Sovereign Hold-Up and Technology Adoption: Evidence from Oil & Gas*

Michele Fioretti† **Alessandro Iaria**‡ **Aljoscha Janssen**§
Clément Mazet-Sonilhac¶ **Robert K. Perrons**‖

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Abstract

In regulated industries, governments' ability to revise fiscal terms creates sovereign hold-up risk, discouraging irreversible investments. A 1985 Norwegian Supreme Court ruling made retroactive changes to petroleum royalties unconstitutional, strengthening Norway's fiscal commitment relative to the UK's. Exploiting this ruling and comparing Norway to the UK, we show that credible commitment accelerated the adoption of Enhanced Oil Recovery (EOR), a major extraction technology, and prompted adopters to increase production, expand asset portfolios, and adopt also other technologies, particularly those related to EOR. Reducing sovereign hold-up risk encourages firms to deploy valuable know-how that would otherwise remain idle in the economy.

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†Bocconi University, Department of Economics, IGIER, and CEPR fioretti.m@unibocconi.it
‡University of Bristol and CEPR, alessandro.iaria@bristol.ac.uk
§Singapore Management University, ajanssen@smu.edu.sg
¶Bocconi University, Department of Finance and IGIER, clement.mazetsonilhac@unibocconi.it
‖Queensland University of Technology, robert.perrons@qut.edu.au

1 Introduction

Technology adoption often involves costly and irreversible investments. Firms must allocate resources not only to physical capital but also to organizational restructuring and the accumulation of technology-specific know-how. Such commitments make technology adoption highly sensitive to uncertainty: when firms face an unstable economic environment, the expected returns to technology adoption become riskier. As a result, they may postpone or abandon technology adoption altogether.

Because institutions shape the stability of the economic environment, they play a pivotal role in firms' technology adoption decisions. When governments can credibly commit to stable rules—such as predictable taxation—firms are more willing to incur the sunk costs of adoption. Conversely, when governments are unable (or unwilling) to honor their commitments, firms face "sovereign hold-up" risk, which discourages the deployment of profitable technologies and leaves valuable technical expertise underutilized. This risk is amplified by complementarities in technological knowledge:[1] when adoption is path dependent, limited early investment can further depress subsequent adoption. Despite its importance for innovation policy and growth, there is limited empirical evidence on how sovereign hold-up risk affects (i) technology adoption and, in turn, (ii) the extent to which knowledge complementarities generate path dependence—that is, whether differences in firms' preexisting know-how lead to divergent adoption trajectories.

This paper investigates these questions in the context of the North Sea oil & gas (O&G) industry, a highly regulated environment in which governments allocate exploration and production rights through long-term licenses that specify royalty and taxation regimes, and where technology adoption requires large irreversible investments, making the risk of sovereign hold-up central to firms' technology adoption decisions.

Addressing these questions presents three main challenges. First, data availability: firm-level information on technology adoption, intensity of use, and associated returns is rarely observed. As a result, much of the literature relies on industry-level proxies—often based on R&D expenditures—to study convergence, diffusion, and productivity catch-up (Griffith *et al.*, 2003, 2004). Second, measurement: existing work typically uses news-based indices to proxy aggregate uncertainty about major economic policies that receive extensive media coverage (Baker *et al.*, 2016, Gulen and Ion, 2016). Much less is known about how to measure firms' beliefs about sovereign hold-up risk. Third, endogeneity: sovereign commitments, such as those governing taxation, are not exogenous and may respond to firms' production, innovation, and technology adoption decisions, as well as to broader macroeconomic fluctuations.

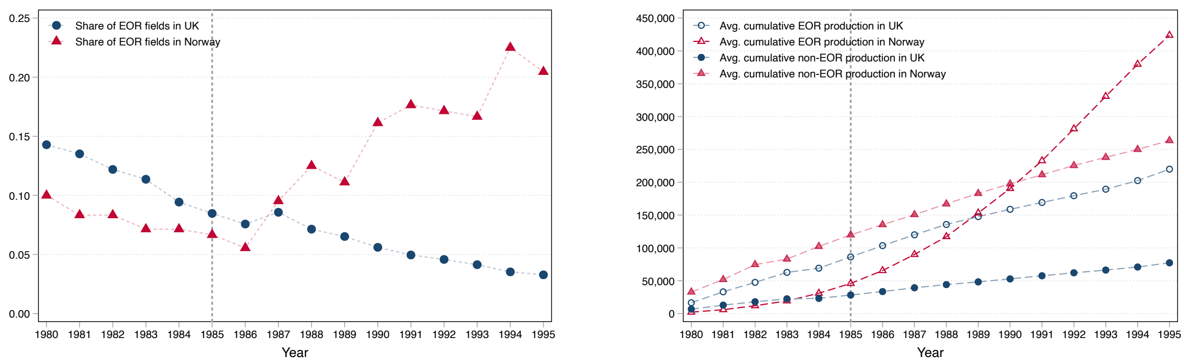
[1] See Aghion and Jaravel (2015) for a review of the literature on knowledge spillovers and complementarities in technological knowledge.

We tackle these challenges in the context of the North Sea O&G industry between 1975 and 1995, and focus on the adoption of the most important extraction technology of the period, Enhanced Oil Recovery (EOR), and how this affects subsequent technology adoption. Our analysis focuses on Norway and the UK (together accounting for 96% of the total oil production of the North Sea) and is based on granular panel data covering firms' portfolios of fields, deployed technologies, and detailed measures of production, costs, and geology.[2] By the 1980s, EOR was a mature and standardized technology that could be implemented through contracts with established service providers. Although EOR adoption did not require in-house innovation, EOR management relied on the technical expertise of field operators. The process of adopting and managing EOR projects built transferable know-how: through collaboration with service engineers and daily operation, firms accumulated technical and organizational expertise that facilitated subsequent adoption of both additional EOR projects and other complementary technologies.

To identify the causal effects of sovereign hold-up risk on investment and technology adoption, we exploit two sources of exogenous variation. First, geological and chemical characteristics of O&G fields determined their suitability for EOR, generating predetermined heterogeneity in adoption incentives across fields and firms. Second, we exploit a landmark 1985 ruling by the Norwegian Supreme Court that sanctioned unilateral retroactive royalty changes as unconstitutional. This decision ruled out retroactive fiscal interventions in Norway, reducing the sovereign hold-up risk associated with contractual commitments, while no comparable change occurred in the UK.

Figure 1: EOR adoption and production in Norway and in the UK

(a) Share of EOR fields (b) Average cumulative production (mboe)



Notes: Panel (a) plots the share of fields adopting EOR by country and year. Panel (b) plots the average cumulative production of EOR-eligible and non-EOR-eligible fields by country and year. The vertical dotted line marks the date of the Norwegian Supreme Court decision, 1985.

Based on these two sources of exogenous variation, our empirical strategy compares

[2]Denmark and the Netherlands, the other two countries operating in the North Sea O&G industry, account for the remaining 4% of total oil production of the region (Jernberg *et al.*, 2024).

firms with similar portfolios of fields in the North Sea but with different exposure to the 1985 Norwegian Supreme Court decision, as determined by the location of firms' EOR-eligible fields on different sides of the border prior to the 1985 ruling. For example, consider two otherwise similar firms with comparable portfolios of fields, except that one firm's EOR-eligible fields were concentrated in Norway and the other's in the UK. The 1985 ruling would be expected to have increased incentives to adopt EOR for the first firm, while leaving incentives for the second unchanged. Figure 1 shows evidence consistent with this intuition. Panel (a) shows that, after the 1985 ruling, EOR adoption rose sharply among EOR-eligible Norwegian fields, while EOR adoption continued its pre-1985 decline in the UK. Panel (b) shows the resulting divergence in production between the two countries and separately by field type: after 1985, the production of Norwegian EOR-eligible fields took off compared to the production of similar British fields.

We formalize the intuition behind our empirical strategy with a dynamic model of technology adoption in the spirit of Jovanovic and Nyarko (1996), where a firm's unobserved state variable is its stock of know-how. This stock rises with successful adoptions, but its relevance for future adoption declines with technological distance—so that, in general, today's adoption facilitates subsequent adoption, but more so for technologies that are closer to today's. The model implies a difference-in-differences design that allows us to estimate the effect of EOR adoption on production, market shares, re-allocations of asset portfolios, and subsequent technology adoption.

Consistently with Figure 1, we show that firms more exposed to the Norwegian Supreme Court decision—those owning a larger share of Norwegian EOR-eligible fields prior to 1985—were significantly more likely to adopt EOR after the ruling. This increase in adoption led to higher production and market shares. Importantly, these did not only stem from EOR's direct productivity gains. Firms also reshaped and expanded their portfolios of assets and technologies: following the ruling, more exposed firms *specialized* in EOR-eligible fields, reallocating their portfolios to assets in which they had a comparative advantage, while also *diversifying* into riskier fields that required different technologies from EOR.

These results suggest that sovereign hold-up risk does more than slow the adoption of individual technologies: it reshapes firms' portfolios of assets and technologies, reshaping the trajectories of their investment strategies. They also point to a seizable *knowledge-based* market failure under policy uncertainty. When fiscal commitments lack credibility, firms under-invest in know-how that is partly transferable across technological domains, distorting both technology adoption in the short run and the evolution of technological portfolios in the long run. Aggregate R&D measures may understate the consequences of this market failure, because they do not capture changes in the composition and diversification of technologies.

To investigate this mechanism, we exploit variation in preexisting EOR-specific expertise across firms. We compare firms that prior to the 1985 ruling were only passive owners—holding equity stakes in EOR-eligible fields—with those who were also operators, responsible for all technological decisions and the management of EOR projects. After 1985, both groups benefited from owning larger shares of Norwegian EOR-eligible fields, but the benefits were substantially higher for operators. Unlike passive owners, operators accumulated EOR-specific technical expertise that proved partly transferable across technological domains: they were more likely to expand their portfolios into riskier assets—such as fields with heavy or sour oil—and to adopt a broader range of technologies. Consistent with the predictions of our model, this diversification was concentrated in extraction technologies that were more similar to EOR than to technological classes that focused on other upstream activities such as exploration.[3]

In aggregate, the Norwegian reduction in sovereign hold-up risk had macro-level consequences for technology adoption and market structure in the region. After 1985, Norway and the UK embarked on divergent technological trajectories: Norway, initially a follower in the early 1980s, rapidly closed the technological gap by the mid-1990s. Importantly, this acceleration in Norway's technology adoption was accompanied—despite substantial entry—by a pronounced increase in market concentration. These findings reveal a novel pathway linking technology adoption with competition and industrial development. Competitive advantage stemmed from transferable know-how across projects within firms: expertise in one technology lowered the cost of adopting others, creating *economies of scope in technology adoption*. This allowed early EOR adopters to establish their positions as technological leaders and contributed to a rise in market concentration.

Our results also underscore a mechanism often overlooked in innovation and competition policy: when know-how is firm-specific and transferable across technologies, early adoption can lock in competitive advantage, with implications for technology diffusion, the evolution of market structure, and industrial policy. Although O&G firms in the North Sea could not influence prices—the region satisfied around 4% of global oil demand—similar forces in other industries can raise welfare concerns, highlighting the need for policies that balance incentives for early technology adoption with long-run competitive outcomes (Igami *et al.*, 2024).

[3] Our findings remain consistent across a wide range of robustness checks. In particular, they hold in a field-level triple-difference specification that controls for country-year fixed effects, parsing out the influence of other country-specific policy changes. They are unchanged when we use alternative definitions of the post-period or explicitly control for fiscal reforms such as the 1983 UK royalty cut, and when we employ alternative engineering definitions of EOR "eligibility." Furthermore, placebo tests on non-EOR-eligible fields confirm that the Supreme Court decision only boosted investments in EOR-eligible fields. Finally, we find no evidence of displacement effects between EOR-eligible and non-EOR-eligible fields.

Literature review. A large literature shows that uncertainty reduces investment by increasing the option value of waiting when capital investment is partially irreversible (Bernanke, 1983, Rodrik, 1991, Bloom and Van Reenen, 2007, Bloom, 2009, Born and Pfeifer, 2014, Baker *et al.*, 2016). Evidence on the consequences of fiscal uncertainty is more limited and is largely theoretical (Hassett and Metcalf, 1999, Lustig *et al.*, 2008, Fernández-Villaverde *et al.*, 2015, Croce *et al.*, 2012) or focuses on how aggregate fiscal risk, such as government debt, is priced in the cross-section of stock returns and relates to innovation expenditures (Croce *et al.*, 2019). We empirically investigate a specific institutional source of fiscal uncertainty arising from sovereign hold-up risk—governments' ability to revise fiscal terms after firms' technology decisions—in a setting where the state, rather than another firm, is the contractual counter-party on long-lived licences.[4] This setting provides a unique opportunity to study how a plausibly exogenous strengthening of sovereign commitment reduces fiscal risk and shapes investment, technology adoption, and the accumulation and redeployment of transferable know-how.[5]

Work on institutions emphasizes that states differ in their ability to make credible commitments, an important source of risk for investors (e.g., Aizenman and Marion, 1993, Acemoglu *et al.*, 2001, Alesina and Perotti, 1996, Besley and Persson, 2011). In settings characterized by large irreversible investments, concerns about ex post fiscal opportunism can discourage long-term investment in oil and gas projects (Osmundsen, 2008). This difference is particularly stark in our setting: Norwegian and British O&G licenses are economically similar but embedded in different legal regimes. In contrast to Norway's *constitutional supremacy*, under which Norwegian courts can disapply legislation that conflicts with the Constitution (Grunnloven), the UK doctrine of *parliamentary sovereignty* means that Parliament can revise the licensing terms through ordinary legislation (Mestad, 1987, Gordon, 2011, Hunter *et al.*, 2020). This contrast in fiscal-term credibility reflects fiscal state capacity—the ability to sustain stable tax rules over time—which has been shown to affect investments (e.g., Besley and Persson, 2010, Dincecco and Katz, 2016, Mastrorocco *et al.*, 2023, Bergeron *et al.*, 2024). We contribute to this literature by showing that institutions also shape the technological specialization and experimentation of firms through the accumulation of transferable know-how.

Recent work has revived interest in industrial policy, emphasizing that effective policy should not only correct market failures, such as knowledge spillovers, but also foster capability accumulation and support complementary private investments that might not occur

[4]The canonical hold-up problem involves private parties making relationship-specific investments under incomplete contracts (e.g., Monteverde and Teece, 1982, Masten, 1984, Joskow, 1987, Anderson and Schmittlein, 1984, Lafontaine and Slade, 2007, Acemoglu *et al.*, 2009).

[5]A recent literature examines how uncertainty about specific environmental policies affects firms' adoption of practices or investment in less-polluting technologies (Shapira and Zingales, 2017, Chen, 2024, Gowrisankaran *et al.*, 2025). We instead study broader fiscal uncertainty and its effects on the adoption of technologies unrelated to the underlying policy.

otherwise (Aghion *et al.*, 2015, Juhász *et al.*, 2023, Bergeaud *et al.*, 2025, Lane, 2025).[6] Much of this literature studies how policies shape knowledge diffusion across firms, sectors, or regions (Jaffe, 1986, Azoulay *et al.*, 2019, Arque-Castells and Spulber, 2022). Our results point to a complementary *within-firm* channel and empirically document how the evolution of internal capabilities affects firms' technological choices in different domains (Teece *et al.*, 1997, Acemoglu *et al.*, 2006, 2007, Fabra and Llobet, 2023, Fioretti *et al.*, 2024). More broadly, our findings suggest that credible sovereign commitment is in itself a powerful form of industrial policy, fostering investment, technology adoption, and the accumulation of transferable know-how.

A related literature examines the gap between social and private returns to innovation that emphasizes firms' ability to learn from the innovation of others, often described as absorptive capacity (Cohen and Levinthal, 1989, Zahra and George, 2002, Fabrizio, 2009, Bloom *et al.*, 2013). Griffith *et al.* (2003, 2004) develop and estimate a model in which this learning drives productivity convergence within industries, and subsequent work links productivity to firms' past R&D choices and organizational practices (Doraszelski and Jaumandreu, 2013, Chaudhry *et al.*, 2017, Bloom *et al.*, 2019, Feigenbaum and Gross, 2021). Our within-firm evidence complements these approaches by showing how technology adoption generates path dependence in subsequent technology adoption through transferable know-how. This highlights how market-based measures of the private value of innovation can be conservative, in that they can miss part of the future returns of transferable know-how (e.g., Pakes, 1986, Kogan *et al.*, 2017, Bergeaud *et al.*, 2022).

The remainder of the paper is organized as follows. Section 2 provides background on the North Sea O&G sector, EOR, and the 1985 Norwegian Supreme Court decision. Section 3 sets out the theoretical framework and empirical strategy, and Section 4 describes the data. Section 5 reports estimates on the effect of sovereign hold-up risk on EOR adoption, productivity, and various robustness checks. Section 6 analyzes how EOR adoption shaped market shares and asset portfolios, while Section 7 investigates the roles of know-how and state ownership. Section 8 examines transferable know-how as a driver of technological diversification and the divergent country-level trajectories of Norway and the UK. Section 9 concludes.

2 The Upstream O&G Sector in the North Sea

Natural gas was first discovered in Groningen in 1959, spurring offshore exploration in the UK and Norway as geological analogs emerged (Yergin, 2011). Major discoveries,

[6] There is also a growing literature on petroleum taxation and its effects on exploration, investment, and misallocation; see, for example, Ahlvik and Harding (2025) on tax refunds and exploration, Stefanski *et al.* (2025) on revenue taxes and misallocation, and Smith (2012) and Osmundsen *et al.* (2015) on how petroleum tax systems distort investments.

including Ekofisk (Norway) and Forties (UK) in 1969, catalyzed rapid development of platforms and pipelines (Shepherd, 2015). Regional production grew until the early 2000s but has since matured, falling from about 8% of global production, at its peak, to 4% in 2020 (Craig *et al.*, 2018, BP, 2021). Our analysis focuses on the two dominant players of the North Sea O&G sector, Norway and the UK, which together account for 96% of the North Sea oil production (Denmark and the Netherlands account for the remaining 4%) (Jernberg *et al.*, 2024). In the following, we outline the core institutions and legal events that shaped the early evolution of the sector in Norway and the UK.

Licenses. Both governments retain sub-sea ownership and allocate exploration and production rights via competitive bidding rounds. Norway issues exploration, production, and facilities licenses through annual (mature areas) or biennial (frontiers) rounds; the UK operates similar rounds under the Petroleum Act (Gordon, 2011, Mace *et al.*, 2017). In both jurisdictions, regulators can block bids if the bids do not meet undisclosed technical, financial, or strategic criteria, and ministries often negotiate operational plans prior to award (Kemp, 2013, Kardel, 2019).

Ownership and state participation. The North Sea regulatory framework utilizes a joint-venture structure where license equity is distributed among a consortium of firms, with a designated "operator" managing daily production and technological strategy. While revenues, capital and operating expenditures are shared pro-rata, the choice of operator is a critical determinant of field-level efficiency. In the 1970s, both nations established national oil companies to internalize technical expertise and maximize rent capture. However, their subsequent trajectories define a sharp institutional divergence.

Norway adopted a model of persistent state-led participation; Statoil (established 1972) was granted statutory preferences in licensing and maintained 50–80% equity stakes in core fields throughout the 1970s and 1980s. Although partially privatized in 2001, the Norwegian state retains a majority share, ensuring a permanent state presence in the sector's operational core. Conversely, the United Kingdom pursued a rapid denationalization strategy. The British National Oil Corporation (BNOC), established in 1975, initially served as a major operator and partner with participation rights in all licenses. Under the Thatcher administration, BNOC's upstream assets were transferred to a new entity, Britoil, in 1982. Crucially, Britoil continued to act as a primary operator in the North Sea until it was acquired by British Petroleum (BP) in 1988 following a hostile takeover. Parallel to this, the UK government liquidated its remaining 31.5% stake in BP in October 1987, as the state exited from direct involvement in oil and gas production.

Fiscal Architectures. Following the 1973 oil shock, the UK and Norway developed nearly parallel fiscal regimes designed to extract Ricardian rents from the North Sea. Both jurisdictions initially employed a "hybrid" model: production-based royalties (12.5% in the UK; 8–16% in Norway) ensuring immediate state revenue, and profit-based corporate taxes. In 1975, both nations introduced sector-specific rent taxes—the Petroleum Revenue Tax (PRT) in the UK and the Special Petroleum Tax (SPT) in Norway—to capture windfall gains. These regimes targeted a high marginal "government take," often reaching aggregate rates of 75–80%, yet were designed to be investment-neutral through two key structural mechanisms: ring-fencing and uplift (UK Parliament, 1975, Norway Parliament, 1975).

The "ring-fence" served as a critical institutional boundary, isolating petroleum income from mainland activities to prevent firms from eroding the resource tax base with unrelated industrial losses. To maintain investment incentives under these high marginal rates, both countries utilized an "uplift" allowance to shield the normal return on capital in the absence of interest deductibility. Following initial recalibrations at the turn of the decade (1979 in the UK; 1980 in Norway), these parameters remained remarkably static throughout the 1980s. While the nominal magnitudes appear disparate—the UK provided an immediate 35% uplift whereas Norway offered a 100% allowance distributed over 15 years—the effective relief was economically aligned in terms of net present values given the prevailing industry interest rates of 7-10% (HM Revenue & Customs, 2016, Øye Gjerde, 2020).

This period of institutional symmetry was further reinforced by synchronous policy adjustments during the 1980s price volatility. Both countries responded to softening oil prices by phasing out royalties for new developing fields (UK in 1983; Norway in 1986) to eliminate the marginal distortions inherent in gross-revenue taxation (UK Parliament, 1983). The regimes only structurally diverged in the early 1990s through differing approaches to license "vintaging." While Norway maintained a uniform, high-tax environment across all producing fields, the UK's Finance Act 1993 aggressively liberalized the regime by abolishing both the PRT and the uplift for all new developments while maintaining the legacy system for pre-1993 assets (UK Parliament, 1993). This shared trajectory from 1975 to 1993—characterized by identical instruments, stable investment allowances, and common responses to exogenous shocks—establishes the UK as a robust control for Norwegian fields (Natural Resource Governance Institute, 2014, Norway Parliament, 1985).

2.1 1985 Norwegian Supreme Court Decision

A critical institutional divergence between the UK and Norway emerged in the 1980s when the Norwegian Supreme Court curtailed the government's ability to retroactively alter fiscal terms. The dispute originated in December 1972, when the Norwegian government amended the Continental Shelf Act of 1963 to require quarterly rather than biannual royalty payments and introduced a graduated royalty rate (8–16%). Crucially, the state did not exempt pre-1972 licenses from these changes (Dalgaard-Knudsen, 1987). Phillips and its partners in the Ekofisk concession protested by continuing to pay every six months until 1977, when the state formally demanded compliance with the new regulation (Frihagen, 1985).

The Phillips group eventually complied but filed suit in 1982 to recover interest losses dating back to 1977. The legal battle progressed from the Oslo City Court (ruling in 1982) to the Eidsivating Court of Appeal (appealed in 1984 and ruling on April 7, 1984), both of which ruled in favor of Phillips (Øye Gjerde, 2020, Frihagen, 1985). On December 19, 1985, the Supreme Court upheld these judgments, declaring any unilateral retroactive change to licensing terms unconstitutional if it violated protections against the arbitrary deprivation of property. The Court awarded Phillips NOK 250 m (approximately USD 32 m) plus interest and established that, absent an urgent public-interest mandate, existing licenses could no longer be amended without compensation (Mestad, 1987, Ulfbeck *et al.*, 2016).[7] Legal actions from other firms followed, securing similar settlements.

This ruling resolved a long-standing ambiguity in Norwegian legal doctrine. While Article 97 of the Constitution stated that "No law may be given retroactive effect," its application in civil matters had historically been subject to a "reasonableness" test. The landmark *Kløfta* case (1976) had established a tripartite "sliding scale" of judicial review, placing economic rights—such as protection against retroactive tax and civil laws—in an intermediate category (**?**). Under this scheme, the Court balanced the degree of retroactivity against the urgency of the public interest. This framework meant that prior to 1985, firms faced a genuine sovereign hold-up risk, as fiscal terms remained subject to legislative interference that the Court might have deemed reasonable under the prevailing social democratic consensus.[8]

In contrast, the UK's doctrine of *parliamentary sovereignty* permitted retroactive amendments through ordinary legislation without a requirement for compensation (Mestad, 1987).[9] This power was frequently used to alter the economic logic of existing investments. Most notably, the *Oil Taxation Act 1975* introduced the *Petroleum Revenue Tax* (PRT) and modified transfer pricing rules retroactively for fields already under development. Simultaneously, the *Petroleum and Submarine Pipelines Act 1975* funda-

[7] 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 [...], at least not unless it was based on a very urgent need for regulation" (Hunter *et al.*, 2020, p. 183).

[8] As analyzed by Hunter *et al.* (2020), while licenses in both nations are administrative in nature, the 1985 ruling entrenched a Norwegian legal culture that treats them as having a "protected contractual character" under the Constitution. This differs from the UK's administrative tradition, where regulatory and fiscal discretion remains paramount.

[9] The British legal system has allowed for retroactive rulings since 1793 (Parliament of Great Britain, 1793, Gobbi, 2010). However, retroactive criminal rulings are prohibited under the European Convention on Human Rights.

mentally altered the "Model Clauses" of existing licenses, granting the state retroactive control over production levels (depletion strategy) and mandating state participation via the newly formed BNOC. Subsequent interventions, including the *Oil and Gas Enterprise Act 1982* and the *Petroleum Act 1987*, continued this pattern of unilaterally restructuring regulatory and decommissioning obligations. While the 1985 ruling effectively eliminated such retroactive interventions in Norway, the UK maintained its capacity to revise terms for existing assets, leaving the sovereign hold-up risk unmitigated.

2.2 Enhanced Oil Recovery (EOR)

Through a reduction in *policy uncertainty*, the Supreme Court decision boosted incentives to adopt technologies that required large capital investments in Norwegian O&G fields. At that time, in the North Sea, one of these technologies was Enhanced Oil Recovery (EOR) (e.g., Awan *et al.*, 2008, Gbadamosi *et al.*, 2018).

As reservoir pressure declines, water or gas injection yields only 20-40% recovery of a reservoir's resources. However, operators can resort to EOR, which increases recovery up to 50-70% by injecting substances that alter fluid properties (Toole and Grist, 2003, Alvarado and Manrique, 2010). EOR requires on-platform storage, injection wells, and separators, increasing capital and operating costs to extend field life.

Only reservoirs that meet specific geological (e.g., adequate size, depth, porosity, permeability, and sulfur content) and technological (e.g., suitable platform design and drive mechanisms) criteria can adopt EOR (see Appendix Table B1 for the detailed criteria), regardless of operator willingness or its managerial skills (Al Adasani and Bai, 2011, Nwidee *et al.*, 2016). If a field is *EOR-eligible*, reservoir engineers model pressure decline and collaborate with petroleum economists to compare incremental recovery against the increases in CAPEX and OPEX. By the 1980s, EOR was a mature technology and field operators did not need to develop it in-house; adoption could be initiated by contracting an established service provider (e.g., Baker Hughes, Halliburton, Schlumberger, and Weatherford).[10] Importantly, however, the decision to adopt EOR and then its daily use and maintenance were the responsibility of field operators.[11]

Since EOR requires large capital and operational investments, the 1985 Supreme Court decision is expected to have boosted EOR adoption in Norway relative to the UK, where the threat of retroactive changes to licenses may have discouraged firms to invest.

[10] By 1985, this technology was mature and widely available. The earliest recorded EOR attempt was by J.W. Goff in 1901 (Rintoul, 1976), who injected steam and air into Kern River wells, California.

[11] Field operators secured development approvals and directed execution, while service providers, acting at the operators' request, provided design, chemical supply, installation, commissioning, and surveillance. Executive power and accountability remained in the hands of field operators according to the laws of all countries participating to the North Sea O&G industry.

3 Empirical Approach

This section presents a regression framework to estimate the effect of sovereign hold-up risk on firm outcomes through observed technology adoption, exploiting the exogenous variation induced by the 1985 Supreme Court decision. Section 3.1 introduces a dynamic model of firm know-how and technology adoption, resulting in a threshold rule for technology adoption. Section 3.2 then demonstrates how this threshold rule, when combined with an exogenous shock to the adoption threshold such as the 1985 Supreme Court decision, enables estimation of the effect of sovereign hold-up risk.

3.1 Conceptual Framework

We consider technology adoption decisions in O&G fields. All fields are homogeneous and jointly owned by multiple firms. In each field, one firm acts as the operator, responsible for decisions such as technology adoption, while the other firms are passive co-owners without decision-making authority. The operator holds share $0 < s \leq 1$, and passive co-owners collectively hold the remaining share $1 - s$. Profits from field operations accrue proportionally to these ownership shares. To simplify exposition, both the ownership shares and the identity of the operator are treated as exogenous.

We analyze the decision-making of a risk-neutral operator who, in each period, decides whether to adopt a new technology in a different field. Every period, each field generates revenue R and incurs production cost K, with $R - K > 0$. Each adoption attempt entails a sunk cost $c > 0$, which is borne solely by the operator (e.g., management time, site preparation, etc.). Any successful adoption increases profits by $\Delta\Pi$, with $R - K + \Delta\Pi < M$ for some finite M. Let A_t be the operator's *transferable know-how*—the accumulated expertise in adopting and managing new technologies. Suppose that $A \in [0, \bar{A}]$ for some finite $\bar{A}$. Successful adoption bears an element of randomness. Adoption given know-how A succeeds with probability $q(A)$, assumed to be continuously differentiable, strictly increasing, and concave.[12] Know-how evolves according to:

$$A_{t+1} = \delta A_t + \gamma \mathbb{1}\{\text{adoption in } t \text{ succeeds}\}, \tag{1}$$

so that it depreciates by $\delta \in (0, 1)$ every period and each successful adoption increases it by $\gamma > 0$. The parameter γ represents knowledge carryover from current to future technology adoption. A small γ means that the knowledge acquired by adopting a technology in t will not be particularly relevant for the adoption of future technologies (e.g.,

[12] Although excessive know-how may backfire—e.g., through "competence traps" (March, 1991), coordination and maintenance burdens (Zahra and George, 2002), and cognitive overload (Lane and Lubatkin, 1998)—we abstract from these concerns, which likely matter for global O&G operations but may be less critical in a regional context.

very different or rapidly evolving technologies). This captures the idea, also in Jovanovic and Nyarko (1996), that every adoption of a new technology, as technology continues to evolve, requires slightly different know-how and that past know-how eventually becomes obsolete if not updated. We assume that $\gamma \leq \bar{A} \cdot (1 - \delta)$, which ensures that knowledge remains bounded within $[0, \bar{A}]$ after adoption.

The optimal adoption decision in each period is derived from the Bellman equation:

$$\begin{aligned} V(A) = \max\Big\{ & s\,(R-K) + \beta\, V(\delta A), \\ & s\big(R - K + q(A)\,\Delta\Pi\big) - c + \beta\big[q(A)\,V(\delta A + \gamma) + (1 - q(A))\,V(\delta A)\big]\Big\}, \end{aligned} \tag{2}$$

where $\beta \in (0,1)$ is the operator's discount factor and V is assumed to be continuously differentiable, strictly increasing, and concave. Given (2), in each period the operator is indifferent between non-adoption and adoption whenever:

$$A \;=\; B(A) \;\equiv\; q^{-1}\left(\frac{c}{s \cdot \Delta\Pi \;+\; \beta\big[V(\delta A + \gamma) - V(\delta A)\big]}\right), \tag{3}$$

where q^{-1} is the inverse of q. Appendix A.1 shows that, under mild regularity conditions, equation (3) has a unique fixed point A^* and that the adoption rule $A \geq B(A)$ is equivalent to the threshold crossing rule $A \geq A^*$.

Comparative statics. The threshold crossing condition and (3) suggest simple comparative statics: lower c or δ, or—symmetrically—higher s, $\Delta\Pi$, β, or γ all imply a lower threshold A^* and a higher chance of adoption.[13] This also means that, for example, operators with higher know-how A should be more likely to diversify into technologies that are more "distant" from their current technology, as distant technologies are likely associated with lower knowledge carryover γ and thus higher adoption thresholds A^*.

Based on these simple observations, we next derive difference-in-differences (DiD) regressions that can be estimated when neither A nor threshold A^* is observable. Later, we also rely on these comparative statics to interpret some of our empirical findings, especially when investigating technological diversification in Section 8.

3.2 Derivation of the Regression Model

The model's comparative statics, combined with the 1985 Norwegian Supreme Court decision, can be used to obtain DiD regressions. In what follows, we illustrate this idea, relaying the details to Appendices A.2 and A.3.

[13]This holds since q^{-1} is strictly increasing, so $B(A)$ is strictly decreasing in s, $\Delta\Pi$, and β, and strictly increasing in c. As V is strictly increasing, $B(A)$ is strictly decreasing in γ. Moreover, by concavity of V, the term $V(\delta A + \gamma) - V(\delta A)$ is strictly decreasing in δ, so $B(A)$ is also strictly increasing in δ.

We consider firm i's total production as outcome variable; however, the same logic applies to any other outcome affected by changes in A^*. For notational simplicity, we assume that each firm i owns N fields in total, with potentially different compositions: $N_{i,\text{Norway EOR}}$ EOR-eligible fields in Norway, $N_{i,\text{UK EOR}}$ EOR-eligible fields in the UK, and $N_{i,\text{Other}} \equiv N - N_{i,\text{Norway EOR}} - N_{i,\text{UK EOR}}$ other fields.[14] We denote i's portfolio of fields by $\mathbf{N}_i = (N_{i,\text{Other}}, N_{i,\text{Norway EOR}}, N_{i,\text{UK EOR}})$.

Let $y_{a,\text{z},t}$ denote production at time $t \in \{\text{pre}, \text{post}\}$ for a field of type $\text{z} \in \{\text{EOR}, \text{Other}\}$ with EOR adoption decision $a \in \{0, 1\}$. Then, $y_{0,\text{EOR},t}$ ($y_{0,\text{Other},t}$) represents the baseline production without EOR adoption for EOR-eligible (non-EOR-eligible) fields in period t. With EOR adoption, an eligible field produces $y_{1,\text{EOR},t} = y_{0,\text{EOR},t} + \Delta y$, where Δy denotes the production gain from adoption. Firm i's total production at t is:

$$\begin{aligned} y_{it} = {} & N_{i,\text{Norway EOR}} \cdot [y_{0,\text{EOR},t} + \Delta y \cdot \mathbb{1}\{A_{it} \geq A^*_{t,\text{Norway}}\}] \\ & + N_{i,\text{UK EOR}} \cdot [y_{0,\text{EOR},t} + \Delta y \cdot \mathbb{1}\{A_{it} \geq A^*_{t,\text{UK}}\}] + N_{i,\text{Other}} \cdot y_{0,\text{Other},t}, \end{aligned} \tag{4}$$

where $\mathbb{1}\{\cdot\}$ is the indicator function for the threshold condition in (3).

Identifying assumption. We make the following identifying assumption:

Assumption 1 *Know-how A_{it} is independent of firm i's portfolio of fields $\mathbf{N}_i$, so that, for any given threshold A^*, $\Pr_t(A_{it} \geq A^* \mid \mathbf{N}_i) = \Pr_t(A_{it} \geq A^*) = 1 - F_t(A^*)$.*

This assumption rules out (dis-)economies of scale in EOR adoption within each period t: i's EOR adoption decisions are made independently for each EOR-eligible field in the portfolio and A_{it} does not evolve within t according to i's adoption decisions in t. F_{pre} denotes the distribution of know-how $A_{i,\text{pre}}$ across operators in $t = \text{pre}$ and F_{post} the distribution of $A_{i,\text{post}}$ in $t = \text{post}$. These distributions may differ as firms' capacities evolve over time according to adoption decisions.

DiD regression. To cast the problem in a DiD framework, rewrite firm i's production in t as:

$$\begin{aligned} y_{it} &= \mathbb{E}[y_{it}] + (y_{it} - \mathbb{E}[y_{it}]) \\ &= \mathbb{E}[y_{i,\text{pre}}] + \mathbb{E}[y_{i,\text{post}} - y_{i,\text{pre}}] \cdot \text{Post}_t + \epsilon_{it}, \end{aligned} \tag{5}$$

where the second line decomposes i's expected production at time t ($\mathbb{E}[y_{it}]$) into pre- and post-period averages using indicator Post_t for $t = \text{post}$ and it captures deviations around these averages ($y_{it} - \mathbb{E}[y_{it}]$) in the error term ϵ_{it}.

[14] A DiD regression equation similar to (8) below can be obtained also when the number of fields N_i varies across firms, but it requires a more involved notation without adding any insight.

Using the distributions $F_t(\cdot)$ and equation (4), the expected difference between post- and pre-period outcomes in the second line of (5) can be written as:

$$\begin{aligned}
\mathbb{E}[y_{i,\text{post}} - y_{i,\text{pre}}] = N_{i,\text{Other}} &\cdot [y_{0,\text{Other},\text{post}} - y_{0,\text{Other},\text{pre}}] \\
&+ (N_{i,\text{Norway EOR}} + N_{i,\text{UK EOR}}) \cdot [y_{0,\text{EOR},\text{post}} - y_{0,\text{EOR},\text{pre}}] \\
&+ N_{i,\text{Norway EOR}} \cdot \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,Norway}})] \\
&+ N_{i,\text{UK EOR}} \cdot \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{pre}})].
\end{aligned} \tag{6}$$

Define $\Delta_{\text{Other}} = y_{0,\text{Other},\text{post}} - y_{0,\text{Other},\text{pre}}$ and $\Delta_{\text{EOR}} = y_{0,\text{EOR},\text{post}} - y_{0,\text{EOR},\text{pre}}$ as the baseline production changes for each field type, and let firm i's shares of Norwegian and North Sea EOR-eligible fields be:[15]

$$\text{Share EOR Norway}_i = \frac{N_{i,\text{Norway EOR}}}{N}, \quad \text{Share EOR}_i = \frac{N_{i,\text{Norway EOR}} + N_{i,\text{UK EOR}}}{N}.$$

With this notation, Appendix A.2 shows that equation (6) simplifies to:

$$\begin{aligned}
\mathbb{E}[y_{i,\text{post}} - y_{i,\text{pre}}] = N \cdot \Delta_{\text{Other}}& \\
&+ \left\{\Delta_{\text{EOR}} - \Delta_{\text{Other}} + \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{pre}})]\right\} \cdot N \cdot \text{Share EOR}_i \\
&+ \Delta y \cdot [F_{\text{post}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,Norway}})] \cdot N \cdot \text{Share EOR Norway}_i.
\end{aligned} \tag{7}$$

The first line of (7) represents the baseline trend in production for non-EOR-eligible fields. The second line captures both the differential trend in baseline production between EOR-eligible and non-EOR-eligible fields ($\Delta_{\text{EOR}} - \Delta_{\text{Other}}$) and any difference in production due to changes in EOR adoption that are independent of the Norwegian policy change (changes in the probability of EOR adoption from $1 - F_{\text{pre}}$ to $1 - F_{\text{post}}$). Finally, the third line represents the increase in production due to the *extra* EOR adoption induced by the Norwegian policy change (the lower adoption threshold $A^*_{\text{post,Norway}}$).

Combining equation (7) with the expectation of equation (4) in equation (5) yields the following DiD regression with firm and time fixed effects:

$$y_{it} = \gamma_{\text{treat}} \cdot \text{Share EOR Norway}_i \cdot \text{Post}_t + \gamma_1 \cdot \text{Share EOR}_i \cdot \text{Post}_t + \alpha_i + \psi_t + \epsilon_{it}, \tag{8}$$

where the coefficients correspond to:

$$\begin{aligned}
\gamma_{\text{treat}} &\equiv N \cdot \Delta y \cdot [F_{\text{post}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,Norway}})], \\
\gamma_1 &\equiv N \cdot \left\{\Delta_{\text{EOR}} - \Delta_{\text{Other}} + \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{pre}})]\right\},
\end{aligned}$$

[15] It follows that firm i's UK share of EOR-eligible fields is Share EOR$_i$ – Share EOR Norway$_i$.

$$\begin{aligned}\alpha_i &\equiv N \cdot \big\{y_{0,\text{Other,pre}} \cdot (1 - \text{Share EOR}_i) + y_{0,\text{EOR,pre}} \cdot \text{Share EOR}_i \\ &\quad + \Delta y \cdot [1 - F_{\text{pre}}(A^*_{\text{pre}})] \cdot \text{Share EOR}_i\big\}, \\ \psi_t &\equiv N \cdot \Delta_{\text{Other}} \cdot \text{Post}_t.\end{aligned}$$

The coefficient of interest γ_{treat} captures the effect of a change in the adoption threshold due to the Norwegian policy change (as in the third line of (7)), while γ_1 captures changes affecting all EOR-eligible fields that are not related to the Norwegian policy change (as in the second line of (7)). The coefficients α_i and ψ_t instead represent a time-invariant firm-specific effect and a common time effect, respectively.

Crucially, under Assumption 1, the residual term $\epsilon_{it} \equiv y_{it} - \mathbb{E}[y_{it}]$ in (8) satisfies the desired orthogonality condition $\mathbb{E}[\epsilon_{it} \mid \text{Share EOR}_i, \text{Share EOR Norway}_i] = 0$ (see details in Appendix A.2).[16] This ensures that γ_{treat} can be consistently estimated, even though ϵ_{it} may depend on firm i's portfolio shares. To avoid endogeneity from changes in firms' field portfolios over t that could violate this condition, we evaluate the portfolio shares in equation (8) using their pre-1985 values.

In Appendix A.3, we derive analogous regressions at the field level, which take the form of a triple-differences specification across country (Norway vs. UK), field EOR status (eligible vs. not), and time (pre vs. post).

Discussion. In practice, identification relies on comparing firms with nearly identical shares of EOR-eligible fields before 1985, where "treated" firms had an additional EOR-eligible field in Norway while "control" firms had an additional EOR-eligible field in the UK. By controlling for firm and time fixed effects, other policy changes are expected to affect both groups similarly, effectively "canceling out" in DiD regression (8).[17] The observed difference in post-1985 outcomes then identifies γ_{treat}.

4 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.

4.1 Field-level Data

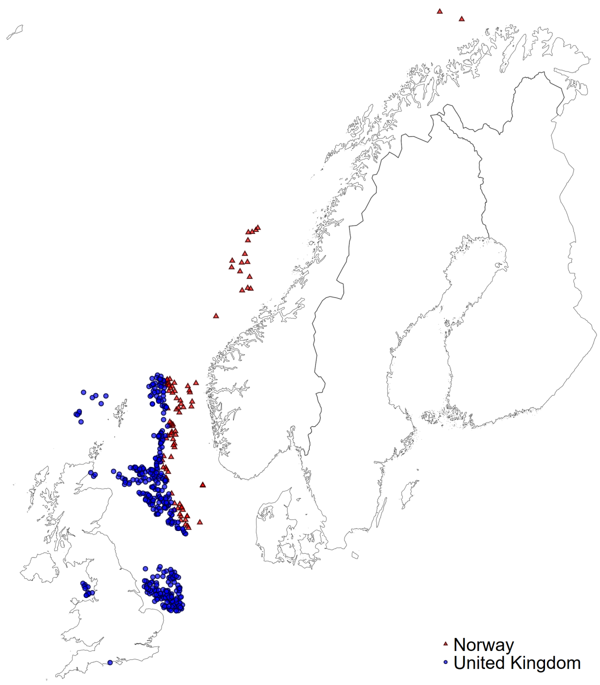
We use data for the North Sea under the jurisdiction of the UK and Norway between 1975 and 1995, as shown in Figure 2. Blue dots represent UK fields, while red triangles

[16] In the more realistic case in which the number of fields N_i is specific to each firm i, the orthogonality condition $\mathbb{E}[\epsilon_{it} \mid \text{Share EOR}_i, \text{Share EOR Norway}_i] = 0$ additionally requires that N_i and portfolio composition are independent: that is, $\mathbb{E}[N_i \mid \text{Share EOR}_i, \text{Share EOR Norway}_i] = \mathbb{E}[N_i]$.

[17] Field-level regressions also controlling for country-by-year fixed effects confirm this (Section 5).

indicate Norwegian fields. Most fields are located on the continental shelf between the two countries, though the UK jurisdiction extends further south. The UK hosts a larger number of O&G fields, reflecting an earlier industrial development relative to Norway.

Figure 2: British and Norwegian O&G fields in the North Sea



Notes: The figure displays O&G fields in the southern basin of the North Sea. Blue dots denote fields under the jurisdiction of the UK and red triangles of Norway.

Columns 3 and 6 of Table 1 show that British and Norwegian O&G fields are broadly comparable across geology (Panel a), oil types (Panel b), technology (Panel c), and operational practices (Panel d). In Panel (a), while Norwegian reservoirs are somewhat larger with more oil in place, most fields in both countries are similar in size, are located in shallow waters, and have similar geological characteristics. Panel (b) indicates a similar oil-gas mix, with nearly identical API gravity (40.64° in the UK vs. 40.30° in Norway), suggesting that heavy oil fields are rare in both regions.

Technology adoption is also comparable across countries. We classify fields as EOR-eligible following established engineering criteria detailed in Appendix Table B1. Panel (c) of Table 1 shows that the share of EOR-eligible fields is similar in both countries—35% in the UK and 40% in Norway.[18] Adoption rates, however, differ markedly: drawing on Awan *et al.* (2008) and Gbadamosi *et al.* (2018), who list EOR adoptions, we find that Norwegian fields adopted EOR at roughly twice the rate of UK fields by 1995.

[18] Our main definition of EOR eligibility excludes porosity and permeability. Although there are some differences in porosity and permeability between British and Norwegian fields (Panel a), these are largely within the limits of EOR eligibility, see Appendix Table B1. For completeness, we also repeat our analyses using a "robust" definition of eligibility that considers porosity and permeability, which yields similar shares of 34% and 35%, respectively. All results in the paper are similar under both measures.

Table 1: Descriptive statistics at the field level

	UK			Norway		
	Pre-1985 (1)	Post-1985 (2)	Total (3)	Pre-1985 (4)	Post-1985 (5)	Total (6)
Panel (a): 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)	1,005.56	750.62	828.34	965.30	1,602.79	1,415.70
% 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 (b): 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 (c): 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 platforms	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 platforms	0.01	0.01	0.01	0.00	0.05	0.04
Panel (d): 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
Panel (e): 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

Notes: Summary statistics are reported for fields in the UK (Columns 1-3) and Norway (Columns 4-6). Columns 1 and 4 present averages for active fields in the exploration or production phase before 1985, Columns 2 and 5 present averages after 1985, and Columns 3 and 6 report averages for all active fields in our 1975-1995 sample. The criteria for a field's EOR eligibility are detailed in Appendix Table B1.

Before 1985, EOR adoption was more common in the UK, whose larger and more technologically advanced O&G industry hosted nearly four times as many firms and twice as many operators as Norway (Panel e). This expertise translated into higher adoption rates and a greater share of active EOR-eligible fields (52% vs. 28%). After the 1985 Norwegian Supreme Court ruling limiting unilateral fiscal changes, the pattern reversed: in Norway, the share of active EOR-eligible fields rose to 45% and adoption to 16%, while in the UK they fell to 30% and 5% (Columns 2 and 5, Panel c). These shifts also appear in production, with Norway sustaining output through extended field lifespans, while UK production declined sharply, alongside similar trends in CAPEX and OPEX.

4.2 Firm-level Data

Table 2 compares firms by whether they held shares in Norwegian EOR-eligible fields before the 1985 Supreme Court decision. Panel (a) shows that, on average, 14.8 firms per year owned at least one such field, with state-owned companies like Statoil and BP operating about 25% of their fields. Firms without Norwegian EOR-eligible holdings expanded from 57 to 73 over the sample, but operated a smaller share (8%). Global majors such as Amoco and Shell were active in both the UK and Norway. Panel (b) indicates that firms with pre-1985 EOR-eligible fields held larger portfolios, reflecting Statoil's scale and early EOR efforts like Phillips' at Ekofisk.

Table 2: Descriptive statistics at the firm level

	Firms that owned EOR-eligible fields in Norway before 1985					
	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: Summary statistics are reported for firms with (Columns 1-3) and without (Columns 4-6) EOR-eligible fields in Norway before 1985. Columns 1 and 4 present yearly averages for the pre-1985 period, Columns 2 and 5 for the post-1985 period, and Columns 3 and 6 for the entire 1975-1995 sample. The criteria for a field's EOR eligibility are detailed in Appendix Table B1.

Panel (c) highlights differences in EOR adoption. Firms without Norwegian EOR-eligible fields before 1985 held a larger share of such fields overall, indicating that ownership patterns did not simply reflect self-selection. Yet far fewer eligible fields actually adopted EOR: post-1985, adoption rose by 66.7% among firms without Norwegian holdings and by 80% among those with them. The latter reflects both higher adoption within existing fields (intensive margin) and investment in new EOR-eligible fields (extensive margin). Their share of eligible fields grew from 0.46 to 0.50, while it fell from 0.65 to 0.44 for other firms. As a result, firms with Norwegian EOR-eligible fields before 1985 expanded, raising their share of North Sea production from 4% to 5%, while others declined (Panel a), potentially connected to drops in global oil prices (Vreugdenhil, 2023).

5 EOR Adoption and Production

We estimate equation (8) to assess the impact of sovereign hold-up risk on firms' EOR adoption and production. We define "Share EOR Norway$_i$" as the average share of Norwegian EOR-eligible fields in firm i's North Sea portfolio prior to 1985. Similarly, "Share EOR$_i$" is the average share of EOR-eligible fields across both Norway and the UK in the same period. To address potential endogeneity, we use field counts rather than ownership-weighted shares, although results are consistent with both definitions.

Table 3: Firm-level EOR adoption and production

	Adoption	Production	
Dependent variable	Share EOR	$\ln(1 + \text{prod}_{it})$	$\text{prod}_{it}/\text{OPEX}_{it}$
	(1)	(2)	(3)
Share EOR Norway × Post	0.347***	3.193***	0.257*
	(0.116)	(0.831)	(0.140)
Share EOR × Post	0.021	-0.402	-0.024
	(0.013)	(0.266)	(0.090)
Average dependent variable	0.053	2.562	0.328
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	1406	1406	1245
R-squared	0.70	0.86	0.43

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

Notes: Estimated coefficients from regression (8). 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 was active in the North Sea in year t. The other dependent variables are production in log (Column 2) and the ratio of production (in Kboe) to OPEX (Column 3). The variable "Share EOR Norway" ("Share EOR") refers to the fraction of Norwegian (North Sea) EOR-eligible fields among all the fields in which firm i was active in the North Sea 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 3 reports the coefficient estimates. Column 1 confirms the intuition from Figure 1: firms with a pre-1985 portfolio of fields that included 10 percentage points (p.p.) more Norwegian EOR-eligible fields had a 3.5 p.p. larger share of fields in their portfolios that adopted EOR after 1985.[19] In contrast, firms with a pre-1985 portfolio that included British but not Norwegian EOR-eligible fields (with Share EOR$_i > 0$ and Share EOR Norway$_i = 0$) were not more likely to adopt EOR after 1985. Considering that the average share of fields within a firm's portfolio that adopted EOR was around 4% in the period 1975-1995, these estimates confirm that the Supreme Court decision played a major role in fostering the diffusion of this technology in Norway.

Column 2 shows that firms with a pre-1985 portfolio of fields that included 10 p.p.

[19] As reported in Table 2, firms with "Share EOR 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 p.p. 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.

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. Moreover, for these firms, the increase in production was greater than the increase in operative costs (OPEX), implying a reduction in average variable costs (Column 3). Differently, firms with a pre-1985 portfolio that included British but not Norwegian EOR-eligible fields (with Share EOR$_i > 0$ and Share EOR Norway$_i = 0$) moved—if at all—in the opposite direction after 1985, slightly decreasing production and increasing average variable costs.

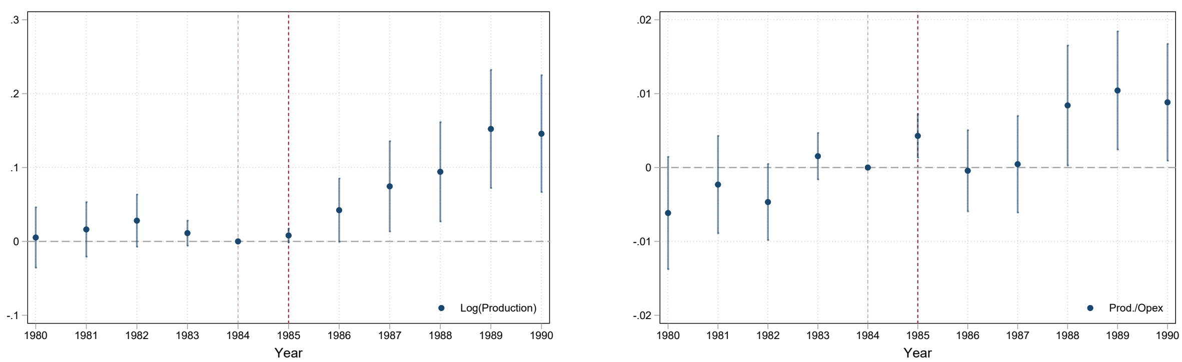
As discussed in Section 3, the condition $\mathbb{E}[\epsilon_{it} \mid \text{Share EOR}_i, \text{ Share EOR Norway}_i] = 0$ ensures that the error term is uncorrelated with the explanatory variables, which is crucial for the consistent estimation of DiD regression (8). This can be interpreted as a parallel trends assumption, where in the absence of the Supreme Court decision, the changes in outcomes for firms with different pre-1985 shares of EOR-eligible fields would have followed the same trends over time. The following event study examines this assumption:

$$\begin{aligned} y_{it} = & \sum_{d=-4}^{5} \gamma_{\text{treat},d} \cdot \text{Share EOR Norway}_i \cdot \mathbb{1}\{t - 1985 = d\} \\ & + \sum_{d=-4}^{5} \gamma_{1,d} \cdot \text{Share EOR}_i \cdot \mathbb{1}\{t - 1985 = d\} + \alpha_i + \psi_t + \epsilon_{it}, \end{aligned} \tag{9}$$

+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 (8), α_i and ψ_t are firm and year fixed effects. We report the estimates of $\gamma_{\text{treat},d}$ in Figure 3, which shows parallel trends in the pre-1985 period for both production and production over OPEX.

Figure 3: Firm-level event study for production and productivity

(a) Production, $\ln(1 + \text{prod}_{it})$ (b) Inverse Avg. Var. Cost, $\text{prod}_{it}/\text{OPEX}_{it}$



Notes: Estimated coefficients from regression (9). Panel (a) shows the estimates of $\widehat{\gamma}_{\text{treat},d}$ using production (in log) as dependent variable, while Panel (b) using production over OPEX (Panel (b)). The variable "Share EOR Norway" ("Share EOR") refers to the fraction of Norwegian (North Sea) EOR-eligible fields among all the fields in which firm i was active in the North Sea before 1985. Each regression includes firm and year fixed effects. Vertical bars around each estimate represent 95% confidence intervals. Standard errors are clustered at the firm level. Vertical dotted lines mark the years of the rulings of the Eidsivating Court of Appeal (1984) and the Norwegian Supreme Court (1985).

5.1 Robustness Checks

In Appendix D, we discuss a series of robustness checks, which we summarize here.

Field-level and national policy controls. To ensure our results are not driven by national-level shocks or divergent energy policies, we estimate a field-level triple-difference specification derived in Appendix A.3. This approach incorporates field fixed effects (τ_f) and country-by-year fixed effects ($\iota_{c(f)t}$), which soak up all variation occurring at the national level in any given year. As shown in Appendix Table D1 (Panels a and b), Norwegian EOR-eligible fields were 27.6 p.p. more likely to adopt EOR and saw significant production gains across both intensive and extensive margins. The corresponding event study (Appendix Figure D1) shows flat pre-trends and sharp increases immediately following the 1985 decision, mirroring our firm-level findings.

These findings are mirrored at the firm level in Appendix Table D2 (Panels a and b), even when controlling for a firm's general exposure to the Norwegian market via a "Share $\text{Norway}_i \cdot \text{Post}_t$" interaction (Appendix Table D4), which control for heterogeneous effects across firms based on firms' exposure to Norway.[20]

Royalty phases-outs. A key concern is that the UK (1983) and Norway (1986) phased out royalties for new fields, which could act as a prospective fiscal incentive. To isolate the Supreme Court's effect on existing assets, we re-estimate our models on a "cleansed" sample excluding all fields discovered or licensed after 1983. This ensures all included fields were already operating under sunk legal terms before the ruling. Results in Appendix Table D1 (Panel d) and Table D2 (Panel c) remain unchanged, confirming the response was driven by the legal protection of existing contracts rather than prospective tax breaks. Similarly, results are robust to defining treatment as beginning with the 1984 Court of Appeal signal (Table D1, Panel c).

Mechanisms and displacement. We validate our conceptual framework through several additional tests. First, we confirm a central prediction of our model in Section 3.1: EOR adoption was primarily driven by operators with larger ownership stakes (s), who capture more of the gains from adoption and thus have higher incentives to overcome hold-up risks (Appendix Table D3). Second, results are robust to broader EOR-eligibility criteria based on permeability and porosity (Appendix Table D1, Panel e). Finally, we find no evidence of investment "crowding-out"; production in non-EOR-eligible Norwegian fields remained stable, and firms without EOR-eligible Norwegian assets showed no decline in output (Appendix Figures D2 and D3). These results collectively support our

[20] The inclusion of this regressor never affect our results qualitatively but, being highly correlated with the other interactions, inflates the standard errors and, for this reason, we exclude it from the main text.

interpretation that reduced sovereign hold-up risk unlocked net new investment.

Other types of Norwegian fields. Although our analysis focuses on EOR-eligible fields, one may wonder whether the Supreme Court decision encouraged, more broadly, investment in all types of Norwegian fields. Columns 1-2 of Table 4 present estimates of firm-level regression (8) using the same dependent variables as Columns 2-3 of Table 3, but replacing the ownership shares of EOR-eligible fields with the ownership shares of non-EOR-eligible fields. Columns 3-4 of Table 4 are discussed in Section 6.

Recognizing that significant R&D efforts in the North Sea have focused on the recovery of deep oil due to the discovery of ultra-deep well fields (Doornenbal *et al.*, 2022), Panel (a) of Table 4 examines the shares of deep well fields (reservoir depth greater than 2,000 meters and non EOR eligible). Panel (b) investigates shares of sour-oil fields (fields with sulfide presence), which pose challenges such as corrosion and production losses, though new technologies have improved their viability (Burgers *et al.*, 2011). Panel (c) considers shares of other non-deep, non-sour, non-EOR-eligible fields, while Panel (d) examines the total shares of a firm's non-EOR-eligible fields (i.e., the total of the shares from Panels (a)-(c)). These results illustrate that the increases in production and productivity documented for EOR-eligible fields in Table 3 did not occur for other field types.

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

6 Market Shares

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. We now investigate whether this increase in production allowed EOR adopters in Noway to acquire larger shares of the O&G market in the North Sea.

We begin by estimating firm-level regression (8), with North Sea production market shares as the dependent variable. Column 1 of Table 5 shows that firms whose pre-1985 portfolios included 10 p.p. more Norwegian EOR-eligible fields had post-1985 market shares 39 p.p. higher. Given that the average firm's share was about 1%, this is a 39% increase. Restricting to producing firm-years (Column 2), the effect is 0.73 p.p., or a 73% increase. By contrast, firms with British but not Norwegian EOR-eligible fields

Table 4: Firm-level production and market shares—non-EOR-eligible fields

	Production		Market Share	
Dependent variable	$\ln(1+\text{prod}_{it})$ (1)	prod_{it} / OPEX_{it} (2)	All (3)	Positive (4)
Panel (a): Non-EOR, Deep Well Fields (Deep)				
Share Deep Norway × Post	0.789	0.157	0.013	0.008
	(0.841)	(0.140)	(0.018)	(0.023)
Share Deep × Post	-0.050	-0.176	0.001	0.005*
	(0.304)	(0.130)	(0.003)	(0.003)
R-squared	0.84	0.41	0.82	0.84
Panel (b): Non-EOR, Sour Oil Fields (Sour)				
Share Sour Norway × Post	0.482	0.075	0.051	0.060
	(1.313)	(0.231)	(0.045)	(0.046)
Share Sour × Post	-0.291	-0.205	-0.007	-0.004
	(0.338)	(0.156)	(0.005)	(0.005)
R-squared	0.84	0.42	0.82	0.85
Panel (c): Non-EOR, Non-Deep, Non-Sour Oil Fields (Other)				
Share Other Norway × Post	0.773	0.035	0.009	0.003
	(1.039)	(0.112)	(0.022)	(0.032)
Share Other × Post	0.214	0.079	-0.001	0.000
	(0.343)	(0.077)	(0.002)	(0.002)
R-squared	0.85	0.41	0.82	0.84
Panel (d): Non-EOR Fields				
Share non-EOR Norway × Post	0.551	0.184	0.016	0.014
	(0.739)	(0.703)	(0.016)	(0.020)
Share non-EOR × Post	0.190	0.005	-0.004	-0.001
	(0.304)	(0.894)	(0.003)	(0.002)
R-squared	0.84	0.35	0.82	0.84
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	1406	1406	1406	1232

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

Notes: Estimated coefficients from regression (8). In Panel (a), "Share Deep Norway" ("Share Deep") refers to the fraction of Norwegian (North Sea) deep, non-EOR-eligible fields among all the fields in which firm i was active in the North Sea before 1985. Similarly, Panel (b) focuses on sour, non-EOR-eligible fields, Panel (c) on the remaining (other) non-EOR-eligible fields, and Panel (d) on all non-EOR-eligible fields. The dependent variables used in Columns 1-2 are production (in log) and the ratio of production to OPEX, while the dependent variables used in Columns 3-4 are the North Sea production market shares. Column 4 restricts attention to firms with positive market shares. 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.

experienced no change.[21] Columns 3-4 of Table 4 further show that this increase in market shares was experienced only by owners of Norwegian EOR-eligible fields, as the market shares of owners of other Norwegian field types did not increase after 1985.

[21] Appendix Table D4 confirms these results by including also Share $\text{Norway}_i \cdot \text{Post}_t$ as a regressor, to control for possible confounding changes affecting the owners of any Norwegian field.

Appendix Figure C3 plots the estimates of event study regression (9) using North Sea production market shares as the dependent variable and shows parallel trends in the pre-1985 period for firms with Norwegian EOR-eligible fields, even excluding state-owned firms—a pattern we investigate further in Section 7.[22]

In addition to the increased productivity of the EOR-eligible fields already included in the portfolio, the market share gains documented in Columns 1-2 of Table 5 could also have been driven by portfolio expansions at the extensive margin—through acquisitions of new fields—or at the intensive margin—by increasing the ownership shares of fields already included in the portfolio. We analyze these portfolio expansion strategies in turn.

Extensive margin. Columns 3-5 of Table 5 examine whether the Norwegian Supreme Court decision led firms to expand their portfolios of fields. Firms with 10 p.p. more Norwegian EOR-eligible fields before 1985 expanded their portfolios by one additional field post-1985 (0.1×10.42), with 56.5% of this growth in EOR-eligible fields (Column 4, 5.88/10.42) and 43.5% in non-EOR-eligible fields (Column 5, 4.53/10.42). In contrast, firms with 10 p.p. more British but not Norwegian EOR-eligible fields reduced their portfolios by about 0.76 fields (24% EOR-eligible, 76% non-EOR-eligible).

Intensive margin. Next, we investigate whether the Norwegian Supreme Court decision also led firms to increase their ownership shares of fields already included in their portfolios. We do so by estimating field-level triple-difference regressions derived in Appendix A.3. Columns 1-3 of Table 6 show that after 1985, ownership shares of Norwegian EOR-eligible fields rose relative to those of UK fields by 27.3 p.p. for operators, 29.1 p.p. for the largest owner, and 40.4 p.p. for the top three owners. Consistently, Columns 4-5 indicate greater ownership concentration in Norwegian EOR-eligible fields after 1985, as measured by the HHI (with the normalized index in Column 5 accounting for differences in the number of field owners). Column 6 shows that this was partly driven by a lower number of owners per field, which fell by 0.39 on average, nearly a 10% decline.[23]

Discussion. These results suggest that the reduction in sovereign hold-up risk due to the Norwegian Supreme Court decision enabled EOR adopters in Norway to acquire larger shares of the O&G market in the North Sea. Importantly, these market share gains were not only due to the increased productivity of the EOR-eligible fields already included in the portfolios, but were also achieved through two separate portfolio expansion strategies. First, pre-1985 owners of Norwegian EOR-eligible fields expanded their portfolios at the extensive margin, acquiring ownership shares of fields that were not already in

[22] Appendix Tables E1 and E2 present robust checks for different definitions of the post period (since 1984) and EOR eligibility (including porosity and permeability, whose values are missing for some fields).

[23] Appendix Table E3 confirms robustness when defining "Post_t" as the years since 1984, the year of the Court of Appeal decision instead of the year of the Supreme Court decision.

Table 5: Market shares and portfolio expansions

Dependent variable	Market Share All (1)	Market Share Positive (2)	Number of Fields All Fields (3)	Number of Fields EOR Eligible (4)	Number of Fields Non-EOR Eligible (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 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	0.83	0.86	0.81	0.80	0.79

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

Notes: Estimated coefficients from regression (8). "Market share" is a firm's market share of production in the North Sea. "All Fields" is a firm's total number of fields that were in exploration, development, or production in the North Sea in year t. 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 variable "Share EOR Norway" ("Share EOR") refers to the fraction of Norwegian (North Sea) EOR-eligible fields among all the fields in which firm i was active in the North Sea 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.

their portfolios. Second, they also expanded their portfolios at the intensive margin, increasing their ownership shares of Norwegian EOR-eligible fields that were already in their portfolios.

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*,[24] supported Statoil's early growth,

[24] 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%

Table 6: Concentration in field ownership

Dependent variable	Share of Operator (1)	Share of Top 1 (2)	Share of Top 3 (3)	HHI Standard (4)	HHI Normalized (5)	Number of Firms per Field (6)
Norway × EOR × Post	0.273*	0.291**	0.404**	0.204*	0.249*	-0.390**
	(0.141)	(0.147)	(0.196)	(0.115)	(0.141)	(0.196)
EOR × Post	-0.024	-0.020	0.021	-0.019	0.023	0.208
	(0.053)	(0.054)	(0.089)	(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-squared	0.59	0.47	0.46	0.64	0.52	0.96

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

Notes: Estimated coefficients from the triple-difference regression at field level (see equation (8) and its derivation in Appendix A.3). The dependent variables used in Columns 1-3 are the ownership share of the operator, the largest, and the combined shares of the three largest firms in a field. The dependent variables used in Columns 4-5 are 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 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 by field.

allowing expansion until these benefits were phased out in the early 1990s (Austvik, 2014).

Although Statoil played an important role in the success of Norway's O&G 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 know-how to state-owned companies, with Norwegian firms gradually assimilating 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 a gradual limitation of its power, including a redistribution of its ownership shares to a state-controlled investment company 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 above, 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.

when production started. These principles were abolished only in 1992-93.

7.1 Empirical Strategy

To separately isolate the importance of know-how and state ownership, we categorize firms using two indicator variables, "K-H$_i$" and "S-O$_i$," meant to capture whether firm i possessed EOR-specific know-how and/or was stated-owned by 1985. The indicator variable "K-H$_i$" equals one if firm i was the *operator* of at least a field in the North Sea which adopted EOR before 1985. This definition of know-how ensures an active role for firm i in the adoption and management of EOR prior to the Norwegian Supreme Court decision, rather than only passive ownership of EOR-eligible fields. Differently, the indicator variable "S-O$_i$" equals one if firm i was state-owned before 1985.[25]

Because nearly all state-owned firms possessed EOR-specific know-how (in the sense of "K-H$_i$ = 1") but not all firms with EOR-specific know-how were state-owned, 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] We then estimate the heterogeneous effects of the Norwegian Supreme Court decision for each firm category by augmenting the treatment in regression (8) as follows:

$$
\begin{aligned}
y_{it} = {} & \theta^{\text{S-O}}_{\text{treat}} \cdot \text{K-H \& S-O}_i \cdot \text{Share EOR Norway}_i \cdot \text{Post}_t \\
& + \theta^{\text{K-H}}_{\text{treat}} \cdot \text{K-H Only}_i \cdot \text{Share EOR Norway}_i \cdot \text{Post}_t \\
& + \theta_1 \cdot \text{Share EOR Norway}_i \cdot \text{Post}_t + \theta_2 \cdot \text{Share EOR}_i \cdot \text{Post}_t \\
& + \alpha_i + \psi_t + \epsilon_{it}.
\end{aligned} \tag{10}
$$

As in regression (8), θ_1 captures the effect of a higher pre-1985 involvement in EOR-eligible fields in Norway after the Norwegian Supreme Court decision. $\theta^{\text{S-O}}_{\text{treat}}$ captures the additional effect of the Supreme Court decision on state-owned firms. Because state-owned firms also had direct expertise on EOR adoption in the North Sea by 1985, $\theta^{\text{S-O}}_{\text{treat}}$ combines the additional returns due to the advantageous conditions of state ownership with any extra return related to EOR-specific know-how.[27] In contrast, $\theta^{\text{K-H}}_{\text{treat}}$ isolates

[25] Appendix Table B2 lists the state-owned firms operating in the North Sea between 1975 and 1995.

[26] In our baseline regressions, we exclude two firms that were state-owned but did not have any EOR-eligible field in their pre-1985 portfolios. These are Norway State DFI, 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 regressions in the separate category "S-O Only$_i$" (stated-owned without know-how) does not affect our results (see Appendix F).

[27] 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 learning, 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 Statoil to become for the first time operator in 1981. Another significant form of support happened in 1987, when the government transferred operatorship of Statfjord from Mobil to Statoil, a move that did not seem fully justified on the ground of technical competence according to the authors.

the extra returns of EOR-specific know-how—returns other than those implied by state ownership or the financial benefits shared by all owners of Norwegian EOR-eligible fields.

Before proceeding, we note that drilling decisions in a field, due to spatial correlation in well outcomes, usually correlate with drilling decisions in nearby fields (Hodgson, 2024). Similarly, EOR adoption in a field could also be influenced by EOR adoptions in nearby fields. However, as we show in Appendix G, it was operators' know-how—rather than proximity to fields that adopted EOR—the primary driver of EOR adoption. As a consequence, in what follows, we do not further explore the role of geographic proximity.

7.2 Market Shares

Column 1 of Table 7 presents the estimates of firm-level regression (10) using the market share of production in the North Sea as the dependent variable. Column 1 shows that "K-H & S-O" firms with a pre-1985 portfolio of fields that included 10 p.p. more Norwegian EOR-eligible fields had a market share 1.32 p.p. higher after 1985, relative to non-state-owned firms without know-how (or 1.32 + 0.1 = 1.42 p.p. higher relative to firms without EOR-eligible fields). As these firms had an average market share of 0.95% in the period 1975-1985, this corresponded to a 139% increase. Firms that, prior to 1985, were operators in fields that adopted EOR *and* that were not state-owned ("K-H Only") also experienced large gains in market shares, with an increase of 0.5 p.p.. As their average market share was around 0.5% in the period 1975-1985, this corresponded to a 100% increase. In addition, $\widehat{\theta}_1$ is 12 and 5 times smaller than $\widehat{\theta}^{\text{S-O}}_{\text{treat}}$ and $\widehat{\theta}^{\text{K-H}}_{\text{treat}}$, respectively, suggesting that a large portion of the market share expansion documented in Section 6 was driven by operators' expertise in adopting and managing EOR during its life cycle, rather than the financial gains due to the mere ownership of EOR-eligible fields.

This is also supported by the estimates in Columns 2-4 of Table 7, which indicate that know-how was the main force behind the portfolio expansions at the extensive margin documented in Table 5. The estimated effect for "K-H Only" firms is substantially larger than that for "K-H & S-O" firms. "K-O Only" firms with a pre-1985 portfolio of fields that included 10 p.p. more Norwegian EOR-eligible fields expanded their portfolio by about 4.7 new fields (Column 2), with 78% of these being non-EOR-eligible (Column 4). Differently, the portfolios of "K-H & S-O" firms expanded by about 2.8 fields, with 67% of these being non-EOR-eligible.[28] This suggests a broader shift in investment strategy, as firms with EOR-specific know-how exhibited a renewed interest in fields with different characteristics suitable for alternative technologies beyond EOR. The effect of simply

[28] Panel (a) of Appendix Table F1 shows that these results also hold when controlling for "Share Norway$_i$ · Post$_t$". For simplicity, the analysis excludes Britoil and Norway State DFI, the two state-owned firms without know-how. Appendix Table F2 shows similar results to Table F3 when including them in a separate "S-O Only" category.

Table 7: Know-how, market shares, and portfolio expansions

Dependent variable	Market Share (1)	Number of Fields: All Fields (2)	EOR Eligible (3)	Non-EOR Eligible (4)
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)
Average dependent variable	0.012	5.216	2.116	3.100
Share EOR × Post	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	1377	1377	1377	1377
R-squared	0.89	0.85	0.82	0.84

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

Notes: Estimated coefficients from regression (10). The dependent variables are firm i's market share (Column 1), number of fields (Column 2), number of EOR-eligible fields (Column 3), and number of non-EOR-eligible fields (Column 4) in year t. Firms are divided into three categories based on the indicator variables "K-H" (know-how) and "S-O" (state ownership). "K-H" equals 1 if firm i was an operator in a field that adopted EOR before 1985, while "S-O" equals 1 if firm i was state owned during 1975-1995. Because some firms possessed both know-how and were state owned, we create the variables "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. "Share EOR Norway" is the pre-1985 share of firm i's fields that were eligible for EOR. The indicator "Post" equals 1 for the years after 1985, the year of the Supreme Court decision, and 0 otherwise. All regressions control for "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. The two state-owned firms that did not have know-how are excluded from all regressions (Britoil and Norway State DFI). Standard errors are clustered at the firm level.

owning shares of EOR-eligible fields is instead estimated to be negligible.

Oil Majors. Some firms may have acquired EOR-specific expertise outside the North Sea and then leveraged it in Norway after the 1985 Supreme Court decision. In fact, Sheng (2013) documents pervasive EOR adoption by the "Seven Sisters" (BP, Chevron, Exxon, Gulf Oil, Mobil, Shell, Texaco) and other global players (Amoco, Conoco, Eni, Phillips, Total). We estimate a regression similar to (10) that replaces the "K-H$_i$" and "S-O$_i$" indicators with an "Oil Major$_i$" indicator. The estimates of this regression in Appendix Table F3 confirm that the results in Table 7 are not driven by oil majors.

Discussion. These results highlight how 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 2-4) suggests that the expected returns—also in terms of market shares—may have materialized over a longer horizon, as these firms may have invested in different fields requiring other, potentially less mature, technologies.

7.3 Portfolio Diversification

In this section, we further investigate the portfolio diversification strategies of different types of firms in relation to fields' geological characteristics and their implied levels of risk. Table 8 reports estimates of regression (10) using as dependent variables the number of EOR-eligible fields (Columns 1-4) and of non-EOR-eligible fields (Columns 5-8) by geological type. The dependent variables in Columns 1-3 and 5-7 count the number of fields in each firm's portfolio that contain heavy oil, sour oil, or have deep wells, features commonly associated with high risk.[29] Columns 4 and 8, instead, count the remaining number of fields that do not have these features and are commonly considered low risk.

The results of Table 8 complement those of Table 7, clarifying that the aggressive portfolio expansion of “K-H Only” firms took place primarily toward high-risk fields. Compared to “K-H & S-O” firms, “K-H Only” firms not only specialized more in EOR-eligible fields, but also diversified more 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 p.p. more Norwegian EOR-eligible fields expanded their portfolios 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 (not 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 low-risk profile (both EOR-eligible and non-EOR-eligible fields). In contrast, firms without know-how exhibited only a modest expansion into deep-well (EOR-eligible) fields while simultaneously reducing their exposure to heavy-oil fields, which are generally ineligible for EOR, suggesting little diversification.[30]

[29] Column 1 of Table 8 is empty as the geology of EOR-eligible fields is incompatible with heavy oil.

[30] Panel (b) of Appendix Table F1 shows similar results including “Share Norway$_i \cdot$ Post$_t$” as an additional regressor. Table F4 replicates the results including state-owned firms without know-how.

Table 8: Know-how and portfolio diversification

Dependent variable	Number of EOR-Eligible Fields				Number of Non-EOR-Eligible Fields			
	Heavy Oil (1)	Sour Oil (2)	Deep Well (3)	Other (Low Risk) (4)	Heavy Oil (5)	Sour Oil (6)	Deep Well (7)	Other (Low Risk) (8)
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)
Average dependent variable	–	0.580	2.015	0.097	0.060	1.864	2.356	0.156
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
Observations	–	1377	1377	1377	1377	1377	1377	1377
R-squared	–	0.77	0.81	0.78	0.33	0.78	0.77	0.70

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

Notes: Estimated coefficients from regression (10). The dependent variables are the numbers of different types of EOR-eligible fields (Columns 1-4) and of different types of non-EOR-eligible fields (Columns 5-8) that were 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. EOR cannot be implemented with heavy oil, hence Column 1 is empty. Firms are divided into three categories based on the indicator variables "K-H" (know-how) and "S-O" (state ownership). "K-H" equals 1 if firm i was an operator in a field that adopted EOR before 1985, while "S-O" equals 1 if firm i was state owned during 1975-1995. Because some firms possessed both know-how and were state owned, we create the variables "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. "Share EOR Norway" is the pre-1985 share of firm i's fields that were eligible for EOR. The indicator "Post" equals 1 for the years after 1985, the year of the Supreme Court decision, and 0 otherwise. All regressions control for "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. The two state-owned firms that did not have know-how are excluded from all regressions (Britoil and Norway State DFI). Standard errors are clustered at the firm level.

Oil Majors. We examine again the role of oil majors by estimating a regression along the lines of (10) that replaces the "K-H$_i$" and "S-O$_i$" indicators with an "Oil Major$_i$" indicator. Appendix Table F5 shows that the Supreme Court decision did not alter the composition of oil majors' portfolios in the North Sea. We find no evidence of increased entry into specific fields or diversification across multiple fields, confirming that the results in Table 8 are not driven by oil majors.

Discussion. These findings indicate that pre-1985 EOR-specific know-how in the North Sea, rather than state support, drove firms' portfolio diversification into high-risk assets after the Supreme Court decision. Firms with this type of expertise not only specialized more in high-risk EOR-eligible fields, but also diversified more into high-risk non-EOR-eligible fields. Importantly, diversification into high-risk fields potentially called for the adoption of risk-mitigating technologies other than EOR. We explore this channel next.

8 Transferable Know-How

The 1980s marked a period of significant technological innovation in the O&G industry in the North Sea. Several key advancements improved extraction efficiency and addressed the harsh offshore conditions of the region. A major development was the use of *concrete gravity base structures* (condeep)—the world's largest man-made movable object of the time (see Appendix Figure C2)—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, hosting the world's first production TLP, installed in 1984. Finally, *horizontal drilling*, which was pioneered in Brynhild (Norway) and later also deployed in Beatrice (UK), improved reservoir drainage.[31]

These examples illustrate the technological transformation of the North Sea O&G industry in the 1980s, which became a laboratory of offshore engineering breakthroughs. In what follows, we investigate whether the reduction in Norwegian sovereign hold-up risk encouraged owners of Norwegian EOR-eligible fields to diversify the range of technologies deployed, and in particular whether the pre-1985 adoption of EOR (which we defined as "know-how") facilitated the subsequent adoption of other technologies.

8.1 Definition of Technological Diversification

For the analysis of technological diversification, we use regressions (8) and (10). For each firm i, we define the following measure of technological *diversification*:

$$1 - \sum_{\tau=1}^{N} \left(\frac{\text{firm } i\text{'s production through technology } \tau \text{ in year } t}{\text{firm } i\text{'s total production in year } t} \right)^2, \tag{11}$$

which is one minus the HHI in terms of firm i's "technological shares." 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 compute the share of firm i's production in year t obtained through τ, relative to i's total production in that

[31]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 "K-H Only" firm. In Oseberg (Norway), the Oseberg A condeep was deployed in 1988 by Mobil, which also "had know-how." Additionally, Frigg (Norway) deployed sub-sea 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.

year (obtained through any technology). To compute firm i's production from technology τ, we weigh the production of each field in i's portfolio by firm i's ownership share in that field in year t, and then standardize the resulting measure (to ease comparisons across technologies). Finally, we use (11) as a dependent variable in (10) and interpret θ_{treat} as the average dispersion in a firm's portfolio of technologies resulting from its response to the Supreme Court decision.

Technologies. We classify technologies in two groups (see details in Appendix H). The first group is *exploration & production* technologies, which includes the infrastructures required for field exploration and subsequent O&G 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 deep-water drilling. A *subsea system* involves wells connected to a platform for remote deep O&G extraction.

The second group is *extraction* technologies, which includes technologies designed to increase recovery rates or improve production by maintaining or increasing reservoir pressure. These include primary and secondary recovery methods, which are used at the early stages of a field's life cycle. In comparison, EOR is a tertiary recovery technology, used only once primary and secondary recovery methods are no longer effective.

Returning to the comparative statics of the model in Section 3.1, we expect that the know-how acquired through EOR adoption transferred more easily to other extraction technologies, which shared common features with EOR (i.e., had higher knowledge carry-over γ), than to exploration & production technologies (i.e., had lower γ). Consequently, firms with EOR-specific know-how should have faced a relatively lower threshold A^* for the subsequent adoption of technologies in the extraction class than in the exploration & production class.

Field characteristics and technologies. Because technological suitability depends on field-specific geology, we also measure technological diversification along two dimensions—well depth and reservoir size—using (11). We first discretize each continuous variable into quintiles across the North Sea, then compute the diversification indices over each category, with τ in (11) denoting a field's quintile of well depth or reservoir size. In this context, larger values of index (11) indicate that a firm obtained its total production through a relatively more diversified portfolio of fields that spanned the range of possible well depths and reservoir sizes in the North Sea.

Technology-related costs. To further assess technological diversification, we compute index (11) over fields' cumulative tariffs and CAPEX expenditures per MMboe. Tariffs are the charges for using industry infrastructure—production (processing raw resources in a plant), transportation (moving resources via pipelines, ships, or other networks), and storage (tank farms, underground caverns).[32] For each field, we sum the tariffs and CAPEX per MMboe over all years, discretize each cumulative measure into quintiles across the North Sea, and then calculate the diversification index, with τ indicating the field's tariffs or CAPEX quintile.

Lower values of the resulting diversification index indicate that a firm's production was concentrated in fields with similar tariffs or CAPEX profiles, reflecting operational homogeneity. Importantly, a low index does not specify whether these fields were low or high cost, only that they required comparable levels of services or CAPEX.

8.2 Results

Panel (a) of Table 9 reports estimates of regression (8) using the diversification indices described above as dependent variables. The negative and mostly not significant estimates indicate that larger pre-1985 shares of Norwegian EOR-eligible fields were not sufficient, on their own, to spur technological diversification after the Supreme Court decision.

Panel (b) of Table 9 repeats the analysis of Panel (a) using regression (10). Overall, these results—together with those from Table 8—underscore the central role of know-how in driving technological diversification. In particular, the second row of Panel (b), which corresponds to firms with EOR-specific know-how that were not state owned, consistently reports the largest increases in technological diversification. The estimated effects are two to three times larger for "K-H Only" firms compared to those in the first row, which refer to firms with EOR-specific know-how that were state owned. This difference is significant at the 5% level across all columns except the last, where standard errors are larger.

As mentioned above, since EOR is a tertiary extraction technology, its characteristics overlap more with other extraction technologies in Column 2 (which include primary and secondary methods) than with exploration & production technologies in Column 1. The comparative statics in Section 3.1 predict that pre-1985 EOR-specific know-how should have facilitated the adoption of similar extraction technologies rather than more distant exploration & production technologies. Consistent with this prediction, the estimated diversification in extraction technologies (Column 2) for "K-H Only" firms is substantially larger than that in exploration & production technologies (Column 1).

To test whether this difference is statistically significant, we subtract the dependent variable in Column 1 from that in Column 2 and re-estimate the specification in Panel (b). The coefficient on the interaction with "K-H Only" is 1.51 and statistically significant at the 1% level, implying that a 10 p.p. increase in "Share EOR Norway" led to a 0.15 standard deviation larger increase in diversification in extraction relative to exploration

[32] We observe only the total tariffs for each year and field, without further breakdowns.

Table 9: Know-how and technological diversification

	Diversification in Technological Portfolios (1−HHI)					
Dependent variable	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	-1.131*	-0.944	-0.865	-0.894	-1.240**	-0.937
	(0.641)	(0.609)	(0.683)	(0.655)	(0.534)	(0.643)
Share EOR × Post	-0.723**	-0.407	-0.666**	-0.570*	-0.490*	-0.569**
	(0.297)	(0.275)	(0.281)	(0.298)	(0.280)	(0.283)
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) & State-Owned (S-O)						
K-H & S-O × Share EOR Norway × Post	2.301***	1.419	1.928**	2.542***	1.504**	2.050**
	(0.679)	(0.861)	(0.864)	(0.656)	(0.701)	(0.889)
K-H Only × Share EOR Norway × Post	3.546***	5.055***	4.380***	5.855***	4.321***	3.564***
	(0.854)	(0.920)	(1.134)	(0.820)	(0.892)	(1.176)
Share EOR Norway × Post	-1.481**	-1.257**	-1.206*	-1.347**	-1.536***	-1.263**
	(0.595)	(0.576)	(0.665)	(0.561)	(0.498)	(0.621)
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

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

Notes: Panel (a) presents estimated coefficients from regression (8) and Panel (b) from regression (10). The dependent variables evaluate technological diversification according to (11) across technology types (Columns 1-2), field characteristics (Columns 3-4), and technology-related expenditures (Column 5-6). See main text for more details. Each dependent variable is standardized. In Panel (b), firms are divided into three categories based on the indicator variables "K-H" (know-how) and "S-O" (state ownership). "K-H" equals 1 if firm i was an operator in a field that adopted EOR before 1985, while "S-O" equals 1 if firm i was state owned during 1975-1995. Because some firms possessed both know-how and were state owned, we create the variables "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. "Share EOR Norway" is the pre-1985 share of firm i's fields that were eligible for EOR. The indicator "Post" equals 1 for the years after 1985, the year of the Supreme Court decision, and 0 otherwise. All regressions control for "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. The two state-owned firms that did not have know-how are excluded from all regressions (Britoil and Norway State DFI). Standard errors are clustered at the firm level.

& production technologies. Differently from "K-H Only" firms, state-owned firms with direct expertise in EOR did not diversify more in extraction technologies. Their behavior was inconsistent with our theoretical framework, possibly reflecting alternative, politically motivated objectives—such as a prioritization of the exploration of all potentially productive fields for better planning and future allocation.[33]

[33] Appendix Table F6 also includes state-owned firms without know-how. Consistent with our mechanism, state-owned firms with know-how diversify their technological portfolio more than those without.

Oil Majors. The results in Appendix Table F7 exclude the possibility that oil majors drove technological diversification after the Norwegian Supreme Court decision. In particular, we do not find any significant change in our technological diversification measures for those oil majors that owned more Norwegian EOR-eligible fields before 1985.

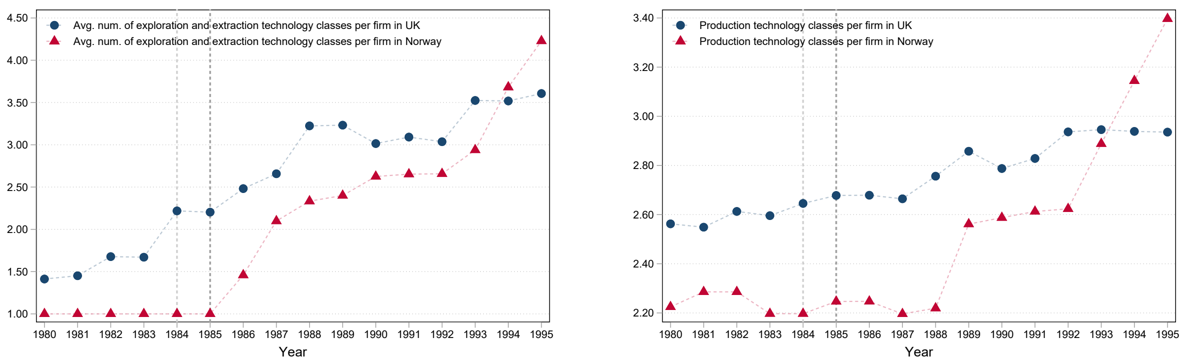
Discussion. Collectively, our results suggest that firms that owned EOR-eligible fields (rather than any other type of field, Table 4) prior to 1985 expanded their production after the Supreme Court decision both directly through EOR adoption (Table 3), but also indirectly by expanding their portfolios with other EOR-eligible fields and non-EOR-eligible fields (Table 5). Firms that already possessed EOR-specific know-how before 1985 were those that experienced the largest increases in market shares, and were also those that expanded their portfolios more aggressively after the Supreme Court decision (Table 7). In particular, these firms not only specialized in other EOR-eligible fields, but also diversified in fields with alternative characteristics (Table 8) that required different technologies (Table 9). Transferable know-how acquired through EOR adoption, rather than state ownership or the financial returns associated to EOR adoption, was the key driver behind the expansion of market shares.

8.3 Country-Level Trajectories

Technology adoption. These findings suggest the possibility of divergent technological trajectories for the O&G sectors in the UK and in Norway. As Figure 4 shows, after 1985 Norway not only closed the technological gap with the UK but, by the early 1990s, it took the lead. Crucially, this comparison is limited to firms operating in both countries, eliminating any bias from post-1985 entry in Norway or exit from the UK.

Figure 4: Range of technology classes adopted by firms in each country

(a) Exploration & production technologies (b) Extraction technologies



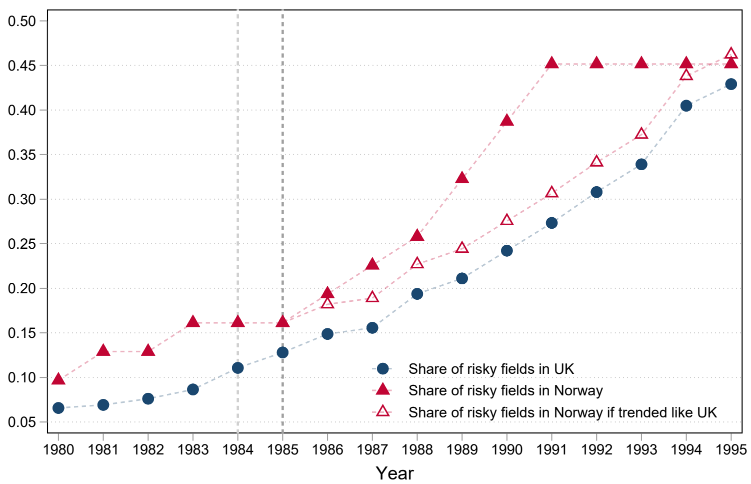
Notes: Panel (a) plots the average number of exploration & production technologies by country (e.g., platform type). Panel (b) plots the average number of extraction technologies by country (e.g., artificial lift). Vertical dotted lines mark the years when the Eidsivating Court of Appeal (1984) and the Norwegian Supreme Court (1985) delivered their rulings.

Panel (a) shows country-specific trends in the adoption of exploration & production technologies as those studied in Column 1 of Table 9. 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 that required 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 technologies deployed in Norway started to widen, eventually overtaking the range deployed in the UK.

Panel (b) of Figure 4 shows similar patterns to those in Panel (a), but for extraction technologies as those studied in Column 2 of Table 9. These include standard extraction methods, artificial lift, injections, drive, and others. In the UK, technology deployment 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 is not the primary driver of these trends. Appendix Figure C4 shows that excluding state-owned firms yields virtually identical patterns.

Figure 5: 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 when the Eidsivating Court of Appeal (1984) and the Norwegian Supreme Court (1985) delivered their rulings.

Development of risky fields. Figure 5 plots trends in the ratios of "active" risky fields in a specific year—whereby "active" we mean fields in exploration, development, or 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. This analysis excludes fields operated by state-owned firms.

Figure 5 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 stabilized at 45%, reflecting our definition of a deep field, since no field deeper than 3,500m was drilled during the period 1990-1995. The gap between the solid and hollow red triangles, depicting a counterfactual where Norway followed the trajectory of the UK, is suggestive of the effect of transferable know-how on the speed of development of risky fields that required more involved technologies.

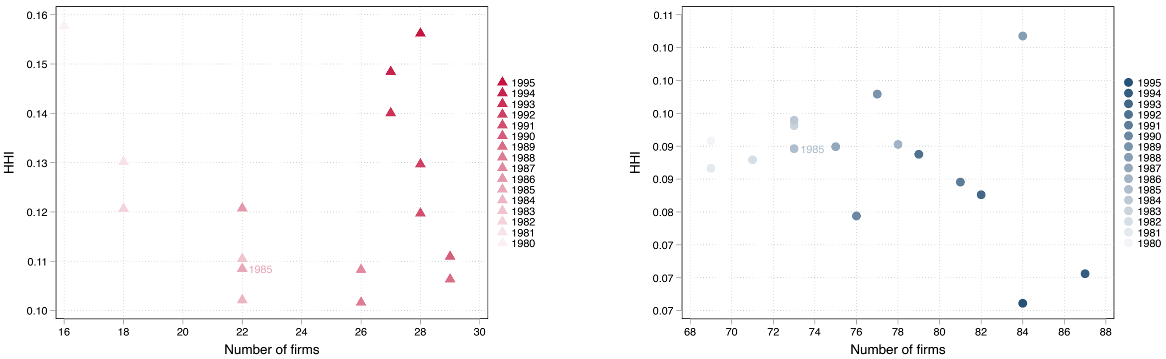
Market concentration. Our results highlight that the Norwegian Supreme Court decision led the owners of EOR-eligible fields in Norway to increase their market shares. We now explore to what extent this *relative* increase translated into an increase in market concentration in Norway relative to the UK. Figure 6 plots the Herfindahl-Hirschman Index (HHI) against the number of active firms separately for Norway (Panel (a)) and the UK (Panel (b)). Triangles and dots are shaded by year, with darker colors indicating more recent observations, and the year 1985 is explicitly labeled in each panel. In Norway, despite a near doubling in the number of active firms from 1975 to 1995, HHI rose markedly, suggesting that incumbents expanded their market presence more aggressively after the Supreme Court ruling. In contrast, in the UK—where firm entry was more modest, around 10%—market concentration declined steadily, consistent with a shift in production toward new entrants.

9 Conclusion

We investigate how sovereign hold-up risk affects technology adoption and firm behavior in regulated industries. Exploiting a 1985 Norwegian Supreme Court ruling that constrained unilateral retroactive changes to petroleum royalties, we show that stronger sovereign commitment accelerated adoption of EOR—a prominent extraction technology—, increased investment and production, and enabled firms to gain larger

Figure 6: Concentration increases in Norway despite large entry while it drops in UK

(a) Norway (b) United Kingdom



Notes: Each panel plots the relationship between HHI and the number of active 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.

shares of the North Sea O&G market. Importantly, these gains were largest for firms with prior operational expertise in EOR—not simply those with financial stakes in EOR-eligible assets or those benefiting from state support.

Our findings point to a knowledge-based market failure under policy uncertainty. Following the ruling, firms with EOR-specific know-how reshaped their portfolios of assets, both specializing in additional EOR-eligible fields and diversifying into fields with different geological characteristics requiring alternative technologies. Consistent with complementarities in technological knowledge, these firms subsequently adopted a broader range of technologies—particularly other extraction technologies that shared technical features with EOR. This pattern of technological diversification, concentrated among technologies similar to EOR, suggests that know-how accumulated through early adoption is partly transferable, generating economies of scope that facilitate subsequent adoption across related technological domains.

These results highlight the importance of institutional credibility to unlock technical expertise that might otherwise remain idle in the economy. When sovereign commitments lack credibility, firms under-invest not only in physical capital but also in transferable know-how. Although our analysis focuses on the O&G industry, the mechanisms we identify—path dependence in capability accumulation and transferability of know-how across related technologies—likely extend to other regulated sectors where governments hold long-term contractual relationships with private firms.

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Online Appendix

A Theory

A.1 Threshold Crossing Rule for Technology Adoption

We supplement the assumptions made in Section 3.1 with the following regularity conditions, which are sufficient for the result:

- q is m-strongly monotone (that is, $q'(A) \geq m > 0$),
- the boundary conditions $B(0) > 0$ and $B(\bar{A}) < \bar{A}$, and
- the parameter restriction $(s\,\Delta\Pi)^2\,m > c\,\beta\,\delta\,L$.

Define $D(A) \equiv s\,\Delta\Pi + \beta\,[V(\delta A + \gamma) - V(\delta A)]$. Since V is strictly increasing, $\gamma > 0$, and $\beta > 0$, we have $V(\delta A + \gamma) > V(\delta A)$, thus $D(A) > s\,\Delta\Pi > 0$. Taking derivatives, $D'(A) = \beta\,\delta\,[V'(\delta A + \gamma) - V'(\delta A)]$. Since V is concave, V' is non-increasing, so $V'(\delta A + \gamma) \leq V'(\delta A)$, implying $D'(A) \leq 0$. Since $V \in C^1$ and concave on the compact interval $[0, \bar{A}]$, it is Lipschitz continuous with some constant $L < \infty$, meaning $0 < V'(\cdot) \leq L$. Therefore, we have $V'(\delta A) - V'(\delta A + \gamma) \leq L$ (the maximal difference between $V'(\delta A) = L$ and $V'(\delta A + \gamma)$ just above 0), thus $-D'(A) \leq \beta\,\delta\,L$.

For $B(A) = q^{-1}(c/D(A))$, differentiation yields $B'(A) = \frac{-c \cdot D'(A)}{D(A)^2 \cdot q'(B(A))} = \frac{c \cdot (-D'(A))}{D(A)^2 \cdot q'(B(A))}$. Since $\beta\,\delta\,L \geq -D'(A) \geq 0$, $D(A) > s\,\Delta\Pi > 0$, and $q'(B(A)) \geq m$, we have $0 \leq B'(A) < \frac{c\,\beta\,\delta\,L}{(s\,\Delta\Pi)^2\,m} < 1$, where the strict inequality in the middle follows from $D(A) > s\,\Delta\Pi$ and the last inequality follows from the parameter restriction.

Defining $h(A) \equiv B(A) - A$, we then obtain $h'(A) = B'(A) - 1 < 0$, which means that h is strictly decreasing. Moreover, since V and q are continuous and $D(A) > s\,\Delta\Pi > 0$, the map $A \mapsto c/D(A)$ is continuous, and because q is strictly increasing its inverse is continuous. Hence, $B(A) = q^{-1}(c/D(A))$ and $h(A) \equiv B(A) - A$ are continuous. Given $h(0) = B(0) > 0$ and $h(\bar{A}) = B(\bar{A}) - \bar{A} < 0$ (by the boundary conditions), continuity of h guarantees a unique root $A^* \in (0, \bar{A})$ of $h(A) = 0$. Finally, because $h(A)$ is continuous and strictly decreasing in A, the adoption rule $A \geq B(A)$ is equivalent to $A \geq A^*$

A.2 Additional Details on Firm-Level Regressions

We provide additional details on the derivations in Section 3.2 for DiD regression (8). We start by evaluating firm i's total production in (4) separately for $t \in \{\text{pre, post}\}$. In the pre-period, both Norwegian and UK EOR-eligible fields face the same threshold A^*_{pre}:

$$y_{i,\text{pre}} = N_{i,\text{Other}} \cdot y_{0,\text{Other,pre}} + (N_{i,\text{Norway EOR}} + N_{i,\text{UK EOR}}) \cdot [y_{0,\text{EOR,pre}} + \Delta y \cdot \mathbb{1}\{A_{i,\text{pre}} \geq A^*_{\text{pre}}\}]. \tag{A1}$$

In the post-period, the thresholds instead diverge:

$$\begin{aligned} y_{i,\text{post}} = {} & N_{i,\text{Other}} \cdot y_{0,\text{Other,post}} + N_{i,\text{Norway EOR}} \cdot [y_{0,\text{EOR,post}} + \Delta y \cdot \mathbb{1}\{A_{i,\text{post}} \geq A^*_{\text{post,Norway}}\}] \\ & + N_{i,\text{UK EOR}} \cdot [y_{0,\text{EOR,post}} + \Delta y \cdot \mathbb{1}\{A_{i,\text{post}} \geq A^*_{\text{pre}}\}]. \end{aligned} \tag{A2}$$

Taking expectations of (A1) and (A2) over the relevant distributions yields:

$$\begin{aligned} \mathbb{E}[y_{i,\text{pre}}] = {} & N_{i,\text{Other}} \cdot y_{0,\text{Other,pre}} + (N_{i,\text{Norway EOR}} + N_{i,\text{UK EOR}}) \cdot y_{0,\text{EOR,pre}} \\ & + (N_{i,\text{Norway EOR}} + N_{i,\text{UK EOR}}) \cdot \Delta y \cdot [1 - F_{\text{pre}}(A^*_{\text{pre}})], \end{aligned} \tag{A3}$$

$$\begin{aligned} \mathbb{E}[y_{i,\text{post}}] = {} & N_{i,\text{Other}} \cdot y_{0,\text{Other,post}} + (N_{i,\text{Norway EOR}} + N_{i,\text{UK EOR}}) \cdot y_{0,\text{EOR,post}} \\ & + N_{i,\text{Norway EOR}} \cdot \Delta y \cdot [1 - F_{\text{post}}(A^*_{\text{post,Norway}})] \\ & + N_{i,\text{UK EOR}} \cdot \Delta y \cdot [1 - F_{\text{post}}(A^*_{\text{pre}})]. \end{aligned} \tag{A4}$$

Consequently, the expected change in production from the pre- to the post-period is:

$$\begin{aligned} \mathbb{E}[y_{i,\text{post}} - y_{i,\text{pre}}] = {} & N_{i,\text{Other}} \cdot [y_{0,\text{Other,post}} - y_{0,\text{Other,pre}}] \\ & + (N_{i,\text{Norway EOR}} + N_{i,\text{UK EOR}}) \cdot [y_{0,\text{EOR,post}} - y_{0,\text{EOR,pre}}] \\ & + N_{i,\text{Norway EOR}} \cdot \Delta y \cdot \{[1 - F_{\text{post}}(A^*_{\text{post,Norway}})] - [1 - F_{\text{pre}}(A^*_{\text{pre}})]\} \\ & + N_{i,\text{UK EOR}} \cdot \Delta y \cdot \{[1 - F_{\text{post}}(A^*_{\text{pre}})] - [1 - F_{\text{pre}}(A^*_{\text{pre}})]\} \\ = {} & N_{i,\text{Other}} \cdot [y_{0,\text{Other,post}} - y_{0,\text{Other,pre}}] \\ & + (N_{i,\text{Norway EOR}} + N_{i,\text{UK EOR}}) \cdot [y_{0,\text{EOR,post}} - y_{0,\text{EOR,pre}}] \\ & + N_{i,\text{Norway EOR}} \cdot \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,Norway}})] \\ & + N_{i,\text{UK EOR}} \cdot \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{pre}})], \end{aligned}$$

which is equation (6) in Section 3.2. The term $[F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,Norway}})]$ captures both the direct effect of the threshold change and any distributional shifts between periods for Norwegian fields, while $[F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{pre}})]$ captures only distributional shifts for UK fields. Substituting in equation (6) the expressions for Δ_{Other}, Δ_{EOR}, and the portfolio shares, we obtain equation (7) in Section 3.2:

$$\begin{aligned} \mathbb{E}[y_{i,\text{post}} - y_{i,\text{pre}}] = {} & N \cdot \Delta_{\text{Other}} + N \cdot [\Delta_{\text{EOR}} - \Delta_{\text{Other}}] \cdot \text{Share EOR}_i \\ & + N \cdot \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{pre}})] \cdot \text{Share EOR}_i \\ & + N \cdot \Delta y \cdot [F_{\text{post}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,Norway}})] \cdot \text{Share EOR Norway}_i \end{aligned}$$

$$= N \cdot \Delta_{\text{Other}} + N \cdot \left\{\Delta_{\text{EOR}} - \Delta_{\text{Other}} + \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{pre}})]\right\} \cdot \text{Share EOR}_i$$
$$+ N \cdot \Delta y \cdot [F_{\text{post}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,Norway}})] \cdot \text{Share EOR Norway}_i,$$

where we use the fact that Share EOR UK$_i$ = Share EOR$_i$ − Share EOR Norway$_i$ to re-express the term that multiplies Share EOR UK$_i$ in equation (6).

We then combine these expressions to obtain DiD regression (8) in Section 3.2. To do this, we use the following identity for firm i's production in period t:

$$y_{it} = \mathbb{E}[y_{it}] + (y_{it} - \mathbb{E}[y_{it}]).$$

In particular, we use equations (A3) and (7) to decompose $\mathbb{E}[y_{it}]$ into policy-induced changes (the coefficient of interest γ_{treat}), changes unrelated to the policy (the coefficient γ_1), a time-invariant firm-specific component (the fixed effect α_i), and a common time effect (the fixed effect ψ_t). Define Post$_t$ as an indicator variable equal to 1 when $t = \text{post}$ and 0 otherwise. Then,

$$\mathbb{E}[y_{it}] = \mathbb{E}[y_{i,\text{pre}}] + \mathbb{E}[y_{i,\text{post}} - y_{i,\text{pre}}] \cdot \text{Post}_t$$

can be equivalently written as:

$$\mathbb{E}[y_{it}] = \gamma_{\text{treat}} \cdot \text{Share EOR Norway}_i \cdot \text{Post}_t + \gamma_1 \cdot \text{Share EOR}_i \cdot \text{Post}_t + \alpha_i + \psi_t, \quad \text{(A5)}$$

where the coefficients on the right-hand side are:

$$\begin{aligned}
\gamma_{\text{treat}} &\equiv N \cdot \Delta y \cdot [F_{\text{post}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,Norway}})] \\
\gamma_1 &\equiv N \cdot \left\{\Delta_{\text{EOR}} - \Delta_{\text{Other}} + \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{pre}})]\right\} \\
\alpha_i &\equiv N \cdot \left\{y_{0,\text{Other,pre}} \cdot (1 - \text{Share EOR}_i) + y_{0,\text{EOR,pre}} \cdot \text{Share EOR}_i \right. \\
&\quad \left. + \Delta y \cdot [1 - F_{\text{pre}}(A^*_{\text{pre}})] \cdot \text{Share EOR}_i\right\} \\
\psi_t &\equiv N \cdot \Delta_{\text{Other}} \cdot \text{Post}_t.
\end{aligned}$$

Finally, substituting (4) and (A5) in the above identity, we obtain DiD regression (8) in Section 3.2:

$$y_{it} = \gamma_{\text{treat}} \cdot \text{Share EOR Norway}_i \cdot \text{Post}_t + \gamma_1 \cdot \text{Share EOR}_i \cdot \text{Post}_t + \alpha_i + \psi_t + \epsilon_{it},$$

where the residual term $\epsilon_{it} \equiv y_{it} - \mathbb{E}[y_{it}]$ corresponds to:

$$\begin{aligned}
\epsilon_{it} &\equiv (1 - \text{Post}_t) \cdot N \cdot \text{Share EOR}_i \cdot \Delta y \cdot \left\{\mathbb{1}\{A_{i,\text{pre}} \geq A^*_{\text{pre}}\} - [1 - F_{\text{pre}}(A^*_{\text{pre}})]\right\} \\
&\quad + \text{Post}_t \cdot N \cdot \text{Share EOR Norway}_i \cdot \Delta y \cdot \left\{\mathbb{1}\{A_{i,\text{post}} \geq A^*_{\text{post,Norway}}\} - [1 - F_{\text{post}}(A^*_{\text{post,Norway}})]\right\}
\end{aligned}$$

$$+\,\mathrm{Post}_t \cdot N \cdot \text{Share EOR UK}_i \cdot \Delta y \cdot \left\{ \mathbb{1}\{A_{i,\text{post}} \geq A^*_{\text{pre}}\} - [1 - F_{\text{post}}(A^*_{\text{pre}})] \right\}.$$

A.3 Derivation of Field-Level Regressions

In this Appendix, we adapt the firm-level derivations of Section 3.2 to obtain field-level triple-difference regression (A10), similar to regression (8) from the main text.

Consider a field f operated by firm $i(f)$ in country $c(f) \in \{\text{Norway}, \text{UK}\}$. Let EOR_f be an indicator equal to 1 if field f is EOR-eligible and 0 otherwise. Following the framework of Section 3.2, field f's production in period $t \in \{\text{pre}, \text{post}\}$ is:

$$y_{ft} = \begin{cases} y_{0,\text{Other},t} & \text{if } \text{EOR}_f = 0 \\ y_{0,\text{EOR},t} + \Delta y \cdot \mathbb{1}\{A_{i(f),t} \geq A^*_{t,c(f)}\} & \text{if } \text{EOR}_f = 1, \end{cases}$$

where $A^*_{t,c(f)}$ denotes the adoption threshold in period t for EOR-eligible fields in country $c(f)$. As discussed in Section 3.2, the 1985 Norwegian Supreme Court decision induced a change in thresholds. Before 1985, all EOR-eligible fields faced the same threshold:

$$A^*_{\text{pre,Norway}} = A^*_{\text{pre,UK}} = A^*_{\text{pre}}.$$

After 1985, the threshold for Norwegian EOR-eligible fields decreased while that for UK fields remained unchanged:

$$A^*_{\text{post,Norway}} < A^*_{\text{pre}}, \quad A^*_{\text{post,UK}} = A^*_{\text{pre}}.$$

The analogous of Assumption 1 at the field level is:

Assumption 2 *know-how A_{it} is distributed across operators independently of the status of EOR eligibility and country of the fields they operate, or* $\Pr_t(A_{it} \geq A^* \mid EOR_f, c(f)) = \Pr_t(A_{it} \geq A^*) = 1 - F_t(A^*)$.

Given Assumption 2, taking expectations:

$$\mathbb{E}[y_{ft}] = (1 - \text{EOR}_f) \cdot y_{0,\text{Other},t} + \text{EOR}_f \cdot y_{0,\text{EOR},t} + \text{EOR}_f \cdot \Delta y \cdot [1 - F_t(A^*_{t,c(f)})].$$

In the pre-period, this is:

$$\mathbb{E}[y_{f,\text{pre}}] = (1 - \text{EOR}_f) \cdot y_{0,\text{Other,pre}} + \text{EOR}_f \cdot y_{0,\text{EOR,pre}} + \text{EOR}_f \cdot \Delta y \cdot [1 - F_{\text{pre}}(A^*_{\text{pre}})]. \tag{A6}$$

Let Norway_f be an indicator equal to 1 if $c(f) = \text{Norway}$ and 0 if $c(f) = \text{UK}$. The expected production in the post-period is:

$$\begin{aligned}\mathbb{E}[y_{f,\text{post}}] = &(1-\text{EOR}_f)\cdot y_{0,\text{Other,post}} + \text{EOR}_f \cdot y_{0,\text{EOR,post}} \\ &+ \text{EOR}_f \cdot \text{Norway}_f \cdot \Delta y \cdot [1 - F_{\text{post}}(A^*_{\text{post,Norway}})] \\ &+ \text{EOR}_f \cdot (1-\text{Norway}_f) \cdot \Delta y \cdot [1 - F_{\text{post}}(A^*_{\text{pre}})].\end{aligned} \tag{A7}$$

The expected change in production from pre- to post-period is:

$$\begin{aligned}\mathbb{E}[y_{f,\text{post}} - y_{f,\text{pre}}] = &(1-\text{EOR}_f)\cdot \Delta_{\text{Other}} + \text{EOR}_f \cdot \Delta_{\text{EOR}} \\ &+ \text{EOR}_f \cdot \text{Norway}_f \cdot \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,Norway}})] \\ &+ \text{EOR}_f \cdot (1-\text{Norway}_f) \cdot \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{pre}})],\end{aligned}$$

where $\Delta_{\text{Other}} = y_{0,\text{Other,post}} - y_{0,\text{Other,pre}}$ and $\Delta_{\text{EOR}} = y_{0,\text{EOR,post}} - y_{0,\text{EOR,pre}}$. Rearranging, we obtain:

$$\begin{aligned}\mathbb{E}[y_{f,\text{post}} - y_{f,\text{pre}}] = &\Delta_{\text{Other}} + \text{EOR}_f \cdot [\Delta_{\text{EOR}} - \Delta_{\text{Other}}] \\ &+ \text{EOR}_f \cdot \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{pre}})] \\ &+ \text{EOR}_f \cdot \text{Norway}_f \cdot \Delta y \cdot [F_{\text{post}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,Norway}})].\end{aligned} \tag{A8}$$

We now combine expressions (A6), (A7), and (A8) to obtain a field-level triple-difference regression. We start from the following identity for field f's production in period t:

$$y_{ft} = \mathbb{E}[y_{ft}] + (y_{ft} - \mathbb{E}[y_{ft}]).$$

We can use our previous expressions to decompose $\mathbb{E}[y_{ft}]$ into policy-induced changes (the coefficient of interest β_{treat}), changes unrelated to the policy (the coefficient β_1), a time-invariant field-specific component (the fixed effect τ_f), and a country-time effect (the fixed effect $\iota_{c(f)t}$). Define Post_t as an indicator variable equal to 1 when t = post and 0 otherwise. Then,

$$\mathbb{E}[y_{ft}] = \mathbb{E}[y_{f,\text{pre}}] + \mathbb{E}[y_{f,\text{post}} - y_{f,\text{pre}}] \cdot \text{Post}_t$$

can be decomposed as:

$$\mathbb{E}[y_{ft}] = \beta_{\text{treat}} \cdot \text{Norway}_f \cdot \text{EOR}_f \cdot \text{Post}_t + \beta_1 \cdot \text{EOR}_f \cdot \text{Post}_t + \tau_f + \iota_{c(f)t}, \tag{A9}$$

where the coefficients on the right-hand side are:

$$\begin{aligned}\beta_{\text{treat}} &\equiv \Delta y \cdot [F_{\text{post}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,Norway}})] \\ \beta_1 &\equiv \Delta_{\text{EOR}} - \Delta_{\text{Other}} + \Delta y \cdot [F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{pre}})]\end{aligned}$$

$$\begin{aligned}\tau_f &\equiv (1-\mathrm{EOR}_f)\cdot y_{0,\mathrm{Other,pre}} + \mathrm{EOR}_f\cdot[y_{0,\mathrm{EOR,pre}} + \Delta y\cdot(1-F_{\mathrm{pre}}(A^*_{\mathrm{pre}}))] \\ \iota_{c(f)t} &\equiv \Delta_{\mathrm{Other}}\cdot \mathrm{Post}_t.\end{aligned}$$

In words, β_{treat} captures the average treatment effect of the Norwegian policy change, representing the additional mass of operators in the post-period with know-how between the two thresholds; while β_1 captures both the differential trend in baseline production between EOR-eligible and non-eligible fields and any distributional shifts that affect all EOR fields equally. Substituting expression (A9) for $\mathbb{E}[y_{ft}]$ in the above identity, we obtain field-level triple-difference regression:

$$y_{ft} = \beta_{\text{treat}}\cdot \mathrm{Norway}_f\cdot \mathrm{EOR}_f\cdot \mathrm{Post}_t + \beta_1\cdot \mathrm{EOR}_f\cdot \mathrm{Post}_t + \tau_f + \iota_{c(f)t} + \epsilon_{ft}, \tag{A10}$$

where the the error term is:

$$\begin{aligned}\epsilon_{ft} &\equiv y_{ft} - \mathbb{E}[y_{ft}] \\ &= (1-\mathrm{Post}_t)\cdot \mathrm{EOR}_f\cdot \Delta y\cdot\left\{\mathbb{1}\{A_{i(f),\mathrm{pre}} \geq A^*_{\mathrm{pre}}\} - [1-F_{\mathrm{pre}}(A^*_{\mathrm{pre}})]\right\} \\ &\quad + \mathrm{Post}_t\cdot \mathrm{EOR}_f\cdot \mathrm{Norway}_f\cdot \Delta y\cdot\left\{\mathbb{1}\{A_{i(f),\mathrm{post}} \geq A^*_{\mathrm{post,Norway}}\} - [1-F_{\mathrm{post}}(A^*_{\mathrm{post,Norway}})]\right\} \\ &\quad + \mathrm{Post}_t\cdot \mathrm{EOR}_f\cdot (1-\mathrm{Norway}_f)\cdot \Delta y\cdot\left\{\mathbb{1}\{A_{i(f),\mathrm{post}} \geq A^*_{\mathrm{pre}}\} - [1-F_{\mathrm{post}}(A^*_{\mathrm{pre}})]\right\}.\end{aligned}$$

Under Assumption 2, we obtain the desired orthogonality condition $\mathbb{E}[\epsilon_{ft} \mid \mathrm{EOR}_f, \mathrm{Norway}_f] = 0$. This independence assumption ensures that operators' absorptive capacities are not systematically related to the types of fields they operate or their geographic location, allowing for consistent estimation of β_{treat} even though the error term is a function of field characteristics. Note that this field-level specification corresponds to the special case of firm-level DiD regression (8) where each firm operates exactly one field.

B EOR Eligibility and State-Owned Firms

Table B1: Criteria for EOR eligibility

Field Characteristic	EOR eligibility requirement	EOR eligibility	
		Standard	Robust
Hydrocarbon	oil, 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 gravity	Between 22.6 and 47.6	✓	✓
Reservoir depth (m)	Between 909.68 and 4,460.23	✓	✓
Porosity (%)	Between 10 and 40		✓
Permeability (mD)	Between 0 and 4,000		✓

Notes: Technical and geological field's characteristics that define EOR eligibility Al Adasani and Bai (2011), Nwidee *et al.* (2016).

- *Hydrocarbon* refers to the type of hydrocarbons.
- *Development type* refers to the type of infrastructure used for oil drilling.
- *Field size* is corresponds 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 150m from the water surface, and "deep water."
- *Field primary resource* categorizes the type of resource in the field. "Conventional shelf" refers to conventional resources in shallow-water O&G fields located on the continental shelf, typically in water depths of less than 150m. Examples include the Gulf of Mexico, the North Sea, and the Persian Gulf.
- *API gravity* measures the density of crude oil and is measured in "API degrees."
- *Reservoir depth* is the total vertical distance between the surface and the reservoir. Shallow reservoirs are less than 1,500m, intermediate reservoirs range from 1,500m to 3,000m, and deep reservoirs range from 3,000m to 5,000m.
- *Porosity (%)* refers to the amount of empty space within a rock that can store hydrocarbons.
- *Permeability (mD)* is the ability of a rock to allow fluids to flow through.

Table B2: List of of state-owned companies in 1975-1995

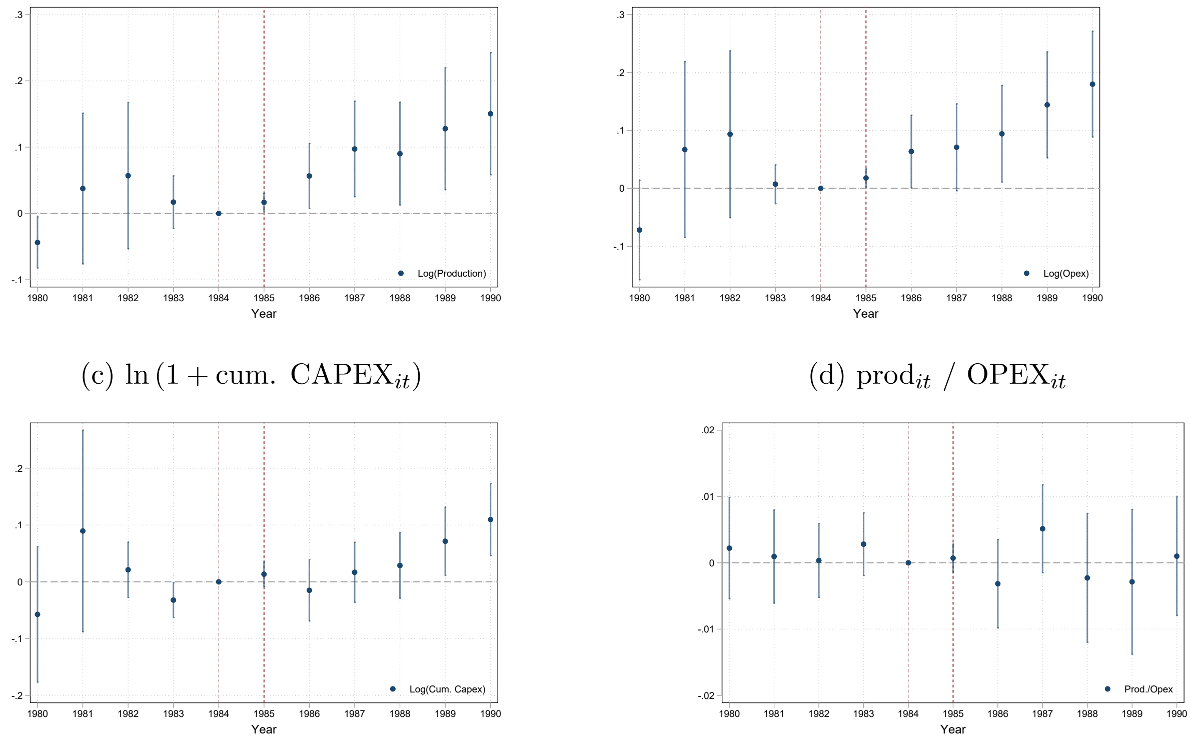
Company Name	**Description and North Sea Involvement**
BP	British multinational O&G company. Originally known as British Petroleum, was a key player in North Sea oil exploration and production during the 1970s and 1980s. The company was state owned until it was fully privatized in 1987. In 1988, BP acquired 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.

C Additional Figures

Figure C1: Firm-level event study of production and costs: Including "Share Norway$_i$"

(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: Estimated coefficients from a regression along the lines of (9) but which additionally controls for the variable "Share Norway." The dependent variables used are production (in log, Panel a), OPEX (in log, Panel b), cumulative CAPEX (in log, Panel c), and the ratio of production to OPEX (Panel d). The variable "Share EOR Norway" ("Share EOR") refers to the fraction of Norwegian (North Sea) EOR-eligible fields among all the fields in which firm i was active in the North Sea before 1985. Similarly, the variable "Share Norway" refers to the fraction of Norwegian fields among all the fields in which firm i was active in the North Sea before 1985. Each regression includes firm and year fixed effects. Vertical bars around each estimate represent 95% confidence intervals. Standard errors are clustered at the firm level. Vertical dotted lines mark the years when the Eidsivating Court of Appeal (1984) and the Norwegian Supreme Court (1985) delivered their rulings.

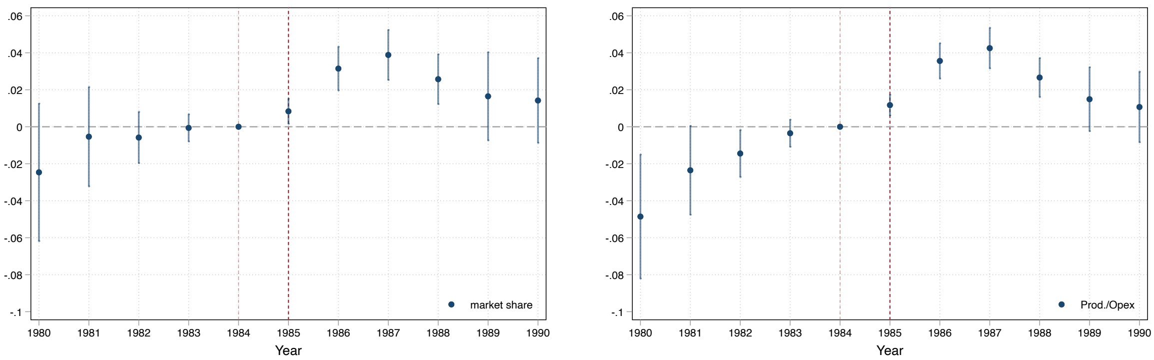
Figure C2: The condeep in Troll field

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

Figure C3: Market shares

(a) All firms

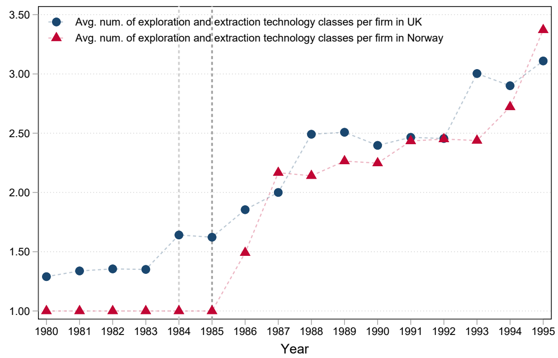
(b) Excluding State-Owned Firms



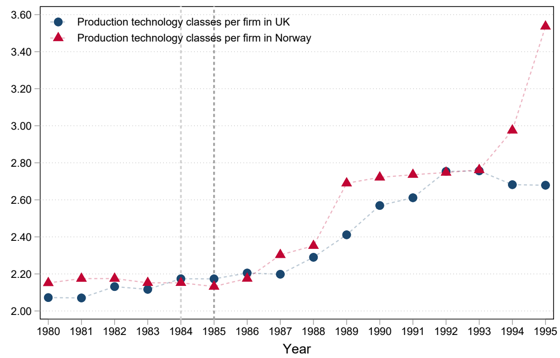
Notes: Estimated coefficients from regression (9) that uses firm's i market share in year t as dependent variable. Panel (b) excludes state-owned firms such as BP and Statoil and their subsidiaries. Each regression includes firm and year fixed effects. Vertical bars around each estimate represent 95% confidence intervals. Standard errors are clustered at the firm level. The regressions also includes indicator variables for the Share Norway treatment and lagged cumulative capital expenditures (in logs) to control for time varying difference in firms' size. Vertical dotted lines mark the years when the Eidsivating Court of Appeal (1984) and the Norwegian Supreme Court (1985) delivered their rulings.

Figure C4: 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 & production technologies by country (e.g., platform type). Panel (b) plots the average number of extraction technologies by country (e.g., artificial lift). The analyses include only firms that were not state owned in the sample period. Vertical dotted lines mark the years when the Eidsivating Court of Appeal (1984) and the Norwegian Supreme Court (1985) delivered their rulings.

D Robustness Checks

Field-level regressions. To account for potential confounding variation across countries and years, such as divergent national policies, which are not directly controlled in Equation (8), we estimate a field-level triple-difference specification (A10) (see Appendix A.3 for a derivation along the lines of Section 3.2):

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

where τ_f and $\iota_{c(f)t}$ denote field and country-year fixed effects, respectively. Results are presented in Appendix Table D1, Panel (a). Column 1 shows that Norwegian EOR-eligible fields were 27.6 percentage points (p.p.) more likely to adopt EOR after 1985 than comparable UK fields.[1]

Columns 2–4 report significant production gains. Column 2 shows a 12.6-fold total increase in production for these Norwegian fields ($\exp(2.610) - 1$). Decomposing this growth, Column 3 documents a 5-fold rise at the intensive margin (fields active by 1985), while Column 4 finds a 44 p.p. increase at the extensive margin (the probability that previously inactive fields commenced production).

Finally, Column 5 shows that EOR drove substantial efficiency gains. Norwegian EOR-eligible fields produced an additional 60.11 barrels per \$1,000 of OPEX relative to the UK baseline. This represents a 67.5% increase over the average efficiency of 89.04 bbl/kUSD, with implied average variable costs falling from \$11.23 to \$6.70 per barrel. Panel (b) confirms similar estimates across production and efficiency measures. These results suggest the policy shift boosted EOR adoption and output across both active and previously inactive fields.

Thus, the Supreme Court decision boosted EOR adoption and production for both active and previously inactive EOR-eligible fields even after accounting for country-by-year fixed effects.

To track changes in production and costs over time, we estimate the event study regression:

$$\begin{aligned} y_{ft} = & \sum_{d=-4}^{5} \beta_{\text{treat},d} \cdot \text{Norway}_f \cdot \text{EOR}_f \cdot \mathbb{1}\{t - 1985 = d\} \\ & + \sum_{d=-4}^{5} \beta_{1,d} \cdot \text{EOR}_f \cdot \mathbb{1}\{t - 1985 = d\} + \tau_f + \iota_{c(f)t} + \epsilon_{ft}. \end{aligned} \tag{A11}$$

Appendix Figure D1 shows that production and the production-to-OPEX ratio all in-

[1] We do not estimate the adoption equation (Column 1) via PPML because the dependent variable is binary; instead, we employ a linear probability model suited for Bernoulli-distributed outcomes.

creased sharply after 1985. The flat pre-trends and the statistically significant increases in 1985 and 1986 suggest that the observed changes cannot be attributed to the phasing out of Norwegian royalties in 1986, which mirrored a similar decision in the UK in 1983, on which we come back in the following paragraphs.

Timing of treatment. We also check whether firms began responding to the 1984 appeal, anticipating the Norwegian Supreme Court decision. We re-compute the portfolio shares in (8) using 1983 as the last year of the pre-period and re-estimate both firm- and field-level regressions, defining Post_t as 1 for the years since 1984 and 0 otherwise. Both field-level (Panel c, Appendix Table D1) and the firm-level (Panel a, Appendix Table D1) results lead to similar conclusions as those presented above.[2]

Excluding post-1983 licenses. As noted in Section 2, the UK and Norway phased out royalties on new fields in 1983 and 1986, respectively. To ensure these changes do not confound our estimates, we re-estimate field-level regression in (A10) on fields discovered before 1983 and define treatment as beginning with the 1984 Court of Appeal ruling (results are similar if we instead use the 1985 Supreme Court decision). Panel (d) of Appendix Table D1 and Panel (c) of Appendix Table D2 confirm that our findings for EOR adoption, production, and costs remain unchanged.

Broader EOR-eligibility criteria. Panel (e) of Appendix Table D1 and Panel (d) of Appendix Table D2 confirm that our results are also robust to an alternative measure of EOR eligibility that accounts for field permeability and porosity. The criteria for a field's EOR eligibility are detailed in Appendix Table B1.

Triple difference at firm level. The first five columns of Appendix Table D4 report estimates of an extension of regression (8) that also controls for "Share $\text{Norway}_i \cdot \text{Post}_t$," 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 the field-level triple-difference regression (A10) and controls also for a firm's exposure to changes in the Norwegian market. Overall, the analyses yield results consistent with those of regression (8), though with slightly larger standard errors due to the high correlation (0.82) between "Share EOR Norway_i" and "Share Norway_i."

Incentives for operators. A direct implication of the model in Section 3.1 is that the adoption threshold decreases with the operator's ownership share—i.e., $\partial B(A)/\partial s < 0$ in equation (3)—as the operator captures a larger portion of the gains from technology

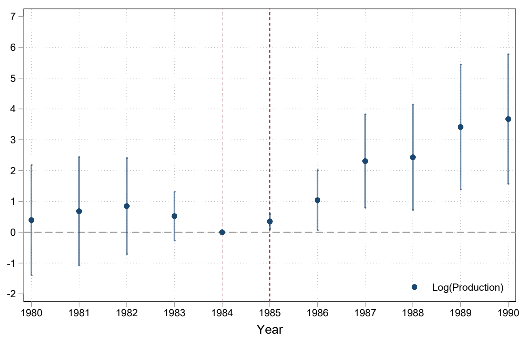
[2]For brevity, we do not report results with the timing of treatment set to 1982 (the year Phillips filed suit), which are quantitatively similar, as also indicated by Figure 3.

adoption. To test this prediction, we extend the field-level regression in equation (A10) by allowing for heterogeneous treatment effects. Specifically, we interact the treatment with an indicator equal to one if the operator's ownership share in field f exceeded its North Sea median in $t-1$. Appendix Table D3 confirms this model prediction: operators with large ownership share s were the main adopters of EOR.

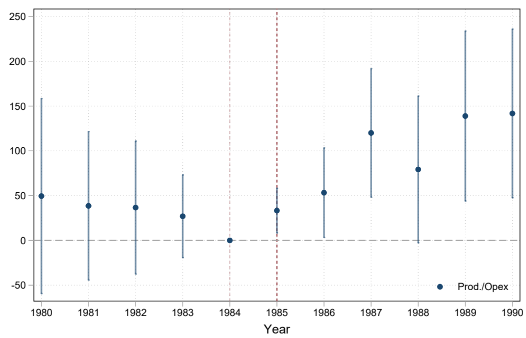
Displacement. To interpret our results, we examine whether the Supreme Court decision induced crowding-out between EOR-eligible and non-EOR-eligible fields. To this end, we examine the production of non-EOR-eligible fields in the UK and Norway around 1985. Panel (a) of Appendix Figure D2 shows that average UK production of these fields rose after 1985, while Norwegian production remained flat. The UK's increase in production appears driven by lower-cost fields (Panel c)—defined as fields with operative costs per barrel below median, with high-cost fields moving in parallel in both countries (Panel b). Thus, we find no evidence of a "crowding-out" effect on non-EOR-eligible fields in Norway, which supports our main interpretation throughout the paper. Moreover, Appendix Figure D3 shows that the yearly production of firms without Norwegian EOR-eligible fields did not decline after 1985.

Figure D1: Field-level event study of production

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



(b) prod_{ft} / OPEX_{ft}



Notes: Estimated coefficients from field-level regression (A11). Each panel shows the estimates of $\widehat{\beta}_{\text{treat},d}$ corresponding to a different dependent variable. The dependent variables are production (in log, Panel a), and the ratio of production to OPEX (in bbl/kUSD, Panel b). 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. Vertical bars around each estimate represent 95% confidence intervals. Standard errors are clustered at the field level. Vertical dotted lines mark the years when the Eidsivating Court of Appeal (1984) and the Norwegian Supreme Court (1985) delivered their rulings.

Table D1: Robustness checks at the field level

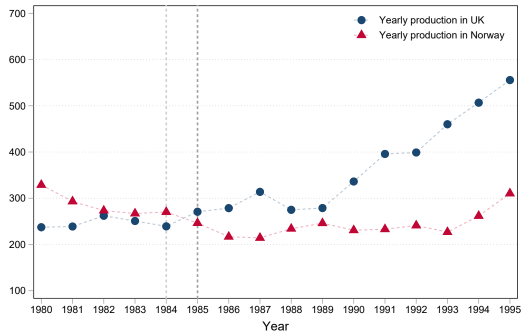
	EOR Adoption	Production Margins			Productivity
		Intensive and Extensive	Only Intensive	Only Extensive	
Dependent variable	$\mathbb{1}\{\text{Adopted EOR}_{ft}\}$	$\ln(1 + \text{prod}_{ft})$	$\ln(1 + \text{prod}_{ft})$	$\mathbb{1}\{\text{prod}_{ft} > 0\}$	prod_{ft} / OPEX_{ft}
	(1)	(2)	(3)	(4)	(5)
Panel (a): Baseline results (OLS)					
Norway × EOR × Post	0.276**	2.610***	1.787***	0.440**	60.110**
	(0.119)	(0.634)	(0.469)	(0.217)	(29.054)
EOR × Post	0.065*	0.621*	0.905**	0.037	23.552
	(0.034)	(0.345)	(0.367)	(0.096)	(26.105)
Field selection	All	All	Prod. < 1985	All	All
Observations	1989	1989	924	1989	1989
R-squared	0.84	0.62	0.64	0.45	0.56
Panel (b): Baseline results (PPML estimator)					
Norway × EOR × Post	–	1.816***	1.346***	0.733***	0.905*
	–	(0.498)	(0.292)	(0.231)	(0.500)
EOR × Post	–	0.293	0.426	0.065	0.317
	–	(0.289)	(0.281)	(0.065)	(0.206)
Field selection	–	All	Prod. < 1985	All	–
Observations	–	1989	924	1989	1905
Pseudo R-squared	–	0.76	0.79	0.05	0.48
Panel (c): Treatment starts in 1984					
Norway × EOR × Post	0.239*	1.918***	2.426***	0.203	40.160
	(0.122)	(0.537)	(0.457)	(0.193)	(33.257)
EOR × Post	0.072*	1.134***	0.977**	0.185*	59.120*
	(0.038)	(0.393)	(0.416)	(0.108)	(32.715)
Field selection	All	All	Prod. < 1983	All	Prod. < 1983
Observations	1989	1989	768	1989	768
R-squared	0.84	0.62	0.68	0.45	0.69
Panel (d): Excluding fields discovered since 1983					
Norway × EOR × Post	0.238**	2.354***	2.785***	0.310*	61.493***
	(0.116)	(0.430)	(0.358)	(0.167)	(21.827)
EOR × Post	0.087**	0.837**	0.742**	0.093	31.960
	(0.035)	(0.333)	(0.364)	(0.092)	(24.112)
Field selection	Disc. < 1983	Disc. < 1983	Disc. < 1983 & Prod. < 1983	Disc. < 1983	Disc. < 1983
Observations	1629	1629	768	1629	1629
R-squared	0.84	0.60	0.67	0.43	0.60
Panel (e): Different criteria for EOR eligibility					
Norway × EOR × Post	0.398***	2.777***	1.666***	0.449*	56.002*
	(0.088)	(0.667)	(0.546)	(0.269)	(30.258)
EOR × Post	0.061*	0.588*	0.831**	0.063	22.566
	(0.037)	(0.346)	(0.369)	(0.095)	(25.303)
Field selection	All	All	Prod. < 1985	All	–
Observations	1989	1989	924	1989	1989
R-squared	0.85	0.61	0.62	0.45	0.56
Country-Year FE	Yes	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes	Yes

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

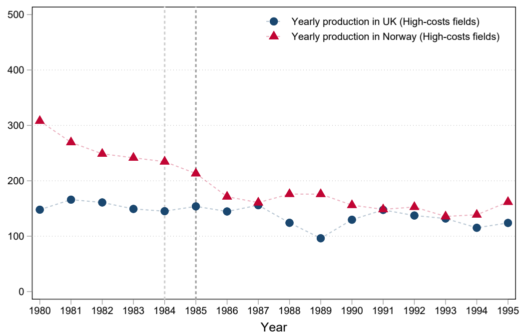
Notes: Estimated coefficients from field-level regression (A10). Panels (a) and (b) present the baseline results using standard OLS or a PPML estimators, respectively. In Panel (c), the variable Post is one for years since 1984 (the year of the appeal and ruling of the Eidsivating Court of Appeal) and zero otherwise. In Panel (d), fields discovered since 1983 in the North Sea are excluded from the analysis. In Panel (e), EOR eligibility is defined according to the "robust" measure in Appendix Table B1, which also account for porosity and permeability. sample The dependent variable in Column 1 is an indicator that equals 1 if field f has adopted EOR by year t and 0 otherwise. The dependent variables in Columns 2-4 are functions of field-level production. Columns 2 and 3 use the log of production, with Column 3 restricting the sample to fields that began production before 1985. The dependent variable in Column 4 is an indicator that equals 1 if the field produces in year t and 0 otherwise. The dependent variable in Column 5 is production / opex, measured in barrels per 1k USD. 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.

Figure D2: Yearly production of non-EOR-eligible fields

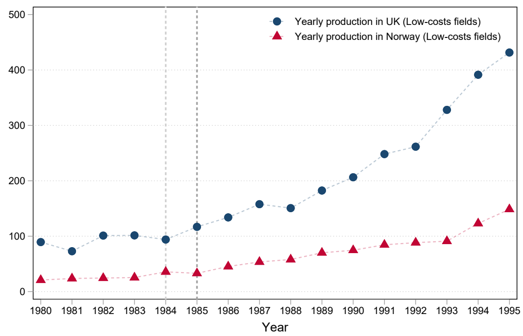
(a) All non-EOR-eligible fields



(b) High-costs non-EOR-eligible fields

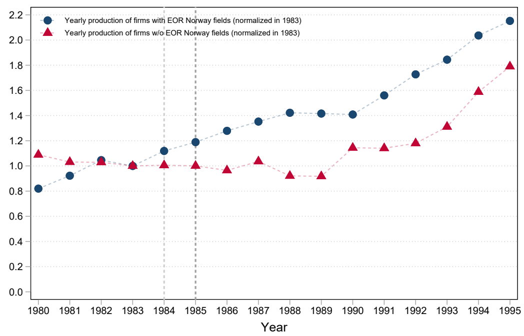


(c) Low-costs non-EOR-eligible fields



Notes: Panel (a) plots the yearly production in MMboe of non-EOR-eligible fields in the UK (blue dots) and in Norway (red triangles). Panel (b) plots yearly production in MMboe of non-EOR-eligible fields in the UK (blue dots) and in Norway (red triangles) for *high*-costs fields, defined as fields with an operative cost of production (dollars per barrel) above median before 1985. Panel (c) plots yearly production in MMboe of non-EOR-eligible fields in the UK (blue dots) and in Norway (red triangles) for *low*-costs fields, defined as fields with an operative cost of production (dollars per barrel) below median before 1985. Vertical dotted lines mark the years when the Eidsivating Court of Appeal (1984) and the Norwegian Supreme Court (1985) delivered their rulings.

Figure D3: Average production of firms with and without Norwegian EOR-eligible fields



Notes: The figure plots the average yearly production (normalized to 1 in 1983) of firms with (blue dots) and without (red triangles) Norwegian EOR-eligible fields as of 1985. Vertical dotted lines mark the years when the Eidsivating Court of Appeal (1984) and the Norwegian Supreme Court (1985) delivered their rulings.

Table D2: Robustness checks at the firm level

	Adoption	Production	
Dependent variable	Share EOR	$\ln(1+\text{prod}_{it})$	$\text{prod}_{it}/\text{OPEX}_{it}$
	(1)	(2)	(3)
Panel (a): Treatment starts in 1984			
Share EOR Norway × Post	0.252***	2.886***	0.270*
	(0.066)	(0.838)	(0.158)
Share EOR × Post	0.013	0.051	0.031
	(0.010)	(0.278)	(0.105)
Average dependent variable	0.054	2.591	0.330
Observations	1382	1382	1225
R-squared	0.66	0.85	0.43
Panel (b): Baseline results (PPML Estimator)			
Share EOR Norway × Post	3.380***	3.592***	0.875***
	(0.544)	(0.635)	(0.236)
Share EOR × Post	0.181	-0.164	-0.089
	(0.391)	(0.326)	(0.082)
Average dependent variable	0.166	62.056	0.328
Observations	449	1387	1241
Pseudo R-squared	0.14	0.91	0.04
Panel (c): Excluding fields discovered since 1983			
Share EOR Norway × Post	0.397***	3.260***	0.270*
	(0.111)	(0.835)	(0.140)
Share EOR × Post	0.012	-0.355	-0.025
	(0.011)	(0.269)	(0.090)
Average dependent variable	0.058	2.534	0.325
Observations	1406	1406	1245
R-squared	0.73	0.86	0.43
Panel (d): Robust definition of EOR eligibility			
Share EOR Norway × Post	0.335***	2.051***	0.289
	(0.120)	(0.671)	(0.179)
Share EOR × Post	0.033**	-0.289	-0.011
	(0.016)	(0.273)	(0.098)
Average dependent variable	0.053	2.562	0.328
Observations	1406	1406	1245
R-squared	0.70	0.85	0.43
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes

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

Estimated coefficients from regression (8). In Panel (a), the variable Post is one for years since 1984 (the year of the appeal and ruling of the Eidsivating Court of Appeal) and zero otherwise. In Panel (b) EOR eligibility is defined according to the "robust" measure in Appendix Table B1, which also account for porosity and permeability. 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 was active in the North Sea in year t. The other dependent variables are production in log (Column 2) and the ratio of production (in Kboe) to OPEX (Column 3). The variable "Share EOR Norway" ("Share EOR") refers to the fraction of Norwegian (North Sea) EOR-eligible fields among all the fields in which firm i was active in the North Sea 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 D3: Field-level adoption—the role of operator ownership

	EOR Adoption			
	Treatment starts in 1986		Treatment starts in 1984	
	(1)	(2)	(3)	(4)
Norway $\times$ EOR $\times$ Post (β_{treat})	0.276**	0.076	0.239*	-0.021
	(0.119)	(0.085)	(0.122)	(0.103)
EOR $\times$ Post (β_1)	0.065*	0.065**	0.072*	0.069*
	(0.034)	(0.033)	(0.038)	(0.036)
Norway $\times$ EOR $\times$ Post $\times$ High Ownership Share (β_{het})		0.260**		0.328**
		(0.123)		(0.146)
Post defined as	years $\geq$ 1986		years $\geq$ 1984	
Country-Year FE	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes
Observations	1,989	1,771	1,989	1,771
R-squared	0.84	0.86	0.84	0.86

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

Notes: Estimated coefficients from field-level regression

$$\begin{aligned} y_{ft} = {} & \beta_{\text{het}} \cdot \text{Norway}_f \cdot \text{EOR}_f \cdot \text{Post}_t \cdot \text{Operator Above Median Ownership}_{f,t-1} \\ & + \beta_{\text{treat}} \cdot \text{Norway}_f \cdot \text{EOR}_f \cdot \text{Post}_t + \beta_1 \cdot \text{EOR}_f \cdot \text{Post}_t + \iota_f + \tau_{c(f)t} + \epsilon_{ft}, \end{aligned}$$

where the dependent variable is an indicator that equals 1 if field f has adopted EOR by year t and 0 otherwise. The indicator variables "Norway," "EOR," and "Post" equal 1 for Norwegian fields, for EOR-eligible fields, and for the years after 1985 / 1983, and 0 otherwise. The indicator variable Operator Above Median Ownership$_{f,t-1}$ equals 1 if field f's operator owned more than the median ownership share in the North Sea in $t-1$. Standard errors are clustered at the field level.

Table D4: Firm-level analysis controlling for "Share Norway · Post"

	Adoption	Production and Costs		Market Share	
Dependent variable	Share EOR	$\ln(1+\text{prod}_{it})$	prod_{it} / OPEX_{it}	All	Positive
	(1)	(2)	(3)	(4)	(5)
Share EOR Norway × Post	0.343*	3.812***	0.208	0.033	0.120**
	(0.179)	(1.032)	(0.161)	(0.024)	(0.052)
Share EOR × Post	0.021*	-0.487*	-0.004	0.000	-0.001
	(0.011)	(0.278)	(0.103)	(0.002)	(0.002)
Share Norway × Post	0.003	-0.469	-0.013	0.005	-0.023
	(0.055)	(0.475)	(0.131)	(0.012)	(0.017)
Average dependent variable	0.053	2.562	0.291	0.015	0.017
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	1406	1406	1406	1406	1232
R-squared	0.70	0.86	0.41	0.83	0.86

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

Notes: Estimated coefficients from regression (8), additionally controlling for "Share Norway · Post." We exclude this regressor in our main analyses because of multicollinearity with "Share EOR Norway · Post" (correlation of 0.8). The table reports estimates for all the key dependent variables analyzed in other tables (a firm's share of EOR adoption, production, production / OPEX, market shares, and positive market shares). The variable "Share EOR Norway" ("Share EOR") refers to the fraction of Norwegian (North Sea) EOR-eligible fields among all the fields in which firm i was active in the North Sea before 1985. "Share Norway" is the share of Norwegian fields in which firm i was active in the North Sea 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.

E Additional Tables on Market Shares and Concentration

Table E1: Market shares and portfolio expansions (treatment starts in 1984)

	Market Share		Number of Fields		
Dependent variable	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 regression (8). "Market share" is a firm's market share of production in the North Sea. "All Fields" is a firm's total number of fields that were in exploration, development, or production in the North Sea in year t. 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). The variable "Share EOR Norway" ("Share EOR") refers to the fraction of Norwegian (North Sea) EOR-eligible fields among all the fields in which firm i was active in the North Sea before 1984. The indicator "Post" equals 1 for the years after 1984, the year the Eidsivating Court of Appeal delivered its ruling, and 0 otherwise. Each regression includes firm and year fixed effects. Standard errors are clustered at the firm level.

Table E2: Market shares and portfolio expansions (different definition of EOR eligibility)

Dependent variable	Market Share All (1)	Market Share Positive (2)	Number of Fields All Fields (3)	Number of Fields EOR Eligible (4)	Number of Fields Non-EOR Eligible (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 regression (8). "Market share" is a firm's market share of production in the North Sea. "All Fields" is a firm's total number of fields that were in exploration, development, or production in the North Sea in year t. 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). The variable "Share EOR Norway" ("Share EOR") refers to the fraction of Norwegian (North Sea) EOR-eligible fields among all the fields in which firm i was active in the North Sea before 1985. EOR eligibility is measured according to the "robust" definition in Appendix Table B1. 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 E3: Concentration in field ownership (treatment starts in 1984)

Dependent variable	Share of Operator (1)	Share of Top 1 (2)	Share of Top 3 (3)	HHI Standard (4)	HHI Normalized (5)	Number of Firms (6)
Norway × EOR × Post	0.184*	0.165	0.282*	0.111	0.183*	-0.298*
	(0.108)	(0.112)	(0.167)	(0.157)	(0.108)	(0.156)
EOR × Post	0.014	0.013	0.076	0.060	0.047	0.173
	(0.051)	(0.051)	(0.089)	(0.082)	(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-squared	0.59	0.47	0.45	0.64	0.52	0.96

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

Notes: Estimated coefficients from field-level regression (A10). The dependent variables used in Columns 1-3 are the ownership share of the operator, the largest, and the combined shares of the three largest firms in a field. The dependent variables used in Columns 4-5 are 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 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 1984, they year the Eidsivating Court of Appeal delivered its ruling, and 0 otherwise. Each regression includes country-by-year and field fixed effects. Standard errors are clustered at the field level.

F Additional Tables on Know-How

Table F1: Analyses in Tables 7, 8, and 9 controlling for "Share Norway · Post"

Panel (a): Replication of Table 7

Dependent variable	Market Share (1)	Number of Fields: All Fields (2)	EOR Eligible (3)	Non-EOR Eligible (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	-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 Table 8

Dependent variable	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)
K-H & S-O × Sh. Eligible Norw. Fields × Post	–	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	–	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	–	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	–	-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	–	-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 (b) of Table 9

Dependent variable	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)
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	-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: Replications controlling for "Share Norway · Post," which is excluded from our baseline analyses because of multicollinearity with "Share EOR Norway · Post" (correlation of 0.8). "Share Norway" is the share of Norwegian fields in which firm i was active in the North Sea before 1985.

Table F2: Know-how, market shares, and portfolio expansions (including state-owned firms without know-how)

Dependent variable	Market Share	Number of Fields		
		All Fields	EOR Eligible	Non-EOR Eligible
	(1)	(2)	(3)	(4)
K-H & S-O × Share EOR Norway × Post	0.132***	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)
Average dependent variable	0.013	5.272	2.151	3.121
Share EOR × Post	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	1406	1406	1406	1406
R-squared	0.86	0.83	0.81	0.81

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

Notes: Estimated coefficients from regression (10). The dependent variables are firm i's market share (Column 1), number of fields (Column 2), number of EOR-eligible fields (Column 3), and number of non-EOR-eligible fields (Column 4) in year t. Firms are divided into four categories based on the indicator variables "K-H" (know-how) and "S-O" (state ownership). "K-H" equals 1 if firm i was an operator in a field that adopted EOR before 1985, while "S-O" equals 1 if firm i was state owned during 1975-1995. Because some firms possessed both know-how and were state owned, we create 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. "Share EOR Norway" is the pre-1985 share of firm i's fields that were eligible for EOR. The indicator "Post" equals 1 for the years after 1985, the year of the Supreme Court decision, and 0 otherwise. All regressions control for "Share EOR $\cdot$ 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 F3: Oil majors, market shares, and portfolio expansions

Dependent variable	Market Share	Number of Fields: All Fields	Number of Fields: EOR Eligible	Number of Fields: Non-EOR Eligible
	(1)	(2)	(3)	(4)
Panel (a): Regression (10) with "Oil Major" instead of "K-H" and "S-O"				
Oil Major × 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) but controlling for "Share Norway · Post"				
Oil Major × 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
Average dependent variable	0.012	5.216	2.116	3.100
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes

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

Notes: Panel (a) presents estimated coefficients from regression (10) where we use the indicator variable "Oil Major" to distinguish oil majors from the other firms. The oil majors include the so-called "seven sisters" (Exxon, Mobil, Chevron, Texaco, Gulf Oil, Royal Dutch Shell, and BP) as well as other very large players of the time (Total, Eni, Phillips Petroleum, Conoco, Amoco). Panel (b) additionally controls for "Share Norway · Post," which is firm i's share of EOR-eligible fields in the North Sea before 1985 times the post-1985 indicator. The dependent variables are firm i's market share (Column 1), and the number of fields (Column 2), number of EOR-eligible fields (Column 3), and number of non-EOR-eligible fields (Column 4) in i's portfolio in year t. All regressions control for firm and year fixed-effects. Standard errors are clustered at the firm level.

Table F4: Know-how and portfolio diversification (including state-owned firms without know-how)

	Number of EOR Eligible Fields				Number of Non-EOR Eligible Fields			
Dependent variable	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)
K-H & S-O × Share EOR Norway × Post	–	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	–	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	–	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	–	-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)
Average dependent variable	–	0.580	2.015	0.097	0.060	1.864	2.356	0.156
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
Observations	–	1406	1406	1406	1406	1406	1406	1406
R-squared	–	0.77	0.81	0.81	0.32	0.77	0.77	0.70

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

Notes: Estimated coefficients from regression (10). The dependent variables are the numbers of different types of EOR-eligible fields (Columns 1-4) and of different types of non-EOR-eligible fields (Columns 5-8) that were 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. EOR cannot be implemented with heavy oil, hence Column 1 is empty. Firms are divided into four categories based on the indicator variables "K-H" (know-how) and "S-O" (state ownership). "K-H" equals 1 if firm i was an operator in a field that adopted EOR before 1985, while "S-O" equals 1 if firm i was state owned during 1975-1995. Because some firms possessed both know-how and were state owned, we create 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. "Share EOR Norway" is the pre-1985 share of firm i's fields that were eligible for EOR. The indicator "Post" equals 1 for the years after 1985, the year of the Supreme Court decision, and 0 otherwise. All regressions control for "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 F5: Oil majors and portfolio diversification

Dependent variable	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 (10) with "Oil Major" instead of "K-H" and "S-O"								
Oil Major × 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) but controlling for "Share Norway · Post"								
Oil Major × 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
Average dependent variable	–	0.580	2.015	0.097	0.060	1.864	2.356	0.156
Year FE	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	–	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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

Notes: Panel (a) presents estimated coefficients from regression (10) where we use the indicator variable "Oil Major" to distinguish oil majors from the other firms. The oil majors include the so-called "seven sisters" (Exxon, Mobil, Chevron, Texaco, Gulf Oil, Royal Dutch Shell, and BP) as well as other very large players of the time (Total, Eni, Phillips Petroleum, Conoco, Amoco). Panel (b) additionally controls for "Share Norway · Post," which is firm i's share of EOR-eligible fields in the North Sea before 1985 times the post-1985 indicator. The dependent variables are the numbers of different types of EOR-eligible fields (Columns 1-4) and of different types of non-EOR-eligible fields (Columns 5-8) that were 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. EOR cannot be implemented with heavy oil, hence Column 1 is empty. All regressions control for firm and year fixed-effects. Standard errors are clustered at the firm level.

Table F6: Know-how and technological diversification (including state-owned firms without know-how)

	Diversification in Technology Portfolio (1−HHI)					
Dependent variable	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	-1.491**	-1.264**	-1.069*	-1.251**	-1.500***	-1.134**
	(0.581)	(0.530)	(0.575)	(0.585)	(0.466)	(0.542)
Share EOR × Post	-0.721**	-0.411	-0.671**	-0.572*	-0.495*	-0.573**
	(0.295)	(0.274)	(0.279)	(0.297)	(0.279)	(0.282)
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) & State-Owned (S-O)						
K-H & S-O × Share EOR Norway × Post	2.287***	1.391	1.906**	2.519***	1.483**	2.031**
	(0.674)	(0.853)	(0.857)	(0.649)	(0.695)	(0.883)
K-H Only × Share EOR Norway × Post	3.520***	4.996***	4.332***	5.809***	4.278***	3.523***
	(0.848)	(0.916)	(1.133)	(0.812)	(0.888)	(1.174)
S-O Only × Share EOR Norway × Post	-2.161***	-1.867***	-1.024	-2.009***	-1.464***	-1.001*
	(0.578)	(0.549)	(0.638)	(0.527)	(0.469)	(0.592)
Share EOR Norway × Post	-1.478**	-1.257**	-1.208*	-1.344**	-1.538***	-1.264**
	(0.591)	(0.570)	(0.660)	(0.555)	(0.493)	(0.616)
Observations	1406	1406	1406	1406	1406	1406
R-squared	0.39	0.33	0.39	0.33	0.39	0.33
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

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

Notes: Panel (a) presents estimated coefficients from regression (8) and Panel (b) from regression (10). The dependent variables evaluate technological diversification according to (11) across technology types (Columns 1-2), field characteristics (Columns 3-4), and technology-related expenditures (Column 5-6). See main text for more details. Each dependent variable is standardized. In Panel (b), firms are divided into four categories based on the indicator variables "K-H" (know-how) and "S-O" (state ownership). "K-H" equals 1 if firm i was an operator in a field that adopted EOR before 1985, while "S-O" equals 1 if firm i was state owned during 1975-1995. Because some firms possessed both know-how and were state owned, we create 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. "Share EOR Norway" is the pre-1985 share of firm i's fields that were eligible for EOR. The indicator "Post" equals 1 for the years after 1985, the year of the Supreme Court decision, and 0 otherwise. All regressions control for "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 F7: Oil majors and technological diversification

Dependent variable	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)
Panel (a): Regression (10) with "Oil Major" instead of "K-H" and "S-O"						
Oil Major × Share EOR Norway × Post	0.094	0.561	0.171	0.120	0.569	0.178
	(1.068)	(1.413)	(1.304)	(1.369)	(1.142)	(1.268)
Share EOR Norway × Post	-1.156	-1.096	-0.911	-0.927	-1.394**	-0.985
	(0.819)	(0.686)	(0.841)	(0.768)	(0.619)	(0.779)
Share EOR × Post	-0.723**	-0.410	-0.667**	-0.571*	-0.494*	-0.570**
	(0.297)	(0.275)	(0.281)	(0.298)	(0.280)	(0.283)
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) but controlling for "Share Norway · Post"						
Oil Major × Share EOR Norway × Post	-0.001	0.243	0.257	0.092	0.573	0.089
	(0.410)	(0.490)	(1.276)	(1.386)	(1.146)	(1.314)
Share EOR Norway × Post	-0.298	-0.586	-1.326	-0.888	-1.485	-0.703
	(0.623)	(0.586)	(1.766)	(1.716)	(1.573)	(1.675)
Share EOR × Post	-0.328***	-0.170*	-0.756***	-0.726**	-0.631**	-0.757***
	(0.103)	(0.090)	(0.259)	(0.278)	(0.263)	(0.258)
Share Norway × Post	-0.099	0.120	0.243	-0.077	0.013	-0.248
	(0.358)	(0.364)	(1.060)	(1.022)	(0.977)	(0.971)
Observations	1353	1353	1353	1353	1353	1353
R-squared	0.38	0.32	0.38	0.32	0.38	0.32
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Panel (a) presents estimated coefficients from regression (10) where we use the indicator variable "Oil Major" to distinguish oil majors from the other firms. The oil majors include the so-called "seven sisters" (Exxon, Mobil, Chevron, Texaco, Gulf Oil, Royal Dutch Shell, and BP) as well as other very large players of the time (Total, Eni, Phillips Petroleum, Conoco, Amoco). Panel (b) additionally controls for "Share Norway · Post," which is firm i's share of EOR-eligible fields in the North Sea before 1985 times the post-1985 indicator. The dependent variables evaluate technological diversification according to (11) across technology types (Columns 1-2), field characteristics (Columns 3-4), and technology-related expenditures (Column 5-6). See main text for more details. Each dependent variable is standardized. All regressions control for firm and year fixed effects. Standard errors are clustered at the firm level.

G Geographic Proximity to Fields Adopting EOR

We investigate whether geographic proximity to a field that already adopted EOR before 1985 increased the likelihood of EOR adoption after 1985. To do this, we extend field-level regression (A10) by interacting the treatment with G-P$_f$, defined as the inverse distance to the nearest pre-1985 EOR-adopting field:

$$
\begin{aligned}
\mathbb{1}\{\text{Adopted EOR}_{ft}\} = {} & \beta_{\text{treat}} \cdot \text{G-P}_f \cdot \text{Norway}_f \cdot \text{EOR}_f \cdot \text{Post}_t \\
& + \beta_1 \cdot \text{G-P}_f \cdot \text{EOR}_f \cdot \text{Post}_t \\
& + \beta_2 \cdot \text{G-P}_f \cdot \text{Post}_t \\
& + \beta_3 \cdot \text{Norway}_f \cdot \text{EOR}_f \cdot \text{Post}_t \\
& + \beta_4 \cdot \text{Post}_t + \tau_f + \omega_{o(f)} + \iota_{c(f)t} + \epsilon_{ft},
\end{aligned}
\tag{G1}
$$

where $\omega_{o(f)}$ is an operator o-specific fixed effect which controls for the possibility that the same operator o was active in multiple fields and therefore that EOR adoption in nearby fields was driven by the same operator rather than by geographical proximity. Table G1 reports the estimation results, which show that geographical proximity to EOR-adopting fields played no role in subsequent EOR adoption. Though less precisely estimated, $\widehat{\beta}_3$ and $\widehat{\beta}_4$ are similar to the corresponding estimates in Column 1 of Appendix Table ??.

Table G1: EOR adoption and geographic proximity to adopting fields

Dept. var.	$\mathbb{1}\{\text{Adopted EOR}_{ft}\}$	
	(1)	(2)
G-P × Norway × EOR × Post (β_{treat})	0.394	-0.091
	(1.383)	(1.546)
G-P × EOR × Post (β_1)	0.665	0.667
	(0.432)	(0.454)
G-P × Post (β_2)	0.044	0.043
	(0.032)	(0.033)
Norway × EOR × Post (β_3)	0.222	0.222
	(0.224)	(0.235)
EOR × Post (β_4)	0.009	0.021
	(0.021)	(0.024)
Country-Year FE	Yes	Yes
Field FE	Yes	Yes
Operator FE	No	Yes
Observations	1989	1808
R-squared	0.85	0.86

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

Notes: Estimated coefficients from field-level regression (A10). The dependent variable is an indicator equal to 1 if field f has adopted EOR by year t and 0 otherwise. Variable G-P$_f$ is field f's inverse distance to the nearest pre-1985 EOR-adopting 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. Column 2 additionally controls for operator fixed effects. Standard errors are clustered at the field level.

H 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 O&G 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 O&G 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 sub-sea wells connected to a platform, often used for remote or deepwater O&G 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 Technologies (for hydrocarbon recovery). These technologies are used for increasing the recovery rate or enhancing production by maintaining or improving reservoir pressure.

- **Artificial Lift**—*Primary Recovery* 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.