521 fields in our final sample.

- *Hydrocarbon* refers to the type of hydrocarbons, classified as either "Oil" or "Oil & Gas".
- *Development type* refers to the type of infrastructure used for oil drilling, such as "Fixed platform", "Subsea", or "Tension leg platform".
- *Field size* is categorized as "Giant", "Grouping", or "Large", which correspond to the size of the reservoir measured during the exploration phase in million barrels of oil equivalent. "Grouping" indicates that reserves or production are aggregated across multiple smaller sites.
- *Water depth* categorizes fields into "Shallow water", defined as having the seafloor less than 150 meters from the water surface, and "Deep water".
- *Field primary resource* refers to the type of resource, such as "Conventional shelf", which refers to conventional resources in shallow-water oil and gas fields located on the continental shelf, typically in water depths of less than 200 meters. Examples include the Gulf of Mexico, the North Sea, and the Persian Gulf.
- *API* gravity measures the density of crude oil, with values ranging between 37 and 51 for certain fields, and between 22.6 and 47.6 for others.
- *Sulphur (%)* measures the sulfur content in the crude oil, with fields having less than 0.5% sulfur.
- *Reservoir depth* is the total vertical distance between the surface and the reservoir. Shallow reservoirs are less than 1,500 meters, intermediate reservoirs range from 1,500 to 3,000 meters, and deep reservoirs range from 3,000 to 5,000 meters.
- *Recoverable reserves (mbl)* refers to the amount of oil or gas that can be extracted from a field, measured in million barrels of oil equivalent.
- *Porosity (%)* refers to the amount of empty space within a rock that can store hydrocarbons, with exclusions for values greater than 40%.
- *Permeability (mD)* is the ability of a rock to allow fluids to flow through it, with exclusions for values greater than 4,000 mD.

Table B2: Field-level production: Intensive vs. extensive margin: Treatment starts in 1983

	EOR Adoption	Production Margins		
Dept. var.	$\mathbb{1}\{\text{Adopted EOR}_{ft}\}$ (1)	Intensive and Extensive $\ln(1+\text{prod}_{ft})$ (2)	Only Intensive $\ln(1+\text{prod}_{ft})$ (3)	Only Extensive $\mathbb{1}\{\text{prod}_{ft}>0\}$ (4)
Norway × EOR × Post	0.239*	1.918***	2.426***	0.203
	(0.122)	(0.537)	(0.457)	(0.193)
EOR × Post	0.072*	1.134***	0.977**	0.185*
	(0.038)	(0.393)	(0.416)	(0.108)
Field selection	All	All	Prod. < 1983	All
Country-Year FE	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes
Observations	1989	1989	768	1989
R-squared	0.84	0.62	0.68	0.45

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (1). The dependent variable in column 1 is an indicator that equals 1 if field f has adopted EOR by year t and 0 otherwise. Columns 2–4 use functions of field-level production as dependent variables. Columns 2 and 3 use the log of production, with column 3 restricting the sample to fields that began production before 1985, isolating variation in the intensive margin (i.e., among fields already producing in 1985). The dependent variable in column 4 is an indicator that equals 1 if the field produces in year t and 0 otherwise, capturing only the extensive margin of production. The indicator variables "Norway," "EOR," and "Post-1983" equal 1 for Norwegian fields, for EOR-eligible fields, and for the years after 1983 (the year of Phillips's lawsuit), and 0 otherwise. Each regression includes country-by-year and field fixed effects. Standard errors are clustered at the field-level.

Table B3: Field-level production: Intensive vs. extensive margin: Excluding fields discovered after 1985

	EOR Adoption	Production Margins		
Dept. var.	$\mathbb{1}\{\text{Adopted EOR}_{ft}\}$	Intensive and Extensive $\ln(1+\text{prod}_{ft})$	Only Intensive $\ln(1+\text{prod}_{ft})$	Only Extensive $\mathbb{1}\{\text{prod}_{ft}>0\}$
	(1)	(2)	(3)	(4)
Norway × EOR × Post	0.276**	2.610***	2.352***	0.440**
	(0.119)	(0.635)	(0.422)	(0.218)
EOR × Post	0.065*	0.622*	0.724*	0.037
	(0.035)	(0.346)	(0.386)	(0.097)
Field selection	Disc. < 1985	Disc. < 1985	Disc. < 1985	Disc. < 1985
Field selection			Prod. < 1985	All
Country-Year FE	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes
Observations	1783	1783	768	1783
R-squared	0.84	0.60	0.66	0.42

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (1). The dependent variable in column 1 is an indicator that equals 1 if field f has adopted EOR by year t and 0 otherwise. Columns 2–4 use functions of field-level production as dependent variables. Columns 2 and 3 use the log of production, with column 3 restricting the sample to fields that began production before 1983, isolating variation in the intensive margin (i.e., among fields already producing in 1983). The dependent variable in column 4 is an indicator that equals 1 if the field produces in year t and 0 otherwise, capturing only the extensive margin of production. The indicator variables "Norway," "EOR," and "Post" equal 1 for Norwegian fields, for EOR-eligible fields, and for the years after 1985, and 0 otherwise. The analysis includes only fields discovered before 1985; column 3 includes only fields already producing by 1985. Each regression includes country-by-year and field fixed effects. Standard errors are clustered at the field-level.

Table B4: Field-level production: Intensive vs. extensive margin: Different definition of EOR eligibility

	EOR Adoption	Production Margins		
Dept. var.	$\mathbb{1}\{\text{Adopted EOR}_{ft}\}$	Intensive and Extensive $\ln(1+\text{prod}_{ft})$	Only Intensive $\ln(1+\text{prod}_{ft})$	Only Extensive $\mathbb{1}\{\text{prod}_{ft}>0\}$
	(1)	(2)	(3)	(4)
Norway × EOR × Post	0.398***	2.777***	1.666***	0.449*
	(0.088)	(0.667)	(0.546)	(0.269)
EOR × Post	0.061*	0.588*	0.831**	0.063
	(0.037)	(0.346)	(0.369)	(0.095)
Field selection	All	All	Prod. < 1985	All
Country-Year FE	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes
Observations	1989	1989	924	1989
R-square	0.85	0.61	0.62	0.45

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (1). The dependent variable in column 1 is an indicator that equals 1 if field f has adopted EOR by year t and 0 otherwise. Columns 2–4 use functions of field-level production as dependent variables. Columns 2 and 3 use the log of production, with column 3 restricting the sample to fields that began production before 1985, isolating variation in the intensive margin (i.e., among fields already producing in 1985). The dependent variable in column 4 is an indicator that equals 1 if the field produces in year t and 0 otherwise, capturing only the extensive margin of production. The indicator variables "Norway," "EOR," and "Post" equal 1 for Norwegian fields, for EOR-eligible fields, and for the years after 1985, and 0 otherwise. This analysis uses the more encompassing definition of EOR eligibility explained in Section 3. Standard errors are clustered at the field-level.

Table B5: Field-level costs and productivity: Treatment starts in 1983

Dept. var.	$\ln(1+\text{opex}_{ft})$	$\ln(1+\text{cum. capex}_{ft})$	prod_{ft} / opex_{ft}
	(1)	(2)	(3)
Norway × EOR × Post	1.945**	0.610**	40.160
	(0.740)	(0.267)	(33.257)
EOR × Post	1.546***	0.334*	59.120*
	(0.475)	(0.170)	(32.715)
Field selection	Prod. < 1983	Prod. < 1983	Prod. < 1983
Country-Year FE	Yes	Yes	Yes
Field FE	Yes	Yes	Yes
Observations	767	768	768
R-square	0.63	0.89	0.69

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (1). The dependent variables are opex and cumulative capex (in logs) in columns 1-2 and the ratio of production to opex in column 3. The indicator variables "Norway," "EOR," and "Post-1983" equal 1 for Norwegian fields, for EOR-eligible fields, and for the years after 1983 (the year of the Supreme Court decision), and 0 otherwise. Each regression includes country-by-year and field fixed effects. Standard errors are clustered at the field-level.

Table B6: Field-level costs and productivity: Excluding fields discovered after 1985

Dept. var.	$\ln(1+\text{opex}_{ft})$ (1)	$\ln(1+\text{cum. capex}_{ft})$ (2)	prod_{ft} / opex_{ft} (3)
Norway × EOR × Post	2.404**	1.219*	60.080**
	(0.971)	(0.646)	(29.115)
EOR × Post	1.006**	0.031	23.582
	(0.451)	(0.185)	(26.160)
Field selection	Disc. < 1985	Disc. < 1985	Disc. < 1985
Country-Year FE	Yes	Yes	Yes
Field FE	Yes	Yes	Yes
Observations	1782	1783	1783
R-square	0.55	0.83	0.55

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (1). The dependent variables are opex and cumulative capex (in logs) in columns 1-2 and the ratio of production to opex in column 3. The indicator variables "Norway," "EOR," and "Post" equal 1 for Norwegian fields, for EOR-eligible fields, and for the years after 1985, and 0 otherwise. Each regression includes country-by-year and field fixed effects. This analysis uses only fields whose exploration or production started before 1985, thereby excluding fields becoming "active" after the Supreme Court decision of 1985. Standard errors are clustered at the field-level.

Table B7: Field-level costs and productivity: Different definition of EOR eligibility

Dept. var.	$\ln(1+\text{opex}_{ft})$ (1)	$\ln(1+\text{cum. capex}_{ft})$ (2)	prod_{ft} / opex_{ft} (3)
Norway × EOR × Post	2.388**	1.461*	56.002*
	(1.118)	(0.789)	(30.258)
EOR × Post	1.056**	0.071	22.566
	(0.446)	(0.181)	(25.303)
Country-Year FE	Yes	Yes	Yes
Field FE	Yes	Yes	Yes
Observations	1988	1989	1989
R-square	0.57	0.84	0.56

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (1). The indicator variables "Norway," "EOR," and "Post" equal 1 for Norwegian fields, for EOR-eligible fields, and for the years after 1985, and 0 otherwise. Each regression includes country-by-year and field fixed effects. This analysis uses the more encompassing definition of EOR eligibility explained in Section 3. Standard errors are clustered at the field-level.

Table B8: Firm-level EOR adoption, production, costs, and productivity: Treatment starts in 1983

	Adoption	Production and Costs			
Dept. var.	Share EOR	$\ln(1+\text{prod}_{it})$	$\ln(1+\text{opex}_{it})$	$\ln(1+\text{cum. capex}_{it})$	prod_{it} / opex_{it}
	(1)	(2)	(3)	(4)	(5)
Share EOR Norway × Post	0.252***	2.886***	2.347***	2.510***	0.270*
	(0.066)	(0.838)	(0.677)	(0.887)	(0.158)
Share EOR × Post	0.013	0.051	0.346	-0.440*	0.031
	(0.010)	(0.278)	(0.365)	(0.241)	(0.105)
Average dept. var.	0.054	2.591	3.541	6.725	0.330
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	1382	1382	1378	1382	1225
R-squared	0.66	0.85	0.85	0.94	0.43

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (2). The dependent variable "Adoption - Share EOR" in Column 1 is the share of fields that adopted EOR among all the fields in which firm i is active in the North Sea in year t. The remaining columns have as dependent variables production, opex, cumulative capex, and the ratio of production on opex. The variable "Share EOR Norway" ("Share EOR") refers to the share of Norwegian (North Sea) EOR-eligible fields in which a firm was active before 1983. The indicator "Post" equals 1 for the years after 1983, the year of Phillips's lawsuit, and 0 otherwise. Each regression includes firm and year fixed effects. Standard errors are clustered at the firm-level.

Table B9: Firm-level EOR adoption, production, costs, and productivity: Different definition of EOR eligibility

Dept. var.	Adoption	Production and Costs			
	Share EOR	$\ln(1+\text{prod}_{it})$	$\ln(1+\text{opex}_{it})$	$\ln(1+\text{cum. capex}_{it})$	prod_{it} / opex_{it}
	(1)	(2)	(3)	(4)	(5)
Share EOR Norway × Post	0.335***	2.051***	2.009***	1.372**	0.289
	(0.120)	(0.671)	(0.745)	(0.602)	(0.179)
Share EOR × Post	0.033**	-0.289	0.051	-0.395*	-0.011
	(0.016)	(0.273)	(0.357)	(0.218)	(0.098)
Average dept. var.	0.053	2.562	3.511	6.688	0.328
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	1406	1406	1402	1406	1245
R-squared	0.70	0.85	0.85	0.93	0.43

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (2). The dependent variable "Adoption - Share EOR" in Column 1 is the share of fields that adopted EOR among all the fields in which firm i is active in the North Sea in year t. The remaining columns have as dependent variables production, opex, cumulative capex, and the ratio of production on opex. The variable "Share EOR Norway" ("Share EOR") refers to the share of Norwegian (North Sea) EOR-eligible fields in which a firm was active before 1985. The indicator "Post" equals 1 for the years after 1985, the year of the Supreme Court decision, and 0 otherwise. Each regression includes firm and year fixed effects. This analysis uses the more encompassing definition of EOR eligibility explained in Section 3. Standard errors are clustered at the firm-level.

Table B10: Market shares and portfolio expansions: Treatment starts in 1983

Dept. var.	Market Share		Number of Fields		
	All	Positive	All Fields	EOR Eligible	Non-EOR Eligible
	(1)	(2)	(3)	(4)	(5)
Share EOR Norway × Post	0.051**	0.074**	14.845***	8.335***	6.510***
	(0.022)	(0.032)	(4.164)	(2.053)	(2.436)
Share EOR × Post	0.003	0.003	-6.130***	-1.319**	-4.811***
	(0.003)	(0.003)	(1.332)	(0.534)	(0.958)
Average dependent variable	0.015	0.017	5.929	2.447	3.482
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	1382	1212	1382	1382	1382
R-squared	0.83	0.86	0.81	0.81	0.78

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (2). "Market share" is a firm's market share of production in the North Sea. Column 3 uses as a dependent variable the total number of fields in which a firm is active in the North Sea. The dependent variables in columns 4-5 decompose the total number of fields in column 3 between the number of EOR-eligible fields (column 4) and the number of non-EOR-eligible fields (column 5) in which a firm is active in the North Sea. The dependent variable is a firm's market share. The variable "Share EOR Norway" ("Share EOR") refers to the share of Norwegian (North Sea) EOR-eligible fields in which a firm was active before 1983. The indicator "Post" equals 1 for the years after 1983, the year of Phillips's lawsuit. Each regression includes firm and year fixed effects. Standard errors are clustered at the firm-level.

Table B11: Market shares and portfolio expansions: Different definition of EOR eligibility

	Market Share		Number of Fields		
Dept. var.	All	Positive	All Fields	EOR Eligible	Non-EOR Eligible
	(1)	(2)	(3)	(4)	(5)
Share EOR Norway × Post	0.014	0.016	8.267**	4.037**	4.230*
	(0.017)	(0.039)	(3.932)	(1.838)	(2.287)
Share EOR × Post	0.001	0.000	-7.203***	-1.637**	-5.566***
	(0.003)	(0.002)	(1.511)	(0.632)	(1.049)
Average dependent variable	0.015	0.017	5.858	2.410	3.449
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	1406	1232	1406	1406	1406
R-squared	0.82	0.84	0.81	0.79	0.79

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (2). "Market share" is a firm's market share of production in the North Sea. Column 3 uses as dependent variable the total number of fields in which a firm is active in the North Sea. The dependent variables in columns 4-5 decompose the total number of fields in column 3 between the number of EOR-eligible fields (column 4) and the number of non-EOR-eligible fields (column 5) in which a firm is active in the North Sea. The dependent variables are a firm's market share The variables "Share EOR Norway" ("Share EOR") refers to the share of Norwegian (North Sea) EOR-eligible fields in which a firm was active before 1985. The indicator "Post" equals 1 for the years after 1985, the year of the Supreme Court decision. Each regression includes firm and year fixed effects. This analysis uses the more encompassing definition of EOR eligibility explained in Section 3. Standard errors are clustered at the firm-level.

Table B12: Firm-level results controlling for "Share Norway × Post"

	Adoption	Production and Costs				Market Share	
Dept. var.	Share EOR	$\ln(1+\text{prod}_{it})$	$\ln(1+\text{opex}_{it})$	$\ln(1+\text{cum. capex}_{it})$	prod_{it} / opex_{it}	All	Positive
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Share EOR Norway × Post	0.343*	3.812***	4.536***	2.871***	0.208	0.033	0.120**
	(0.179)	(1.032)	(0.959)	(0.929)	(0.161)	(0.024)	(0.052)
Share Norway × Post	0.003	-0.469	-1.118*	-0.578	-0.013	0.005	-0.023
	(0.055)	(0.475)	(0.661)	(0.464)	(0.131)	(0.012)	(0.017)
Share EOR × Post	0.021*	-0.487*	-0.260	-0.574**	-0.004	0.000	-0.001
	(0.011)	(0.278)	(0.372)	(0.231)	(0.103)	(0.002)	(0.002)
Average dept. var.	0.053	2.562	3.511	6.688	0.291	0.015	0.017
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1406	1406	1402	1406	1406	1406	1232
R-squared	0.70	0.86	0.86	0.94	0.41	0.83	0.86

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (2), including also "Share Norway × Post", which we exclude in the main text because of multicollinearity with "Share EOR Norway × Post," since the correlation between the two variables is 0.8. The dependent variables blend key results from other tables (a firm's share of EOR adoption, production, opex, cumulative capex, production/opex, market share, and positive market shares). The variable "Share EOR Norway" ("Share EOR") refers to the share of Norwegian (North Sea) EOR-eligible fields in which a firm was active before 1985. The indicator "Post" equals 1 for the years after 1985, the year of the Supreme Court decision, and 0 otherwise. Each regression includes firm and year fixed effects. Standard errors are clustered at the firm-level.

Table B13: Concentration in field ownership: Treatment starts in 1983

	Share of			HHI		Number of
Dept. var.	Top 1	Top 3	Top 5	Standard	Normalized	Firms
	(1)	(2)	(3)	(4)	(5)	(6)
Norway × Post × EOR	0.165	0.283*	0.322*	0.111	0.183*	-0.298*
	(0.113)	(0.158)	(0.167)	(0.096)	(0.108)	(0.156)
Post × EOR	0.013	0.061	0.076	0.005	0.047	0.173
	(0.051)	(0.083)	(0.089)	(0.045)	(0.062)	(0.153)
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1988	1988	1988	1988	1781	1988
R-square	0.59	0.47	0.45	0.64	0.52	0.96

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Results from regression (1) based on field-level variation. Columns 1-3 use the (combined) share of the largest, three largest, five largest firms by ownership share in a field as dependent variable. Columns 4-5 employ the Herfindahl-Hirschman concentration index (HHI) computed in terms of asset interest shares at the field-level. "Normalized HHI" in column 5 is computed as $\frac{\text{HHI}-1/N}{1-1/N}$ and helps comparing the HHI across fields in which the number of active firms N vary. "Number of Firms" in column 6 is the number of partnering firms in a specific field. The indicator variables "Norway," "EOR," and "Post" equal 1 for Norwegian fields, for EOR-eligible fields, and for the years after 1985. Each regression includes country-by-year and field fixed effects. Standard errors are clustered at the field-level.

Table B14: Results from the analyses in Tables 9, 10, and 11: Including "Share Norway$_i$" as a regressor

Panel (a): Replication of Panel (c) of Table 9 adding "Share Norway$_i$" as a control

Dept. var.	Market Share	Number of Fields		
		All Fields	EOR Eligible	Non-EOR Eligible
	(1)	(2)	(3)	(4)
K-H & S-O × Share EOR Norway × Post	0.136***	23.868**	6.107*	17.761**
	(0.029)	(11.517)	(3.298)	(8.835)
K-H Only × Share EOR Norway × Post	0.050**	48.537***	11.312**	37.225***
	(0.023)	(10.443)	(4.564)	(6.358)
Share EOR Norway × Post	0.015	-2.162	-1.434	-0.728
	(0.011)	(6.591)	(3.072)	(3.867)
Share EOR × Post	0.000	-5.994***	-0.916*	-5.078***
	(0.002)	(1.389)	(0.473)	(1.113)
Share Norway × Post-1985	-0.005	5.974	4.432**	1.542
	(0.008)	(5.201)	(2.198)	(3.261)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	1377	1377	1377	1377
R-squared	0.88	0.83	0.82	0.81

Panel (b): Replication of Panel (c) of Table 10 adding "Share Norway$_i$" as a control

Dept. var.	Number of EOR Eligible Fields:				Number of Non-EOR Eligible Fields:			
	Heavy Oil	Sour Oil	Deep Well	Other (Lower Risk)	Heavy Oil	Sour Oil	Deep Well	Other (Lower Risk)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
K-H & S-O × Sh. Eligible Norw. Fields × Post-1985	–	0.776	5.019*	1.138*	0.914***	8.292	14.071	1.487**
	–	(0.670)	(2.955)	(0.639)	(0.114)	(7.002)	(8.632)	(0.592)
K-H Only × Sh. Eligible Norw. Fields × Post-1985	–	2.994***	11.319***	0.062	0.814	35.265***	29.898***	3.482
	–	(0.796)	(4.045)	(0.635)	(0.790)	(5.737)	(6.950)	(2.229)
Sh. Eligible Norw. Fields × Post-1985	–	0.096	-1.525	0.108	-0.049	0.088	-0.315	-0.263
	–	(0.463)	(2.983)	(0.141)	(0.098)	(2.265)	(3.035)	(0.364)
Sh. Eligible North Sea Fields × Post-1985	–	-0.162	-0.871*	-0.039	0.055	-3.133***	-4.243***	-0.108*
	–	(0.211)	(0.467)	(0.033)	(0.053)	(0.871)	(1.006)	(0.063)
Share Norway × Post-1985	–	-0.085	4.411**	0.003	-0.081	-0.234	0.512	0.485
	–	(0.399)	(2.152)	(0.142)	(0.086)	(2.034)	(2.626)	(0.301)
Year FE	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	–	1377	1377	1377	1377	1377	1377	1377
R-squared	–	0.77	0.82	0.78	0.33	0.78	0.77	0.71

Panel (c): Replication of Panel (d) of Table 11 adding "Share Norway$_i$" as a control

Dept. var.	Diversification in Technology Portfolio (1-HHI)					
	Exploration & Prod. Tech.	Extraction Technologies	Well Depth	Field Sizes	Tariff Intensity	Capex Intensity
	(1)	(2)	(3)	(4)	(5)	(6)
K-H & S-O × Share EOR Norway × Post	0.895**	0.426	0.621	0.918**	0.534	0.804*
	(0.393)	(0.439)	(0.457)	(0.380)	(0.390)	(0.451)
K-H Only × Share EOR Norway × Post	1.249***	1.828***	1.592***	2.047***	1.558***	1.268***
	(0.312)	(0.306)	(0.385)	(0.283)	(0.316)	(0.432)
Share EOR Norway × Post	-0.402	-0.591	-0.558	-0.427	-0.567	-0.341
	(0.497)	(0.507)	(0.537)	(0.490)	(0.486)	(0.493)
Share EOR × Post	-0.262**	-0.112	-0.208**	-0.188*	-0.162	-0.208**
	(0.108)	(0.095)	(0.100)	(0.104)	(0.101)	(0.100)
Share Norway × Post-1985	-0.103	0.114	0.100	-0.037	0.011	-0.092
	(0.367)	(0.377)	(0.402)	(0.366)	(0.366)	(0.362)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1377	1377	1377	1377	1377	1377
R-squared	0.37	0.32	0.35	0.33	0.34	0.34

Notes: Replication of the last panels in Tables 9, 10, and 11, while adding "Share Norway" as an independent variable. We do not include this variable in the main text because of multicollinearity.

Table B15: List of of state owned companies in 1975-1995

Company Name	**Description and North Sea Involvement**
BP	British multinational oil and gas company. originally known as British Petroleum, was a key player in North Sea oil exploration and production during the 1970s and 1980s. The company was state-owned until it was fully privatized in 1987. In 1988, BP acquired Britoil, strengthening its North Sea presence. It merged with Amoco in 1998.
Britoil	A British oil company active in the North Sea during the 1970s and 1980s, focused on exploration and production. It was acquired by BP in 1988, which enhanced BP's presence in the North Sea and contributed to its leadership in the region.
Norway State DFI	From 1973 to 1985, Statoil was awarded a majority of Norway's petroleum development licenses. In the 1980s, as Statoil's cash flow grew significantly with respect to Norway's gross national product, the government restructured its ownership for political reasons. On January 1, 1985, the State's Direct Financial Interest (SDFI) was created, with Statoil retaining 20% of its original portfolio and transferring the rest to SDFI.
Statoil	Founded in 1972, Statoil was initially a state-owned company involved in the exploration and production of oil in the North Sea. It was privatized in 2001. It merged with Hydro to form StatoilHydro in 2007. It was later rebranded as Equinor in 2018.

Table B16: Know-how, market shares, and portfolio expansions: Including state-owned firms without know-how

Dept. var.	Market Share	Number of Fields		
		All Fields	EOR Eligible	Non-EOR Eligible
	(1)	(2)	(3)	(4)
Panel (a): Know-How (K-H)				
K-H × Share EOR Norway × Post	0.088**	32.081***	8.785***	23.296***
	(0.040)	(10.625)	(2.888)	(8.820)
Share EOR Norway × Post	0.029	6.771*	4.887**	1.884
	(0.020)	(3.514)	(2.146)	(1.531)
Observations	1406	1406	1406	1406
R-squared	0.84	0.83	0.81	0.81
Panel (b): State-Owned (S-O)				
S-O × Share EOR Norway × Post	0.126***	14.775**	6.236**	8.539*
	(0.011)	(6.529)	(2.520)	(4.511)
Share EOR Norway × Post	0.010**	7.051*	4.464**	2.586
	(0.005)	(3.934)	(2.175)	(2.023)
Observations	1406	1406	1406	1406
R-squared	0.86	0.82	0.81	0.79
Panel (c): Know-How (K-H) & State-Owned (S-O)				
K-H & S-O × Share EOR Norway × Post	0.132***	28.083***	9.253***	18.830**
	(0.025)	(9.807)	(2.788)	(7.796)
K-H Only × Share EOR Norway × Post	0.050**	47.330***	10.469**	36.861***
	(0.023)	(10.435)	(4.844)	(6.225)
S-O Only × Share EOR Norway × Post	0.127***	10.272***	5.193**	5.078***
	(0.004)	(3.297)	(2.172)	(1.272)
Share EOR Norway × Post	0.008**	5.226	4.061*	1.165
	(0.004)	(3.254)	(2.127)	(1.343)
Observations	1406	1406	1406	1406
R-square	0.86	0.83	0.81	0.81
Share EOR × Post	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Average dependent variable	0.013	5.272	2.151	3.121

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (5). The dependent variables are firm i's market share (column 1), and the number of fields (2), number of EOR-eligible fields (3), and number of non-EOR-eligible fields (4) in i's portfolio in year t. The table consists of three Panels, which vary based on the definition of the heterogeneity investigated. Panel (a) interacts "Share EOR Norway × Post," which is the share of firm i's fields that are eligible for EOR before 1985 times an indicator that is 1 for the years after 1985, with "K-H," an indicator that is 1 if firm i was an operator in a field that adopted EOR before 1985, and zero otherwise, which we define as know-how. Panel (b) interacts "Share EOR Norway" with "S-O" (sate ownership) an indicataor that is 1 if firm i was state owned during 1975-1995. Since some firms have both know-how and are state-owned, we decompose the effect of "K-O" and "S-O" in Panel (c) by creating the variables "K-H & S-O," an indicator for a state-owned firm with know-how, "K-H Only," an indicator for a non-state-owned firm with know-how, and "S-O Only," an indicator for a state-owned firm without know-how. All regression control for the "Share EOR × Post," which is firm i's share of EOR-eligible fields in the North Sea before 1985 times the post-1985 indicator, and firm and year fixed-effects. Standard errors are clustered at the firm-level.

Table B17: Oil majors, market shares, and portfolio expansions

Dept. var.	Market Share	Number of Fields		
		All Fields	EOR Eligible	Non-EOR Eligible
	(1)	(2)	(3)	(4)
Panel (a): Regression (5) with "Oil Major$_i$" instead of "Know-How$_i$"				
Oil Majors × Share EOR Norway × Post	-0.027	2.381	-3.163	5.544
	(0.023)	(12.024)	(4.303)	(8.109)
Share EOR Norway × Post	0.031	9.031*	6.209**	2.822
	(0.021)	(5.250)	(2.880)	(2.597)
Share EOR × Post	-0.000	-7.553***	-1.813***	-5.740***
	(0.003)	(1.487)	(0.610)	(1.041)
Observations	1377	1377	1377	1377
R-squared	0.87	0.81	0.80	0.79
Panel (b): as in Panel (a) plus "Share Norway$_i$" as a regressor				
Oil Majors × Share EOR Norway × Post	-0.027	5.176	-1.444	6.620
	(0.021)	(11.384)	(3.769)	(7.883)
Share EOR Norway × Post	0.029	-1.536	-0.292	-1.245
	(0.021)	(8.520)	(3.868)	(4.919)
Share EOR × Post	0.000	-6.208***	-0.986**	-5.222***
	(0.002)	(1.436)	(0.488)	(1.138)
Share Norway × Post	0.002	7.505	4.617**	2.888
	(0.011)	(5.380)	(2.190)	(3.374)
Observations	1377	1377	1377	1377
R-squared	0.87	0.82	0.82	0.79
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Average dependent variable	0.012	5.216	2.116	3.100

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (5) in which we replaced "Know-how" for "Oil Major," an indicator variable that is one for oil majors and zero otherwise. The list of oil majors includes the so called "seven sisters" (Exxon, Mobil, Chevron, Texaco, Gulf Oil, Royal Dutch Shell, BP) as well as other very large players of the time (Total, Eni, Phillips Petroleum, Conoco, Amoco). Panel (b) also includes "Share Norway$_i$," the average share of Norwegian fields in firm i's portfolio before 1985 as a regressor. The dependent variables are firm i's market share (column 1), and the number of fields (2), number of EOR-eligible fields (3), and number of non-EOR-eligible fields (4) in i's portfolio in year t. The regressions excludes firms that were state-owned and had no know-how. Including these observations does not change the results qualitatively. All regression control for firm and year fixed-effects. Standard errors are clustered at the firm-level.

Table B18: Know-how and portfolio diversification: Including state-owned firms without know-how)

Dept. var.	Number of EOR Eligible Fields: Heavy Oil (1)	Sour Oil (2)	Deep Well (3)	Other (Lower Risk) (4)	Number of Non-EOR Eligible Fields: Heavy Oil (5)	Sour Oil (6)	Deep Well (7)	Other (Lower Risk) (8)
Panel (a): Know-How (K-H)								
K-H × Share EOR Norway × Post-1985	–	1.299	8.169***	0.660	0.852***	16.057	18.426**	2.171**
	–	(0.854)	(2.644)	(0.442)	(0.240)	(9.957)	(8.273)	(0.937)
Share EOR Norway × Post-1985	–	0.051	4.603**	0.282	-0.154***	-0.416	0.668	0.454*
	–	(0.278)	(1.995)	(0.201)	(0.057)	(0.690)	(1.078)	(0.264)
Observations	–	1406	1406	1406	1406	1406	1406	1406
R-squared	–	0.76	0.80	0.80	0.32	0.76	0.76	0.70
Panel (b): State-Owned (S-O)								
S-O × Share EOR Norway × Post-1985	–	0.400	5.186**	1.073***	0.273	1.145	5.797	1.006**
	–	(0.355)	(2.466)	(0.238)	(0.291)	(3.064)	(3.873)	(0.442)
Share EOR Norway × Post-1985	–	0.108	4.350**	0.113	-0.119	1.148	1.442	0.472
	–	(0.330)	(2.104)	(0.125)	(0.077)	(1.489)	(1.600)	(0.305)
Observations	–	1406	1406	1406	1406	1406	1406	1406
R-squared	–	0.76	0.80	0.81	0.31	0.74	0.75	0.68
Panel (c): Know-How (K-H) & State-Owned (S-O)								
K-H & S-O × Share EOR Norway × Post-1985	–	0.704	8.150***	1.140*	0.856***	8.078	14.399*	1.835***
	–	(0.559)	(2.485)	(0.577)	(0.093)	(6.383)	(7.793)	(0.488)
K-H Only × Share EOR Norway × Post-1985	–	2.988***	10.481**	0.060	0.829	35.194***	29.703***	3.400
	–	(0.782)	(4.335)	(0.634)	(0.781)	(5.681)	(6.825)	(2.295)
S-O Only × Share EOR Norway × Post-1985	–	0.455	4.178**	1.035***	-0.027	-0.328	2.814***	0.763***
	–	(0.281)	(2.102)	(0.116)	(0.047)	(0.662)	(0.954)	(0.261)
Share EOR Norway × Post-1985	–	-0.010	3.946*	0.111	-0.150**	-0.221	0.298	0.340
	–	(0.297)	(2.049)	(0.130)	(0.062)	(0.785)	(1.039)	(0.260)
Observations	–	1406	1406	1406	1406	1406	1406	1406
R-squared	–	0.77	0.81	0.81	0.32	0.77	0.77	0.70
Share EOR × Post-1985	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Average dependent variable	–	0.580	2.015	0.097	0.060	1.864	2.356	0.156

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (5). The dependent variables are the number of fields eligible for EOR (columns 1-4) and non-eligible for EOR (columns 5-8) where in firm i's portfolio in year t. Each column focuses on different field types (heavy, sour, deep well, or other non-heavy, non-sour, non-deep fields). EOR cannot be implemented with heavy oil, and hence, column 1 is empty. The table consists of three Panels, which vary based on the definition of the heterogeneity investigated. Panel (a) interacts "Share EOR Norway × Post," which is the share of firm i's fields that are eligible for EOR before 1985 times an indicator that is 1 for the years after 1985, with "K-H," an indicator that is 1 if firm i was an operator in a field that adopted EOR before 1985, and zero otherwise, which we define as know-how. Panel (b) interacts "Share EOR Norway" with "S-O" (sate ownership) an indicataor that is 1 if firm i was state owned during 1975-1995. Since some firms have both know-how and are state-owned, we decompose the effect of "K-O" and "S-O" in Panel (c) by creating the variables "K-H & S-O," an indicator for a state-owned firm with know-how, "K-H Only," an indicator for a non-state-owned firm with know-how, and "S-O Only," an indicator for a state-owned firm without know-how. All regression control for the "Share EOR × Post," which is firm i's share of EOR-eligible fields in the North Sea before 1985 times the post-1985 indicator, and firm and year fixed-effects. Standard errors are clustered at the firm-level.

Table B19: Oil majors and portfolio diversification

Dept. var.	Number of EOR Eligible Fields:				Number of Non-EOR Eligible Fields:			
	Heavy Oil (1)	Sour Oil (2)	Deep Well (3)	Other (Lower Risk) (4)	Heavy Oil (5)	Sour Oil (6)	Deep Well (7)	Other (Lower Risk) (8)
Panel (a): Regression (5) with "Oil Major$_i$" instead of "Know-How$_i$"								
Oil Majors × Share EOR Norway × Post	–	0.422	-3.104	-0.121	0.013	7.790	5.476	-0.042
	–	(0.775)	(4.091)	(0.282)	(0.222)	(6.852)	(7.176)	(0.804)
Share EOR Norway × Post	–	0.049	5.967**	0.261	-0.040	-0.307	1.291	0.649*
	–	(0.349)	(2.746)	(0.187)	(0.127)	(1.027)	(1.791)	(0.390)
Share EOR × Post	–	-0.170	-1.754***	-0.050	0.056	-3.380***	-4.647***	-0.226***
	–	(0.188)	(0.603)	(0.032)	(0.051)	(0.768)	(0.899)	(0.074)
Observations	–	1377	1377	1377	1377	1377	1377	1377
R-squared	–	0.76	0.80	0.77	0.31	0.75	0.75	0.67
Panel (b): as in Panel (a) plus "Share Norway$_i$" as a regressor								
Oil Majors × Share EOR Norway × Post	–	0.410	-1.420	-0.093	0.003	8.006	6.087	0.167
	–	(0.781)	(3.571)	(0.260)	(0.220)	(6.782)	(7.041)	(0.748)
Share EOR Norway × Post	–	0.095	-0.400	0.156	-0.003	-1.123	-1.020	-0.143
	–	(0.563)	(3.707)	(0.202)	(0.142)	(2.640)	(3.732)	(0.486)
Share EOR × Post	–	-0.176	-0.943*	-0.037	0.052	-3.276***	-4.353***	-0.125**
	–	(0.212)	(0.483)	(0.032)	(0.053)	(0.905)	(1.027)	(0.061)
Share Norway × Post	–	-0.033	4.522**	0.075	-0.026	0.580	1.641	0.563*
	–	(0.392)	(2.129)	(0.117)	(0.101)	(1.987)	(2.656)	(0.292)
Observations	–	1377	1377	1377	1377	1377	1377	1377
R-squared	–	0.76	0.81	0.77	0.31	0.75	0.75	0.68
Year FE	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Average dependent variable	–	0.580	2.015	0.097	0.060	1.864	2.356	0.156

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Estimated coefficients from (5) in which we replaced "Know-how" for "Oil Major," an indicator variable that is one for oil majors and zero otherwise. The list of oil majors includes the so called "seven sisters" (Exxon, Mobil, Chevron, Texaco, Gulf Oil, Royal Dutch Shell, BP) as well as other very large players of the time (Total, Eni, Phillips Petroleum, Conoco, Amoco). Panel (b) also includes "Share Norway$_i$," the average share of Norwegian fields in firm i's portfolio before 1985 as a regressor. The dependent variables are the number of fields eligible for EOR (columns 1-4) and non-eligible for EOR (columns 5-8) where in firm i's portfolio in year t. Each column focuses on different field types (heavy, sour, deep well, or other non-heavy, non-sour, non-deep fields). EOR cannot be implemented with heavy oil, and hence, column 1 is empty. The table consists of three Panels, which vary based on the definition of the heterogeneity investigated. The regressions excludes firms that were state-owned and had no know-how. Including these observations does not change the results qualitatively. All regression control for firm and year fixed-effects. Standard errors are clustered at the firm-level.

Table B20: Know-how and technological diversification: Including state-owned firms without know-how

Dept. var.	Diversification in Technology Portfolio (1-HHI)					
	Exploration & Prod. Tech. (1)	Extraction Technologies (2)	Well Depth (3)	Field Sizes (4)	Tariff Intensity (5)	Capex Intensity (6)
Panel (a): Baseline						
Share EOR Norway × Post	-0.533**	-0.452**	-0.384*	-0.439**	-0.540***	-0.408**
	(0.208)	(0.190)	(0.207)	(0.205)	(0.168)	(0.195)
Share EOR × Post	-0.258**	-0.147	-0.241**	-0.201*	-0.178*	-0.206**
	(0.106)	(0.098)	(0.101)	(0.104)	(0.101)	(0.101)
Observations	1406	1406	1406	1406	1406	1406
R-squared	0.37	0.31	0.35	0.32	0.34	0.33
Panel (b): Know-How (K-H)						
K-H × Share EOR Norway × Post	1.070***	0.981**	0.999**	1.333***	0.912**	0.945***
	(0.273)	(0.480)	(0.399)	(0.394)	(0.379)	(0.343)
Share EOR Norway × Post	-0.655***	-0.564***	-0.498**	-0.590***	-0.644***	-0.515***
	(0.191)	(0.176)	(0.196)	(0.176)	(0.154)	(0.184)
Observations	1406	1406	1406	1406	1406	1406
R-squared	0.38	0.32	0.36	0.33	0.35	0.34
Panel (c): State-Owned (S-O)						
S-O × Share EOR Norway × Post	-0.220	-0.307	-0.039	-0.193	-0.194	-0.001
	(0.555)	(0.412)	(0.400)	(0.550)	(0.372)	(0.396)
Share EOR Norway × Post	-0.483**	-0.382*	-0.376	-0.395*	-0.496**	-0.408*
	(0.217)	(0.222)	(0.247)	(0.215)	(0.192)	(0.228)
Observations	1406	1406	1406	1406	1406	1406
R-squared	0.37	0.31	0.35	0.32	0.34	0.33
Panel (d): Know-How (K-H) & State-Owned (S-O)						
K-H & S-O × Share EOR Norway × Post	0.818***	0.498	0.685**	0.883***	0.534**	0.731**
	(0.241)	(0.305)	(0.308)	(0.228)	(0.250)	(0.318)
K-H Only × Share EOR Norway × Post	1.260***	1.788***	1.558***	2.037***	1.540***	1.268***
	(0.303)	(0.328)	(0.408)	(0.285)	(0.320)	(0.423)
S-O Only × Share EOR Norway × Post	-0.773***	-0.668***	-0.368	-0.705***	-0.527***	-0.360*
	(0.207)	(0.196)	(0.229)	(0.185)	(0.169)	(0.213)
Share EOR Norway × Post	-0.529**	-0.450**	-0.434*	-0.471**	-0.554***	-0.455**
	(0.212)	(0.204)	(0.237)	(0.195)	(0.177)	(0.222)
Observations	1406	1406	1406	1406	1406	1406
R-squared	0.39	0.33	0.36	0.34	0.35	0.34
Share EOR × Post	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Average dependent variable	0.219	0.311	0.338	0.319	0.342	0.341

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Panel (a) presents estimates from (2), whereas the remaining 3 Panels presents estimates from (5), which investigates heterogeneous effects. The dependent variables is computed according to (6) using the categories within each technology type (columns 1-2), field characteristics (columns 3-4), and cost expenditures (column 5-6). In column 5, "tariffs" are costs paid for services needed to the field. Panel (b) interacts "Share EOR Norway × Post," which is the share of firm i's fields that are eligible for EOR before 1985 times an indicator that is 1 for the years after 1985, with "K-H," an indicator that is 1 if firm i was an operator in a field that adopted EOR before 1985, and zero otherwise, which we define as know-how. Panel (c) interacts "Share EOR Norway" with "S-O" (sate ownership) an indicataor that is 1 if firm i was state owned during 1975-1995. Since some firms have both know-how and are state-owned, we decompose the effect of "K-O" and "S-O" in Panel (d) by creating the variables "K-H & S-O," an indicator for a state-owned firm with know-how, "K-H Only," an indicator for a non-state-owned firm with know-how, and "S-O Only," an indicator for a state-owned firm without know-how. All regression control for the "Share EOR × Post," which is firm i's share of EOR-eligible fields in the North Sea before 1985 times the post-1985 indicator, and firm and year fixed-effects. Standard errors are clustered at the firm-level.

Table B21: Oil majors and technological diversification

Dept. var.	Diversification in Technology Portfolio (1-HHI)					
	Exploration & Prod. Tech. (1)	Extraction Technologies (2)	Well Depth (3)	Field Sizes (4)	Tariff Intensity (5)	Capex Intensity (6)
Panel (a): Regression (5) with "Oil Major$_i$" instead of "Know-How$_i$"						
Oil Majors × Share EOR Norway × Post	0.034	0.201	0.061	0.042	0.205	0.064
	(0.381)	(0.506)	(0.469)	(0.480)	(0.411)	(0.457)
Share EOR Norway × Post	-0.413	-0.392	-0.328	-0.325	-0.502**	-0.355
	(0.292)	(0.245)	(0.302)	(0.269)	(0.223)	(0.281)
Share EOR × Post	-0.258**	-0.147	-0.240**	-0.200*	-0.178*	-0.205**
	(0.106)	(0.098)	(0.101)	(0.105)	(0.101)	(0.102)
Observations	1377	1377	1377	1377	1377	1377
R-squared	0.36	0.31	0.34	0.32	0.34	0.33
Panel (b): as in Panel (a) plus "Share Norway$_i$" as a regressor						
Oil Majors × Share EOR Norway × Post	0.014	0.254	0.112	0.045	0.223	0.047
	(0.421)	(0.512)	(0.476)	(0.502)	(0.431)	(0.488)
Share EOR Norway × Post	-0.338	-0.594	-0.517	-0.336	-0.570	-0.290
	(0.632)	(0.598)	(0.649)	(0.612)	(0.579)	(0.613)
Share EOR × Post	-0.268**	-0.121	-0.216**	-0.199*	-0.169*	-0.213**
	(0.108)	(0.095)	(0.099)	(0.103)	(0.100)	(0.099)
Share Norway × Post	-0.053	0.143	0.135	0.008	0.048	-0.046
	(0.372)	(0.375)	(0.399)	(0.372)	(0.367)	(0.364)
Observations	1377	1377	1377	1377	1377	1377
R-squared	0.36	0.31	0.35	0.32	0.34	0.33
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Average dependent variable	0.219	0.311	0.338	0.319	0.342	0.341

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: The table presents estimates from (5), using an indicator variable that is one for oil majors and zero otherwise. The list of oil majors includes the so called "seven sisters" (Exxon, Mobil, Chevron, Texaco, Gulf Oil, Royal Dutch Shell, BP) as well as other very large players of the time (Total, Eni, Phillips Petroleum, Conoco, Amoco). Panel (b) also includes "Share Norway$_i$," the average share of Norwegian fields in firm i's portfolio before 1985 as a regressor. The dependent variables is computed according to (6) using the categories within each technology type (columns 1-2), field characteristics (columns 3-4), and cost expenditures (column 5-6). In column 5, "tariffs" are costs paid for services needed to the field. The regressions excludes firms that were state-owned and had no know-how. Including these observations does not change the results qualitatively. All regression control firm and year fixed-effects. Standard errors are clustered at the firm-level.

C Geographic Proximity to a Field Adopting EOR

To better understand the mechanism driving EOR adoption, we compare the Know-How mechanism that we consider in Section 7 with geographic distance to operators adopting EOR as fields that are near an adopting field may increase their consideration for EOR implementation. Specifically, we examine two key drivers: (1) operators with prior EOR adoption experience, and (2) fields in close proximity to those with EOR adoption.

We run the analysis at the field level. We update regression (1) by investigating heterogeneous effect according to the variable "Φ_f:"

$$\begin{aligned} \text{EOR}_{f,c(f),t} = &\beta_{\text{treat}} \text{ Norway}_{c(f)} \times \text{EOR}_f \times \text{Post}_t \times \Phi_f \\ &+ \beta_1 \text{ Norway}_{c(f)} \times \text{Post}_t \times \text{EOR}_f \\ &+ \beta_2 \text{ Post}_t \times \text{EOR}_f \\ &+ \beta_3 \ \Phi_f \times \text{Post}_t \times \text{EOR}_f \\ &+ \beta_4 \ \Phi_f \times \text{Post}_t + \tau_f + \iota_{c(f)t} + \epsilon_{fct}, \end{aligned} \tag{C1}$$

where the variable "Φ_f" refers to one of the two channels. In particular, when it refers to "Know-How$_f$" as in Section 7, it is the number of other fields that are also operated by field's f operator that already adopted EOR. This number is averaged over the period 1970-1985. On the other hand, when it refers to "Avg. inverse distance to EOR$_f$" it represents the 1/distance from the closest EOR adoption before 1985. Therefore, closer fields to an EOR implementation have higher values of "Avg. inverse distance to EOR$_f$."

The results are in Table C1; the know-how (geographic proximity) channel is in columns 1 and 2 (3 and 4). Even columns include operator fixed effects to account for unobserved differences among operators that remain constant over time, as well as endogenous changes in operators over time. The first two rows show the estimates for $\hat{\beta}_{\text{treat}}$, while the remaining rows present the estimates for the other coefficients in (C1).

Overall, EOR adoption is driven by know-how rather than distance to the EOR-adopting fields before 1985. The coefficient in column 2 suggests that a 10 percentage point increase in know-how raises the probability of adopting EOR by 0.0729, almost doubling the adoption rate (which averages 8%). In contrast, proximity to an EOR-adopting field has no significant impact, as the $\hat{\beta}_{\text{treat}}$ coefficient is small and even negative.

Comparing the estimated β_{treat} and β_3 highlights the full impact of the Supreme Court decision in Norway versus the UK. The negative coefficient for Know-How $\times$ Post $\times$ EOR indicates that know-how played a larger role in Norway than in the UK. Proximity, however, had no differential effect between the two countries.

For these reasons, we focus our analysis in Sections 7 and 8 on know-how rather than geographic proximity.

Table C1: EOR adoption, know-how and geographic proximity to adopting fields

Dept. var.	EOR Adoption (0/1)			
	Testing Know-How		Testing Proximity	
	(1)	(2)	(3)	(4)
Main Independent Variables				
Know-How × Norway × Post × EOR (β_{treat})	0.724***	0.729***		
	(0.091)	(0.093)		
Avg. inverse distance to EOR × Norway × Post × EOR (β_{treat})			-0.090	-0.091
			(1.530)	(1.546)
Control Variables				
Norway × Post × EOR (β_1)	0.065	0.054	0.227	0.222
	(0.120)	(0.122)	(0.233)	(0.235)
Post × EOR (β_2)	0.132**	0.139**	0.019	0.021
	(0.062)	(0.065)	(0.023)	(0.024)
Know-How × Post × EOR (β_3)	-0.089**	-0.095**		
	(0.043)	(0.045)		
Avg. inverse distance to EOR × Post × EOR (β_3)			0.662	0.667
			(0.448)	(0.454)
Know-How × Post (β_4)	-0.000	0.001		
	(0.006)	(0.006)		
Avg. inverse distance to EOR × Post (β_4)			0.048	0.043
			(0.033)	(0.033)
Country-Year FE	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes
Operator FE	No	Yes	No	Yes
Observations	1808	1808	1808	1808
R-squared	0.86	0.86	0.86	0.86

* – $p < 0.1$; ** – $p < 0.05$; *** – $p < 0.01$

Notes: Results of the field-level regression analysis from regression (C1). The top panel shows the estimates of the main coefficient of interest $\hat{\beta}_{treat}$, whereas the bottom panel shows the estimates of the remaining interactions. The indicator variables Norway, EOR, and Post are 1 for Norwegian fields, for EOR-eligible fields, and for years from 1985 onward and 0 otherwise, repsectively. Each regression includes country-by-year and field fixed effects, while even columns also include operator fixed effects. Standard errors are clustered at the field-level.

D Classification of Technologies

Exploration & Production Technologies (for field development): These technologies are primarily associated with the infrastructure and **methods** used to access and produce hydrocarbons from reservoirs.

- **Extended Reach Drilling (ERD)** - *Exploration & Production* technology: Used for drilling wells that reach farther from the rig or platform, typically for exploration and production purposes in hard-to-reach reservoirs.
- **FPSO (Floating Production Storage and Offloading)** - *Production* technology: A floating unit used for offshore oil and gas production, storage, and offloading. Often deployed in deepwater areas without the need for fixed infrastructure.
- **Fixed Platform** - *Production* technology: A stationary platform that supports drilling and production activities in shallow waters.
- **Onshore** - *Production* location: Refers to oil and gas production facilities located on land rather than offshore.
- **Production Jack-up** - *Production* technology: A mobile offshore drilling rig with legs that are lowered to the seabed to provide support for drilling and production.
- **Production Semi-submersible** - *Production* technology: A type of offshore platform that is anchored to the seabed, typically used for deepwater production.
- **Subsea** - *Production* technology: Involves subsea wells connected to a platform, often used for remote or deepwater oil and gas extraction.
- **Tension Leg Platform (TLP)** - *Production* technology: A type of offshore floating platform anchored to the seabed by tendons, typically used in very deep water.
- **Undeveloped** - *Exploration* (stage of development): Refers to a field that has not yet reached the production phase, generally associated with exploration and early development stages.

Extraction & Reservoir Drive Technologies (for hydrocarbon recovery): These are **extraction technologies** used for increasing the recovery rate or enhancing production by maintaining or improving reservoir pressure.

- **Artificial Lift** - *Primary Production* technology: A method used to increase production from a well where the natural reservoir pressure is insufficient to bring oil or gas to the surface. This includes technologies like beam pumps or gas lift.

- **Artificial Lift, Gas Injection** - *Secondary Recovery* technology: Involves injecting gas into the reservoir to maintain pressure and drive additional oil or gas to the surface.
- **Artificial Lift, Gas Injection, Water Injection** - *Secondary Recovery* technology: A combination of artificial lift with both gas and water injection to enhance recovery and pressure support in the reservoir.
- **Artificial Lift, Water Injection** - *Secondary Recovery* technology: Uses water injection alongside artificial lift to maintain pressure and enhance the flow of oil from the reservoir.
- **Gas Injection** - *Secondary Recovery* technology: Involves injecting gas (e.g., CO2, natural gas) into the reservoir to boost pressure and enhance oil recovery.
- **Gas Injection, Water Injection** - *Secondary Recovery* technology: A more advanced method combining both gas and water injection to improve oil recovery efficiency in a reservoir.
- **Unknown** - *Unclassified*: Refers to instances where the method used for extraction or enhancement is not specified or is unclear.
- **Water Injection** - *Secondary Recovery* technology: Involves injecting water into the reservoir to maintain pressure and support the flow of oil or gas from the reservoir.

Second, the extraction technologies that we observe in our dataset are the (i) extended reach drilling

Table D1: Field Technology Frequencies across Panels

Exploration & Production Technologies			
Technology	**Freq.**	**Percent**	**Cum.**
Extended reach drilling (ERD)	148	1.71	1.71
FPSO	311	3.59	5.30
Fixed platform	6,260	72.24	77.53
Onshore	114	1.32	78.85
Production jack-up	21	0.24	79.09
Production semi-submersible	228	2.63	81.72
Subsea	1,341	15.47	97.20
Tension leg platform (TLP)	243	2.80	100.00
Extraction & Reservoir Drive Technologies			
Technology	**Freq.**	**Percent**	**Cum.**
Artificial lift	131	1.51	1.51
Artificial lift, Gas injection, Water injection	87	1.00	2.51
Artificial lift, Water injection	552	6.35	8.85
Gas cap drive, Water drive	63	0.72	9.58
Gas injection	8	0.09	9.67
Gas injection, Water injection	1,029	11.83	21.50
Unknown	135	1.55	23.05
Water drive	34	0.39	23.44
Water injection	3,224	37.07	60.51
Basic	3,435	39.49	100.00
Field Primary Resource Theme			
Technology	**Freq.**	**Percent**	**Cum.**
Conventional shelf	8,615	99.41	99.41
Deepwater	4	0.05	99.46
Heavy oil	47	0.54	100.00
Field Size			
Technology	**Freq.**	**Percent**	**Cum.**
Giant	2,391	27.59	27.59
Grouping	806	9.30	36.89
Large	2,647	30.54	67.44
Moderate	2,384	27.51	94.95
Small	438	5.05	100.00