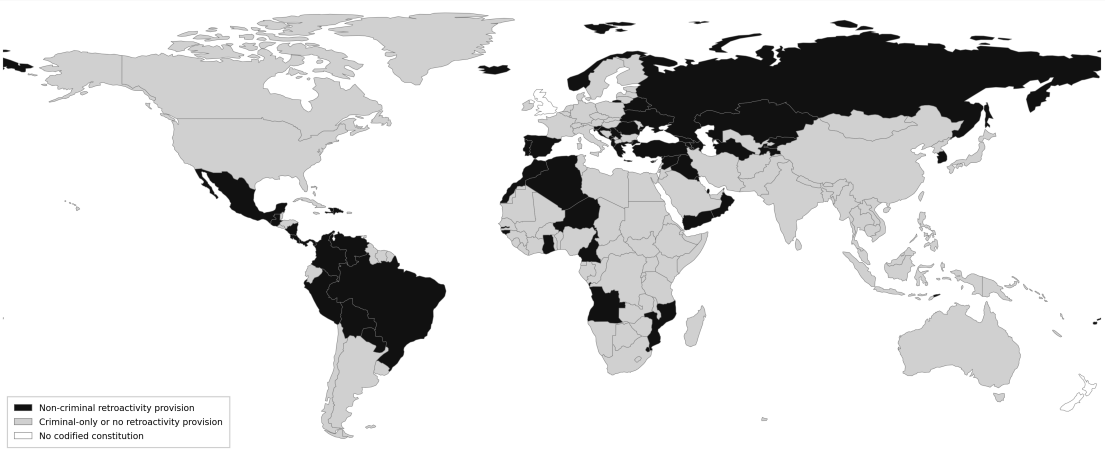

Sovereign Hold-Up and Technology Adoption: Evidence from Oil & Gas

Michele Fioretti *Bocconi* · Alessandro Iaria *Bristol* · Aljoscha Janssen *SMU* · Clément Mazet-Sonilhac *Bocconi* · Robert K. Perrons *QUT*

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- This paper: how credible commitment mobilizes know-how within firms

The Hold-Up Technology: Enhanced Oil Recovery (EOR)

- *Hold-up bites hardest when investment is:*
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  - Long payback
  - Asset-specific

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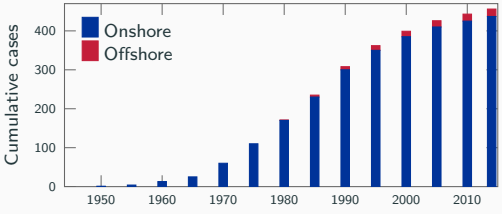


437 onshore vs. **19 offshore** EOR cases globally (1945–2015)

6 of 7 pre-1990 offshore cases: North Sea

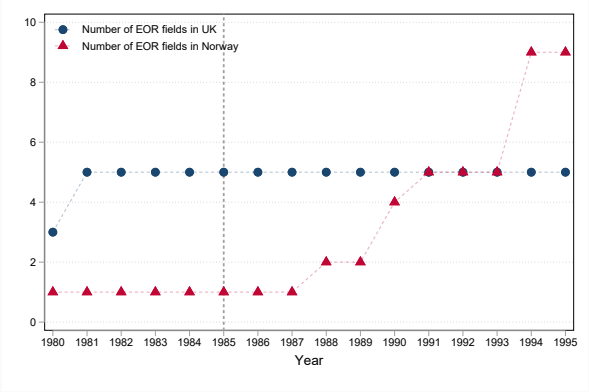
→ Our laboratory IS the offshore frontier

Cumulative figures: Kang et al. (2016)

▸ Other techs

A Quasi-Natural Experiment in the North Sea

- 1985 Norwegian Supreme Court ruling
  - Bars unilateral retroactive license changes
- Two similar regimes diverge:
  - Norway: gains credible commitment
  - UK: retains parliamentary sovereignty
- Sharp divergence in **Enhanced Oil Recovery** adoption
  - Norway: EOR fields rise from 1 to 9
  - UK: stays near 5



Number of EOR fields by country, 1980–1995

Vertical line: 1985 ruling

Preview: Three Findings

1. **Credible commitment unlocks adoption & productivity**
   - 10 pp more Norwegian EOR-eligible fields $\Rightarrow$ $+3.5$ pp EOR adoption (doubles the rate)
   - Production rises $\approx 38\%$; market share rises $\approx 39\%$

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3. **Adoption unlocks technological diversification**
   - K-H firms diversify into *related* extraction tech, not distant from EOR
   - *Path dependence:* learning decays with technological distance

Contribution to the Literature

1. **Hold-up, incomplete contracts & institutional quality**
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   → From *policy uncertainty* to sovereign commitment credibility

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4. **Technology adoption, absorptive capacity & firm capabilities**
   - Arrow (1962), Cohen & Levinthal (1990), Griffith, Redding & Van Reenen (2003, 2004), Aghion & Jaravel (2015), Kellogg (2011)
   - → Sovereign hold-up arrests the deployment of absorptive capacity; commitment unlocks it

Roadmap

1. **Setting and Data**
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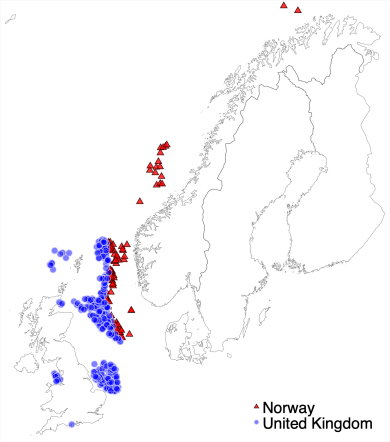
Data: The North Sea, 1975–1995

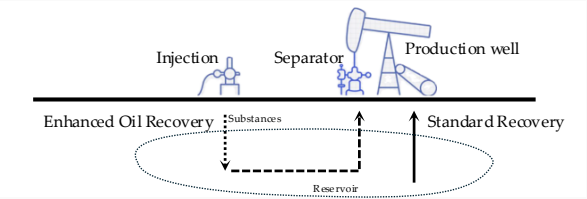
- **Wood Mackenzie** firm-field-year panel
  - UK (•): 426 fields Norway (▲): 95 fields
  - 71 firms; 10 yrs pre / 10 yrs post 1985
- Each field is a **joint venture** among firms
  - Costs & profits accrue *pro-rata* to equity holders
  - One firm is the **operator**: makes production, CAPEX, and technology decisions
- Field-level: geology, technology, production, costs
- Firm-level: ownership-share aggregation
- **N. Sea = 96%** of UK + Norway O&G output
- **Similar geology**: 35–40% EOR-eligible *in both* ▸ Stats



N. Sea O&G fields; cross-border continental shelf.

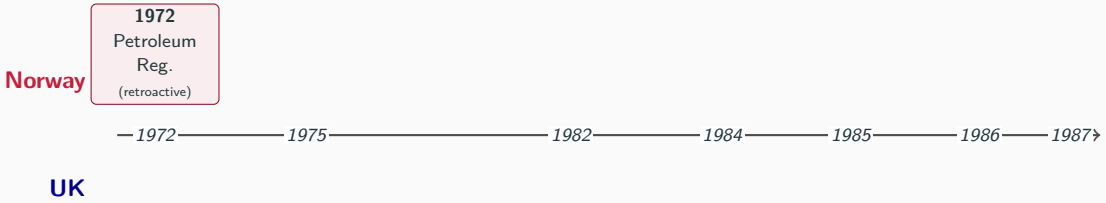
Enhanced Oil Recovery: How It Works

- EOR is a **tertiary** recovery stage:
  - Primary (natural pressure): 5–20% of OOIP
  - Secondary (water/gas flooding): 30–40%
  - Tertiary (EOR injection): 50–70%
- Three families of techniques:
  - Gas/CO_2 injection (most common offshore)
  - Chemical (polymers, surfactants)
  - Thermal (steam — mostly onshore)
- Geology-driven: $\sim$35% of N. Sea fields qualify
- Mature and off-the-shelf by the 1980s



EOR injects fluids that displace residual oil from the reservoir

The 1985 Norwegian Supreme Court Decision



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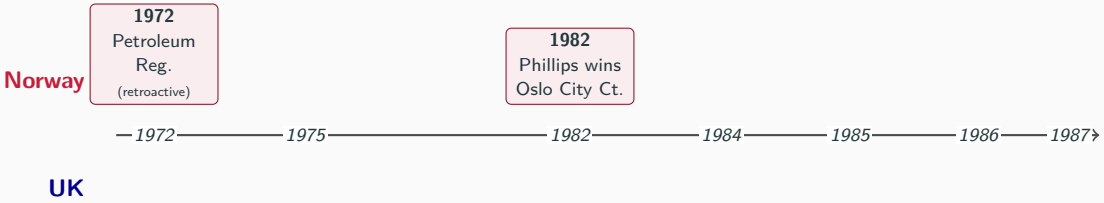

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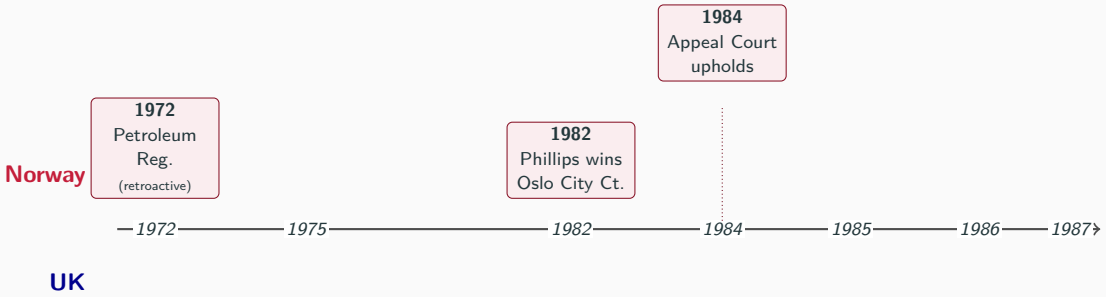

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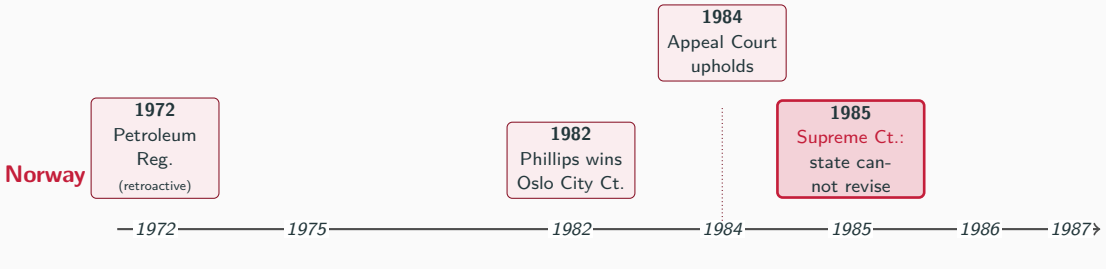

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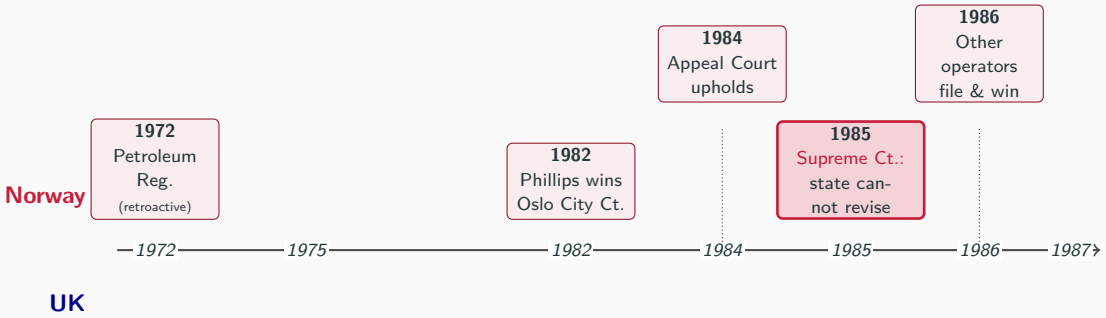

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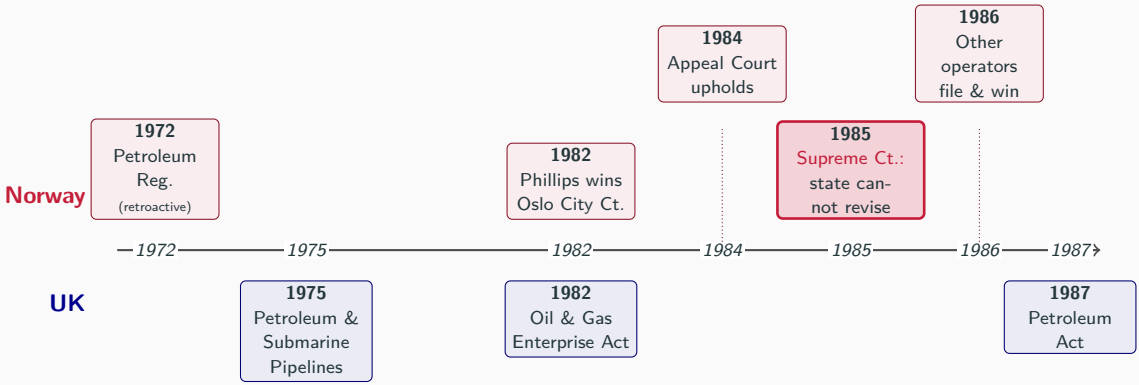

→ **Asymmetric shock to adoption incentives in Norway vs. the UK**

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- 1985 ruling raises $\Delta\Pi$ *only* for Norwegian EOR-eligible fields $\Rightarrow A^*_{\text{post,Norway}} < A^*_{\text{pre}}$

Empirical Strategy: From Model to DiD

- Decomposing the post–pre expected change yields a DiD with two interactions: Derivation

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

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- Field-level robustness: triple-difference, country × EOR-eligibility × Post

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Only EOR Adoption & CAPEX Move – Not Technology Portfolios

Robustness

	EOR	Cum. CAPEX
Dep. variable	Adoption (Share) (1)	
Share EOR Norway × Post	0.230***	
	(0.053)	
Share EOR × Post	0.044**	
	(0.021)	
Avg. dep. var.	0.078	
Year FE	Yes	
Firm FE	Yes	
Observations	1406	
R-squared	0.67	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- 10 pp more Norwegian EOR-eligible fields ⇒ 2.3 pp higher EOR adoption (≈ 30% above the mean)

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	EOR	Cum. CAPEX
Dep. variable	Adoption (Share)	$\ln(1+\cdot)$
	(1)	(2)
Share EOR Norway × Post	0.230***	2.108***
	(0.053)	(0.647)
Share EOR × Post	0.044**	−0.470**
	(0.021)	(0.210)
Avg. dep. var.	0.078	6.69
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observations	1406	1406
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	EOR	Cum. CAPEX	Technological Portfolio Diversification ($1 - HHI$)
Dep. variable	Adoption (Share)	$\ln(1+\cdot)$	Exploration & Prod. Tech
	(1)	(2)	(3)
Share EOR Norway × Post	0.230***	2.108***	−1.131*
	(0.053)	(0.647)	(0.641)
Share EOR × Post	0.044**	−0.470**	−0.723**
	(0.021)	(0.210)	(0.297)
Avg. dep. var.	0.078	6.69	0.219
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	1406	1406	1377
R-squared	0.67	0.94	0.36

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- Technology portfolios are *not* broadened on average

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Robustness

	EOR	Cum. CAPEX	Technological Portfolio Diversification ($1 - HHI$)	
Dep. variable	Adoption (Share)	$\ln(1+\cdot)$	Exploration & Prod. Tech	Extraction Technologies
	(1)	(2)	(3)	(4)
Share EOR Norway × Post	0.230***	2.108***	−1.131*	−0.944
	(0.053)	(0.647)	(0.641)	(0.609)
Share EOR × Post	0.044**	−0.470**	−0.723**	−0.407
	(0.021)	(0.210)	(0.297)	(0.275)
Avg. dep. var.	0.078	6.69	0.219	0.308
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Dep. variable	Adoption (Share)	$\ln(1+\cdot)$	Exploration & Prod. Tech	Extraction Technologies	Well Depth
	(1)	(2)	(3)	(4)	(5)
Share EOR Norway × Post	0.230***	2.108***	−1.131*	−0.944	−0.865
	(0.053)	(0.647)	(0.641)	(0.609)	(0.683)
Share EOR × Post	0.044**	−0.470**	−0.723**	−0.407	−0.666**
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Dep. variable	Adoption (Share)	$\ln(1+\cdot)$	Exploration & Prod. Tech	Extraction Technologies	Well Depth	Reservoir Size
	(1)	(2)	(3)	(4)	(5)	(6)
Share EOR Norway × Post	0.230***	2.108***	−1.131*	−0.944	−0.865	−0.894
	(0.053)	(0.647)	(0.641)	(0.609)	(0.683)	(0.655)
Share EOR × Post	0.044**	−0.470**	−0.723**	−0.407	−0.666**	−0.570*
	(0.021)	(0.210)	(0.297)	(0.275)	(0.281)	(0.298)
Avg. dep. var.	0.078	6.69	0.219	0.308	0.337	0.318
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1406	1406	1377	1377	1377	1377
R-squared	0.67	0.94	0.36	0.31	0.34	0.32

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- 10 pp more Norwegian EOR-eligible fields ⇒ 2.3 pp higher EOR adoption (≈ 30% above the mean)
- Cumulative CAPEX rises by ≈ 23%
- Technology portfolios are *not* broadened on average
  - Of all the technologies a firm could deploy, only EOR moves

Identification: Within-Firm & Operator-Share Tests

Operators with larger stakes drive adoption

Higher operator share $\Rightarrow$ more surplus internalized $\Rightarrow$ lower A^*

	EOR Adoption
	(1)
Norway × EOR × Post	0.276**
	(0.119)
EOR × Post	0.065*
	(0.034)
Norway × EOR × Post × High Op. Share	
Avg. dep. var.	0.079
Country-Year FE	Yes
Field FE	Yes
Observations	1,989

SE clustered at the field level. High Op. Share = above median.

- Baseline triple: 0.276**

Identification: Within-Firm & Operator-Share Tests

Operators with larger stakes drive adoption

Higher operator share $\Rightarrow$ more surplus internalized $\Rightarrow$ lower A^*

	EOR Adoption	
	(1)	(2)
Norway × EOR × Post	0.276**	0.076
	(0.119)	(0.085)
EOR × Post	0.065*	0.065**
	(0.034)	(0.033)
Norway × EOR × Post × High Op. Share		0.260**
		(0.123)
Avg. dep. var.	0.079	0.079
Country-Year FE	Yes	Yes
Field FE	Yes	Yes
Observations	1,989	1,771

SE clustered at the field level. High Op. Share = above median.

- Baseline triple: 0.276**
- High-Op-Share interaction absorbs the average effect
- Direct test of the model's comparative static on s

Identification: Within-Firm & Operator-Share Tests

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	(1)	(2)
Norway × EOR × Post	0.276**	0.076
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EOR × Post	0.065*	0.065**
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Norway × EOR × Post × High Op. Share		0.260**
		(0.123)
Avg. dep. var.	0.079	0.079
Country-Year FE	Yes	Yes
Field FE	Yes	Yes
Observations	1,989	1,771

SE clustered at the field level. High Op. Share = above median.

- Baseline triple: 0.276**
- High-Op-Share interaction absorbs the average effect
- Direct test of the model's comparative static on *s*

Same firm, fields across UK–Norway border

Firm × year FE absorbs all firm-level confounds

	EOR Adoption
	(1)
EOR-Elig. × Norway × Post	0.312***
	(0.084)
Avg. dep. var.	0.089
Firm × Year FE	Yes
Field FE	Yes
Observations	8,005
Clusters (fields)	231

SE clustered at the field level.

- Effect is identified *within* a firm, in the same year

Identification: Within-Firm & Operator-Share Tests

Operators with larger stakes drive adoption

Higher operator share ⇒ more surplus internalized ⇒ lower A^*

	EOR Adoption	
	(1)	(2)
Norway × EOR × Post	0.276**	0.076
	(0.119)	(0.085)
EOR × Post	0.065*	0.065**
	(0.034)	(0.033)
Norway × EOR × Post × High Op. Share		0.260**
		(0.123)
Avg. dep. var.	0.079	0.079
Country-Year FE	Yes	Yes
Field FE	Yes	Yes
Observations	1,989	1,771

SE clustered at the field level. High Op. Share = above median.

- Baseline triple: 0.276**
- High-Op-Share interaction absorbs the average effect
- Direct test of the model's comparative static on *s*

Same firm, fields across UK–Norway border

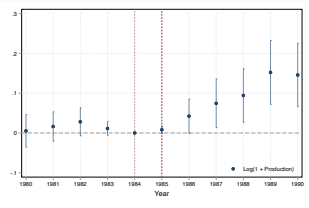
Firm × year FE absorbs all firm-level confounds

	EOR Adoption	Log Production
	(1)	(2)
EOR-Elig. × Norway × Post	0.312***	0.503**
	(0.084)	(0.237)
Avg. dep. var.	0.089	0.823
Firm × Year FE	Yes	Yes
Field FE	Yes	Yes
Observations	8,005	8,005
Clusters (fields)	231	231

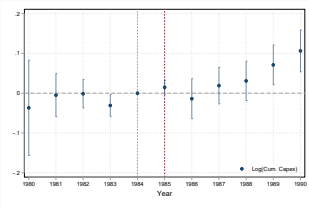
SE clustered at the field level.

- Effect is identified *within* a firm, in the same year
- Rules out financial, strategic, productivity firm-level confounds

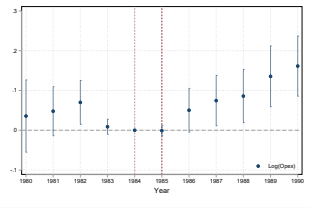
Within-Firm Evidence: Event Studies on Exposed Firms



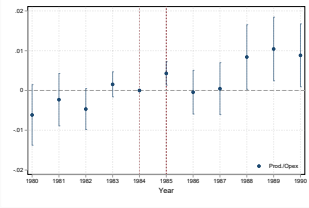
$\ln(1 + \text{prod}_{it})$



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



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



$\text{prod}_{it}/\text{OPEX}_{it}$

Production & Market Shares

Field-level concentration

	Production
Dep. variable	$\ln(1 + \text{prod}_{it})$
	(1)
Share EOR Norway × Post	3.193***
	(0.831)
Share EOR × Post	−0.402
	(0.266)
Avg. dep. var.	2.562
Year FE	Yes
Firm FE	Yes
Observations	1,406
R-squared	0.86

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- Exposed firms increase production by $\approx 38\%$

Production & Market Shares

Field-level concentration

	Production	Market Share	
Dep. variable	$\ln(1 + \text{prod}_{it})$	**All**	
	(1)	(2)	
Share EOR Norway × Post	3.193***	0.039*	
	(0.831)	(0.021)	
Share EOR × Post	−0.402	−0.000	
	(0.266)	(0.003)	
Avg. dep. var.	2.562	0.015	
Year FE	Yes	Yes	
Firm FE	Yes	Yes	
Observations	1,406	1,406	
R-squared	0.86	0.83	

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- Exposed firms increase production by $\approx 38\%$
- Market share rises by $\approx 39\%$

Production & Market Shares

Field-level concentration

	Production	Market Share	
Dep. variable	$\ln(1 + \text{prod}_{it})$	All	Positive
	(1)	(2)	(3)
Share EOR Norway × Post	3.193***	0.039*	0.073**
	(0.831)	(0.021)	(0.033)
Share EOR × Post	−0.402	−0.000	0.001
	(0.266)	(0.003)	(0.003)
Avg. dep. var.	2.562	0.015	0.017
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	1,406	1,406	1,232
R-squared	0.86	0.83	0.86

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- Exposed firms increase production by $\approx 38\%$
- Market share rises by $\approx 39\%$

Production & Market Shares

Field-level concentration

	Production	Market Share		Number of Fields
Dep. variable	$\ln(1+\text{prod}_{it})$	All	Positive	All Fields
	(1)	(2)	(3)	(4)
Share EOR Norway × Post	3.193***	0.039*	0.073**	10.417**
	(0.831)	(0.021)	(0.033)	(4.308)
Share EOR × Post	−0.402	−0.000	0.001	−7.567***
	(0.266)	(0.003)	(0.003)	(1.488)
Avg. dep. var.	2.562	0.015	0.017	5.858
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	1,406	1,406	1,232	1,406
R-squared	0.86	0.83	0.86	0.81

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- Exposed firms increase production by $\approx 38\%$
- Market share rises by $\approx 39\%$
- Portfolio expands by ≈ 1 new field per 10 pp; 56% EOR-eligible (cols 5–6)

Production & Market Shares

Field-level concentration

	Production	Market Share		Number of Fields	
Dep. variable	$\ln(1+\text{prod}_{it})$	All	Positive	All Fields	EOR Eligible
	(1)	(2)	(3)	(4)	(5)
Share EOR Norway × Post	3.193***	0.039*	0.073**	10.417**	5.885***
	(0.831)	(0.021)	(0.033)	(4.308)	(2.207)
Share EOR × Post	−0.402	−0.000	0.001	−7.567***	−1.845***
	(0.266)	(0.003)	(0.003)	(1.488)	(0.614)
Avg. dep. var.	2.562	0.015	0.017	5.858	2.410
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	1,406	1,406	1,232	1,406	1,406
R-squared	0.86	0.83	0.86	0.81	0.80

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- Exposed firms increase production by $\approx 38\%$
- Market share rises by $\approx 39\%$
- Portfolio expands by ≈ 1 new field per 10 pp; 56% EOR-eligible (cols 5–6)

Production & Market Shares

Field-level concentration

	Production	Market Share		Number of Fields		
Dep. variable	$\ln(1+\text{prod}_{it})$	All	Positive	All Fields	EOR Eligible	Non-EOR Eligible
	(1)	(2)	(3)	(4)	(5)	(6)
Share EOR Norway × Post	3.193***	0.039*	0.073**	10.417**	5.885***	4.532**
	(0.831)	(0.021)	(0.033)	(4.308)	(2.207)	(2.253)
Share EOR × Post	−0.402	−0.000	0.001	−7.567***	−1.845***	−5.722***
	(0.266)	(0.003)	(0.003)	(1.488)	(0.614)	(1.043)
Avg. dep. var.	2.562	0.015	0.017	5.858	2.410	3.449
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,406	1,406	1,232	1,406	1,406	1,406
R-squared	0.86	0.83	0.86	0.81	0.80	0.79

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- Exposed firms increase production by $\approx 38\%$
- Market share rises by $\approx 39\%$
- Portfolio expands by ≈ 1 new field per 10 pp; 56% EOR-eligible (cols 5–6)

Roadmap

1. Setting and Data
2. Empirical Strategy
3. Effects: Adoption & Reallocation
4. **Mechanism: Know-How vs. State Ownership**
5. Global Relevance & Conclusion

Know-How vs. State Ownership: Empirical Strategy

- Augmented regression separates two firm characteristics:

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

- $\text{K-H}_i = 1$ if firm i *operated* a North Sea field that adopted EOR pre-1985
- $\text{S-O}_i = 1$ if firm i was state-owned in 1975–1995
- Three groups: K-H & S-O (Statoil, BP), K-H Only (Conoco, Mobil, Shell), other

Mechanism: Know-How – not State Ownership – Drives Gains

	Production
Dep. variable	$\ln(1 + \text{prod}_{it})$
	(1)
K-H & S-O × Share EOR Norway × Post	1.747^{***}
	(0.469)
K-H Only × Share EOR Norway × Post	-1.250^{*}
	(0.695)
Share EOR Norway × Post	2.236^{***}
	(0.359)
Avg. dep. var.	2.531
Share EOR × Post	Yes
Year FE, Firm FE	Yes
Observations	1,378
R-squared	0.46

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- K-H Only firms forgo immediate production (-1.25); they redeploy know-how into portfolio expansion

Mechanism: Know-How – not State Ownership – Drives Gains

	Production	Market
Dep. variable	$\ln(1 + \text{prod}_{it})$	Share
	(1)	(2)
K-H & S-O × Share EOR Norway × Post	1.747***	0.132***
	(0.469)	(0.025)
K-H Only × Share EOR Norway × Post	−1.250*	0.050**
	(0.695)	(0.023)
Share EOR Norway × Post	2.236***	0.010**
	(0.359)	(0.005)
Avg. dep. var.	2.531	0.012
Share EOR × Post	Yes	Yes
Year FE, Firm FE	Yes	Yes
Observations	1,378	1,377
R-squared	0.46	0.89

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- K-H Only firms forgo immediate production (−1.25); they redeploy know-how into portfolio expansion
- K-H Only firms drive market-share gains (col 2)

Mechanism: Know-How – not State Ownership – Drives Gains

	Production	Market	Number of Fields
Dep. variable	$\ln(1 + \text{prod}_{it})$	Share	All Fields
	(1)	(2)	(3)
K-H & S-O × Share EOR Norway × Post	1.747***	0.132***	28.155***
	(0.469)	(0.025)	(9.825)
K-H Only × Share EOR Norway × Post	−1.250*	0.050**	47.503***
	(0.695)	(0.023)	(10.474)
Share EOR Norway × Post	2.236***	0.010**	−1.787
	(0.359)	(0.005)	(3.452)
Avg. dep. var.	2.531	0.012	5.216
Share EOR × Post	Yes	Yes	Yes
Year FE, Firm FE	Yes	Yes	Yes
Observations	1,378	1,377	1,377
R-squared	0.46	0.89	0.85

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- K-H Only firms forgo immediate production (−1.25); they redeploy know-how into portfolio expansion
- K-H Only firms drive market-share gains (col 2)

Mechanism: Know-How – not State Ownership – Drives Gains

	Production	Market	Number of Fields	
Dep. variable	$\ln(1 + \text{prod}_{it})$	Share	All Fields	EOR Eligible
	(1)	(2)	(3)	(4)
K-H & S-O × Share EOR Norway × Post	1.747***	0.132***	28.155***	9.287***
	(0.469)	(0.025)	(9.825)	(2.799)
K-H Only × Share EOR Norway × Post	−1.250*	0.050**	47.503***	10.545**
	(0.695)	(0.023)	(10.474)	(4.858)
Share EOR Norway × Post	2.236***	0.010**	−1.787	2.375
	(0.359)	(0.005)	(3.452)	(2.135)
Avg. dep. var.	2.531	0.012	5.216	2.116
Share EOR × Post	Yes	Yes	Yes	Yes
Year FE, Firm FE	Yes	Yes	Yes	Yes
Observations	1,378	1,377	1,377	1,377
R-squared	0.46	0.89	0.85	0.82

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- K-H Only firms forgo immediate production (−1.25); they redeploy know-how into portfolio expansion
- K-H Only firms drive market-share gains (col 2)

Mechanism: Know-How – not State Ownership – Drives Gains

	Production	Market	Number of Fields		
Dep. variable	$\ln(1+\text{prod}_{it})$	Share	All Fields	EOR Eligible	Non-EOR Eligible
	(1)	(2)	(3)	(4)	(5)
K-H & S-O × Share EOR Norway × Post	1.747***	0.132***	28.155***	9.287***	18.868**
	(0.469)	(0.025)	(9.825)	(2.799)	(7.804)
K-H Only × Share EOR Norway × Post	−1.250*	0.050**	47.503***	10.545**	36.958***
	(0.695)	(0.023)	(10.474)	(4.858)	(6.249)
Share EOR Norway × Post	2.236***	0.010**	−1.787	2.375	−4.162**
	(0.359)	(0.005)	(3.452)	(2.135)	(1.680)
Avg. dep. var.	2.531	0.012	5.216	2.116	3.100
Share EOR × Post	Yes	Yes	Yes	Yes	Yes
Year FE, Firm FE	Yes	Yes	Yes	Yes	Yes
Observations	1,378	1,377	1,377	1,377	1,377
R-squared	0.46	0.89	0.85	0.82	0.84

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the firm level.

- K-H Only firms forgo immediate production (−1.25); they redeploy know-how into portfolio expansion
- K-H Only firms drive market-share gains (col 2)
- Portfolio expansion: K-H Only firms acquire ∼5 new fields per 10 pp exposure
- State ownership *alone* does not explain the gains ▸ K-H ▸ S-O

Know-How Also Unlocks Technological Diversification

Dept. var. (Standardized)	Diversification in Technology Portfolio (1 - HHI)					
	Exploration & Prod. Tech. (1)	**Extraction Technologies** (2)	**Well Depth** (3)	**Reservoir Size** (4)	**Tariff Intensity** (5)	**Capex Intensity** (6)
K-H & S-O × Share EOR Norway × Post						
K-H Only × Share EOR Norway × Post						
Share EOR Norway × Post						
Observations						
R-squared						
Share EOR × Post						
Year FE						
Firm FE						
Avg. dep. var.						

Know-How Also Unlocks Technological Diversification

Dept. var. (Standardized)	Diversification in Technology Portfolio (1 - HHI)					
	Exploration & Prod. Tech. (1)	**Extraction Technologies** (2)	**Well Depth** (3)	**Reservoir Size** (4)	**Tariff Intensity** (5)	**Capex Intensity** (6)
K-H & S-O × Share EOR Norway × Post	2.301***					
	(0.679))					
K-H Only × Share EOR Norway × Post	3.546***					
	(0.854)					
Share EOR Norway × Post	-1.481**					
	(0.595)					
Observations	1377					
R-squared	0.37					
Share EOR × Post	Yes					
Year FE	Yes					
Firm FE	Yes					
Avg. dep. var.	0.219					

- Average firm did not diversify; K-H Only firms diversify $\sim$1.5–3.5$\times$ more

Know-How Also Unlocks Technological Diversification

Dept. var. (Standardized)	Diversification in Technology Portfolio (1 - HHI)					
	Exploration & Prod. Tech. (1)	**Extraction Technologies** (2)	**Well Depth** (3)	**Reservoir Size** (4)	**Tariff Intensity** (5)	**Capex Intensity** (6)
K-H & S-O × Share EOR Norway × Post	2.301***	1.419				
	(0.679))	(0.861)				
K-H Only × Share EOR Norway × Post	3.546***	5.055***				
	(0.854)	(0.920)				
Share EOR Norway × Post	-1.481**	-1.257**				
	(0.595)	(0.576)				
Observations	1377	1377				
R-squared	0.37	0.32				
Share EOR × Post	Yes	Yes				
Year FE	Yes	Yes				
Firm FE	Yes	Yes				
Avg. dep. var.	0.219	0.308				

- Average firm did not diversify; K-H Only firms diversify $\sim$1.5–3.5$\times$ more
- Concentrated in *related* extraction technologies, not in distant E&P

Know-How Also Unlocks Technological Diversification

Dept. var. (Standardized)	Diversification in Technology Portfolio (1 - HHI)					
	Exploration & Prod. Tech. (1)	**Extraction Technologies** (2)	**Well Depth** (3)	**Reservoir Size** (4)	**Tariff Intensity** (5)	**Capex Intensity** (6)
K-H & S-O × Share EOR Norway × Post	2.301***	1.419	1.928**			
	(0.679))	(0.861)	(0.864)			
K-H Only × Share EOR Norway × Post	3.546***	5.055***	4.380***			
	(0.854)	(0.920)	(1.134)			
Share EOR Norway × Post	-1.481**	-1.257**	-1.206*			
	(0.595)	(0.576)	(0.665)			
Observations	1377	1377	1377			
R-squared	0.37	0.32	0.35			
Share EOR × Post	Yes	Yes	Yes			
Year FE	Yes	Yes	Yes			
Firm FE	Yes	Yes	Yes			
Avg. dep. var.	0.219	0.308	0.337			

- Average firm did not diversify; K-H Only firms diversify $\sim$1.5–3.5$\times$ more
- Concentrated in *related* extraction technologies, not in distant E&P

Know-How Also Unlocks Technological Diversification

Dept. var. (Standardized)	Diversification in Technology Portfolio (1 - HHI)					
	Exploration & Prod. Tech. (1)	Extraction Technologies (2)	Well Depth (3)	Reservoir Size (4)	Tariff Intensity (5)	Capex Intensity (6)
K-H & S-O × Share EOR Norway × Post	2.301***	1.419	1.928**	2.542***		
	(0.679))	(0.861)	(0.864)	(0.656)		
K-H Only × Share EOR Norway × Post	3.546***	5.055***	4.380***	5.855***		
	(0.854)	(0.920)	(1.134)	(0.820)		
Share EOR Norway × Post	-1.481**	-1.257**	-1.206*	-1.347**		
	(0.595)	(0.576)	(0.665)	(0.561)		
Observations	1377	1377	1377	1377		
R-squared	0.37	0.32	0.35	0.33		
Share EOR × Post	Yes	Yes	Yes	Yes		
Year FE	Yes	Yes	Yes	Yes		
Firm FE	Yes	Yes	Yes	Yes		
Avg. dep. var.	0.219	0.308	0.337	0.318		

- Average firm did not diversify; K-H Only firms diversify $\sim$1.5–3.5$\times$ more
- Concentrated in *related* extraction technologies, not in distant E&P

Know-How Also Unlocks Technological Diversification

Dept. var. (Standardized)	Diversification in Technology Portfolio (1 - HHI)					
	Exploration & Prod. Tech. (1)	**Extraction Technologies** (2)	**Well Depth** (3)	**Reservoir Size** (4)	**Tariff Intensity** (5)	**Capex Intensity** (6)
K-H & S-O × Share EOR Norway × Post	2.301***	1.419	1.928**	2.542***	1.504**	
	(0.679))	(0.861)	(0.864)	(0.656)	(0.701)	
K-H Only × Share EOR Norway × Post	3.546***	5.055***	4.380***	5.855***	4.321***	
	(0.854)	(0.920)	(1.134)	(0.820)	(0.892)	
Share EOR Norway × Post	-1.481**	-1.257**	-1.206*	-1.347**	-1.536***	
	(0.595)	(0.576)	(0.665)	(0.561)	(0.498)	
Observations	1377	1377	1377	1377	1377	
R-squared	0.37	0.32	0.35	0.33	0.34	
Share EOR × Post	Yes	Yes	Yes	Yes	Yes	
Year FE	Yes	Yes	Yes	Yes	Yes	
Firm FE	Yes	Yes	Yes	Yes	Yes	
Avg. dep. var.	0.219	0.308	0.337	0.318	0.342	

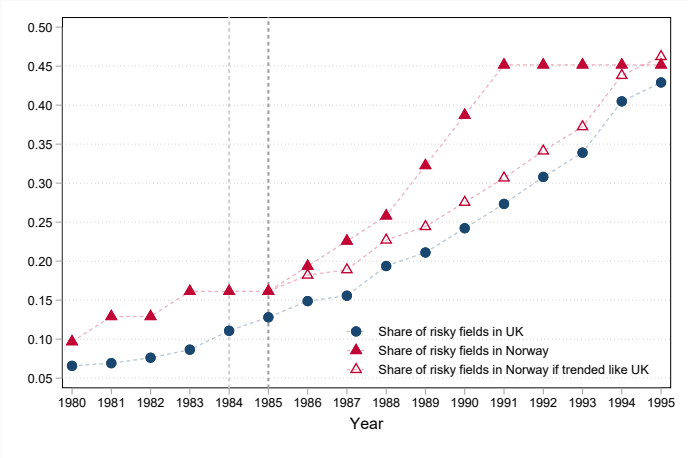
- Average firm did not diversify; K-H Only firms diversify $\sim$1.5–3.5$\times$ more
- Concentrated in *related* extraction technologies, not in distant E&P

Know-How Also Unlocks Technological Diversification

Dept. var. (Standardized)	Diversification in Technology Portfolio (1 - HHI)					
	Exploration & Prod. Tech. (1)	**Extraction Technologies** (2)	**Well Depth** (3)	**Reservoir Size** (4)	**Tariff Intensity** (5)	**Capex Intensity** (6)
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
Avg. dep. var.	0.219	0.308	0.337	0.318	0.342	0.338

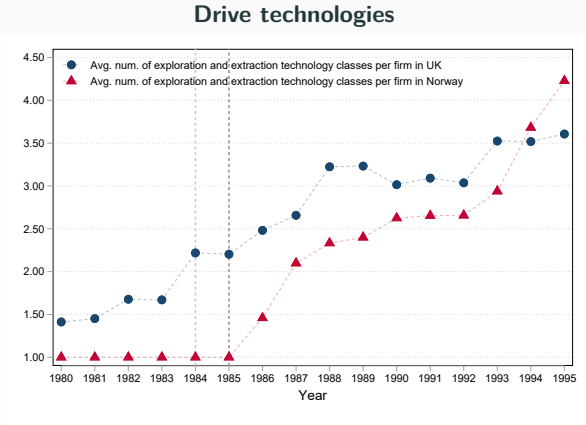
- Average firm did not diversify; K-H Only firms diversify $\sim$1.5–3.5$\times$ more
- Concentrated in *related* extraction technologies, not in distant E&P
- Consistent with **transferable** know-how: learning decays with distance

Norwegian Catch-Up in Developing Risky Fields



Share of risky (deep / sour / heavy) fields operated by private firms; state-owned firms excluded.

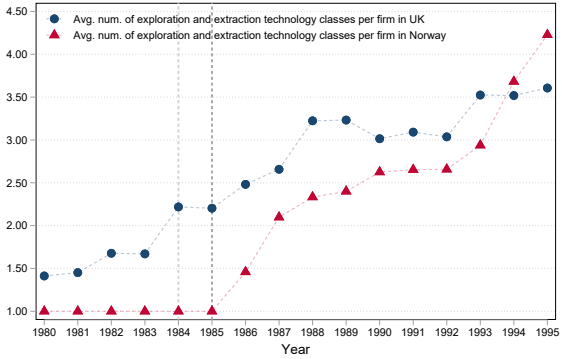
Technology Catch-Up: Norway Closes the Gap



Avg. # of drive technologies deployed per firm

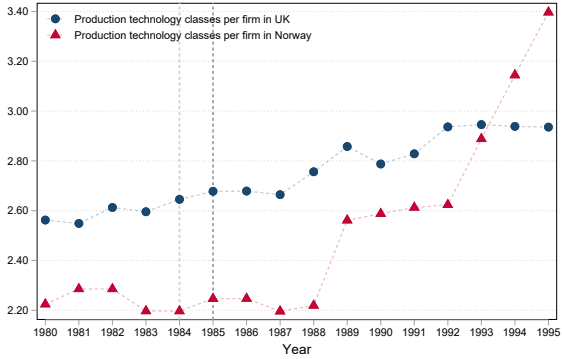
Technology Catch-Up: Norway Closes the Gap

Drive technologies



Avg. # of drive technologies deployed per firm

Extraction technologies

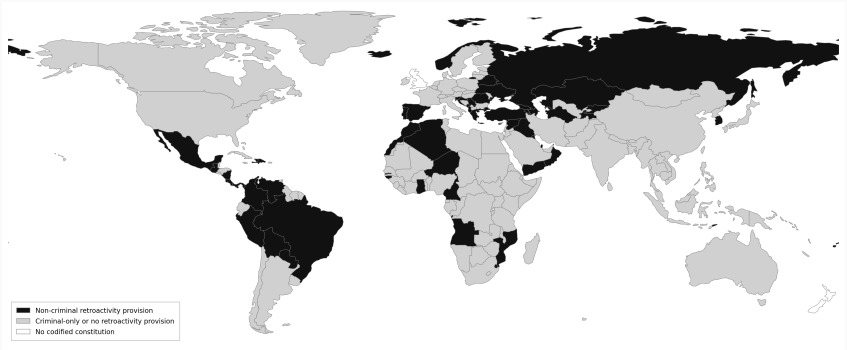


Avg. # of extraction technologies deployed per firm

Roadmap

1. Setting and Data
2. Empirical Strategy
3. Effects: Adoption & Reallocation
4. Mechanism: Know-How vs. State Ownership
5. **Global Relevance & Conclusion**

Sovereign Hold-Up Is a Global Problem



- LLM-assisted survey of 190 codified constitutions (CCP, audited)
- Only **30.6%** prohibit non-criminal retroactive legislation
  - Only 11 of 35 OECD members have such protections
- Long-horizon investments – energy transition, infrastructure – exposed

Sovereign Hold-Up in Action: Recent Episodes

Country	Year	Retroactive policy	Outcome
France	2021	Art. 225 LF cuts solar S06–S10 feed-in tariffs by up to **80%**	Conseil constit. 2021-820 DC: upheld
Italy	2014	DL 91 "spalma-incentivi" cuts Conto Energia tariffs for plants >200 kW	Corte Cost. 16/2017: upheld
Spain	2010–14	Royal decrees cut renewable tariffs retroactively	TC: upheld; lost >€1 bn in ECT arbitrations
UK	2011, 2022	Supplementary Charge 20%→32%; Energy Profits Levy on past months	No constitutional challenge
US	2025	Trump admin. cancels multi-year NSF grants already awarded	Litigation pending
Australia	2010	Mineral Resources Rent Tax applied to existing operations	Industry pushback; repealed 2014

- Same logic every time: a *public-interest* claim trumps investors' legitimate expectations
- None of these constitutions bar non-criminal retroactive legislation
- The 1985 Norwegian ruling is what every one of these systems is missing

Conclusion

Conclusion

Core message: By tying the state's hands, the 1985 ruling turned promises into **credible commitments** – an industrial policy unlocking technological deepening.

- **Adoption:** EOR jumps; technology portfolios otherwise unchanged on average
- **Productivity & reallocation:** +38% production, +39% market share, +1 field per 10 pp
- **Mechanism:** private K-H firms drive the transformation – not SOEs
- **Diversification:** K-H firms broaden into adjacent extraction technologies
- **Global relevance:** 30.6% of constitutions, 11 OECD members

Thank You

Appendix

Robustness Checks: Overview

Back

- **Identification: hold-up channel**
  - UK-only spillover test (R 2): Norway exposure on UK fields $\Rightarrow$ EOR adoption is *0.001* ($p = 0.96$)
  - UK privatization (R 2): drop UK govt.-linked firms; coefficient is unchanged ($3.193 \rightarrow 3.192$)
  - Depletion balance (R 2): the mature pool was British, not Norwegian
- **EOR is the special technology**
  - Placebo horse race (R 1): deep/sour/other exposures all null; only EOR moves
  - Border basins (R 1): restricting to shared cross-border basins yields the same triple
- **Inference**
  - Two-way clustering (R 1): SE rise $<$ 5%; significance preserved

UK-Only Spillover Test

Back

	EOR Adoption	Log Production
	(1)	(2)
Norway EOR Exposure × Post-1985	0.001	−0.035
	(0.025)	(0.194)
Avg. dep. var.	0.052	0.256
Observations	6,327	6,327
Clusters	187	187
Field FE, Year FE	Yes	Yes
Adj. R^2	0.86	0.58

Sample: UK fields only, 1975–1995. SE clustered at the field level.

- Even firms accumulating Norwegian EOR know-how *do not* adopt EOR on their UK fields
- **Sovereign hold-up** — not skill — is the binding constraint in the UK
- Any marginal production spillover biases our main DiD *downward* (conservative LB)

UK Privatization Is Not a Confound

Back

Dep. var.: ln(prod + 1)	**Baseline** (1)	**Drop all govt.** (2)	**Drop UK govt.** (3)	**Ctrl. govt. × Post** (4)
Share EOR Norway × Post	3.193***	2.160***	3.192***	2.843***
	(0.831)	(0.360)	(0.830)	(0.552)
Share EOR × Post	−0.402	−0.373	−0.401	−0.381
	(0.266)	(0.264)	(0.266)	(0.266)
Govt. × Post	—	—	—	0.881
				(0.767)
Avg. dep. var.	2.32	2.21	2.26	2.32
Year FE, Firm FE	Yes	Yes	Yes	Yes
Observations	1,406	1,328	1,365	1,406
R^2	0.86	0.87	0.86	0.87

Col. 2 drops Statoil, BP pre-1999, Britoil, BNOC, Norway State DFI. Col. 3 drops UK govt. firms only.

- Dropping BP (pre-1999), Britoil, and BNOC leaves the main coefficient unchanged
- Triple-difference design absorbs any pan-UK privatization effect

Pre-1985 Depletion Balance

Back

	Norway	UK	Difference	p-value
Panel A: How depleted were EOR-eligible fields by 1985?				
Cum. production by 1985 (kbl)	21,474	117,607	$-96{,}132^{**}$	0.032
Depletion (cum. prod / STOIIP, %)	4.8	87.9	-83.1^{***}	0.000
STOIIP (mbl)	1,554	1,131	423	0.312
Panel B: Field age in 1985				
Years since discovery	2.7	6.8	-4.1^{**}	0.039
Panel C: EOR-eligible fields producing by 1985				
Fraction = producing	2/30	22/50	$-37\%^{***}$	0.000

The mature pool was British, not Norwegian – and adopted EOR less.
Two-sample t-tests with unequal variances.

- By 1985, UK fields were **far more depleted** and **further along their decline curves**
- Yet UK adopted EOR *less* – ruling out the "mature fields drive adoption" confound

Placebo Horse Race: Only EOR Moves

Back

	$\ln(\text{prod}+1)$ (1)	prod/OPEX (2)	Mkt. Share (3)	Mkt. Share >0 (4)
Share EOR Norway × Post	3.482***	0.229***	0.038*	0.101***
	(0.857)	(0.048)	(0.021)	(0.033)
Share Deep Norway × Post	−0.292	−0.009	−0.002	−0.054*
	(0.620)	(0.124)	(0.011)	(0.029)
Share Sour Norway × Post	−1.700	−0.068	0.033	0.073*
	(1.618)	(0.210)	(0.045)	(0.038)
Share non-EOR other Norway × Post	0.413	0.103	−0.006	−0.008
	(0.667)	(0.120)	(0.015)	(0.022)
Avg. dep. var.	2.562	0.328	0.015	0.017
North-Sea level effects, Year FE, Firm FE	Yes	Yes	Yes	Yes
Observations	1,406	1,406	1,406	1,232
R^2	0.87	0.47	0.84	0.87

All non-EOR exposures controlled for the North-Sea-level term. SE clustered at the firm level.

- Exposures to non-EOR field types (deep, sour, other) yield null effects on every outcome
- Only the EOR-Norway exposure drives the post-1985 expansion

Geographic Proximity: Cross-Border Basins

Back

	All fields		Shared border basins	
	Log Prod	**Prod/OPEX**	**Log Prod**	**Prod/OPEX**
	(1)	(2)	(3)	(4)
Norway × EOR-Elig. × Post	2.610***	0.196***	2.213***	0.181**
	(0.634)	(0.052)	(0.726)	(0.071)
Avg. dep. var.	1.67	98.5	1.79	78.2
Country × Year FE	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes
Observations	1,989	1,989	1,173	1,173

Shared basins: Central Graben + Northern North Sea (both straddle the UK–Norway border). Triple-difference (country × EOR-eligibility × Post). SE clustered at the field level.

- Restricting the sample to fields in the shared Central Graben and Northern North Sea basins
- Triple is of the same sign, magnitude, and significance as the full-sample estimate

⇒ **Geology is not the driver**; the 1985 ruling is

Inference: Two-Way Clustering

Back

	EOR Adoption		Log Production		Mkt. Share	
	1-way (firm)	2-way	1-way (firm)	2-way	1-way (firm)	2-way
	(1)	(2)	(3)	(4)	(5)	(6)
Share EOR Norway × Post	0.347***	0.347***	3.193***	3.193***	0.039*	0.039*
	(0.116)	(0.116)	(0.831)	(0.857)	(0.021)	(0.022)
Share EOR × Post	0.021	0.021	−0.402	−0.402	−0.000	−0.000
	(0.013)	(0.015)	(0.266)	(0.318)	(0.003)	(0.003)
Avg. dep. var.	0.053	0.053	2.562	2.562	0.015	0.015
Year FE, Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,406	1,406	1,406	1,406	1,406	1,406

2-way clustering: firm × year. SE rise by $< 5\%$ on every outcome; significance preserved.

- Two-way clustering (firm × year) raises SEs by $< 5\%$ on every outcome
- Significance preserved throughout; conclusions unchanged

Adoption Threshold: Bellman Equation

Back

$$V(A) = \max\Big\{ \underbrace{s\Pi + \beta V(\delta A)}_{\text{no adoption}},\ \underbrace{s\Pi - c + q(A)[\Delta\Pi + \beta V(\delta A + \gamma)] + (1 - q(A))\beta V(\delta A)}_{\text{adopt}} \Big\}$$

- Threshold rule: adopt iff $A \geq A^*$
- A^* falls in s, $\Delta\Pi$; rises with depreciation δ (technological distance)

From Model to DiD: Derivation

Back

1. Firm i owns $\mathbf{N}_i = (N_{\text{Other}}, N_{\text{NOR}}, N_{\text{UK}})$ with $N = \sum N_{i,\cdot\cdot}$. Field-level outcome $y_{a,z,t}$. Firm output:

$$y_{it} = N_{\text{NOR}}\left[y_{0,\text{EOR},t} + \Delta y\, \mathbb{1}\{A_{it} \geq A^*_{t,\text{NOR}}\}\right] + N_{\text{UK}}\left[y_{0,\text{EOR},t} + \Delta y\, \mathbb{1}\{A_{it} \geq A^*_{t,\text{UK}}\}\right] + N_{\text{Other}}\, y_{0,\text{Other},t}$$

2. **Identifying assumption**: $A_{it} \perp \mathbf{N}_i$ in each period, so $\Pr_t\Big(A_{it} \geq A^* \mid \mathbf{N}_i\Big) = 1 - F_t(A^*)$.
3. Take expectations and difference post–pre. With $\Delta_z \equiv y_{0,z,\text{post}} - y_{0,z,\text{pre}}$:

$$\begin{aligned}\mathbb{E}[y_{i,\text{post}} - y_{i,\text{pre}}] = N\,\Delta_{\text{Other}} \\ + \Big\{\Delta_{\text{EOR}} - \Delta_{\text{Other}} + \Delta y\,[F_{\text{pre}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{pre}})]\Big\} \cdot N \cdot \text{Share EOR}_i \\ + \underbrace{\Delta y\,[F_{\text{post}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,NOR}})]}_{\text{extra adopters from Norway's lower post-threshold}} \cdot N \cdot \text{Share EOR Norway}_i\end{aligned}$$

   with $\text{Share EOR Norway}_i = N_{\text{NOR}}/N$, $\text{Share EOR}_i = (N_{\text{NOR}} + N_{\text{UK}})/N$.
4. Combining with $y_{it} = \mathbb{E}[y_{it}] + \varepsilon_{it}$ yields the DiD regression with firm & year FE:

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

   where $\gamma_{\text{treat}} \equiv N\Delta y[F_{\text{post}}(A^*_{\text{pre}}) - F_{\text{post}}(A^*_{\text{post,NOR}})]$ isolates the causal treatment effect.

Field-Level Descriptive Statistics

Back

	UK			Norway		
	Pre-1985 (1)	Post-1985 (2)	Total (3)	Pre-1985 (4)	Post-1985 (5)	Total (6)
Panel (a): Average number of						
Producing fields per year	30.13	101.72	84.61	6.97	21.95	18.62
Panel (b): Field Characteristics types						
% fields Large	0.84	0.53	0.61	0.57	0.72	0.68
% fields Moderate	0.15	0.38	0.32	0.43	0.25	0.30
% fields Small	0.02	0.09	0.07	0.00	0.02	0.02
Porosity (%)	19.34	18.92	19.06	29.85	27.78	28.52
Permeability (Millidarcy)	1005.56	750.62	828.34	965.30	1602.79	1415.70
% shallow and moderate fields (<3000m)	0.82	0.75	0.77	0.50	0.67	0.63
% deep and ultradeep fields (>3000m)	0.18	0.25	0.23	0.50	0.33	0.37
Reservoir depth (meters)	2564	2630	2613	2645	2619	2626
Overburden (meters)	2465	2542	2522	2541	2476	2493
API Gravity (Fahrenheit)	40.42	40.73	40.64	41.67	39.81	40.30
Sulfur content (unit measure)	0.48	0.49	0.48	0.23	0.22	0.22

Field-Level: Ownership Concentrates in Treated Fields

Back

	Share of
Dep. variable	**Operator**
	(1)
Norway × EOR × Post	0.273*
	(0.141)
EOR × Post	−0.024
	(0.053)
Avg. dep. var.	0.335
Country-Year FE	Yes
Field FE	Yes
Observations	1,988
R-squared	0.59

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the field level.

- Triple-difference (country × EOR-eligibility × post) with country-by-year FE
- Operator share, top-1, top-3 all rise; number of firms per field falls
- Concentration is local, on treated fields Non-EOR null

Field-Level: Ownership Concentrates in Treated Fields

Back

	Share of	
Dep. variable	**Operator**	**Top 1**
	(1)	(2)
Norway × EOR × Post	0.273*	0.291**
	(0.141)	(0.147)
EOR × Post	−0.024	−0.020
	(0.053)	(0.054)
Avg. dep. var.	0.335	0.360
Country-Year FE	Yes	Yes
Field FE	Yes	Yes
Observations	1,988	1,988
R-squared	0.59	0.47

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the field level.

- Triple-difference (country × EOR-eligibility × post) with country-by-year FE
- Operator share, top-1, top-3 all rise; number of firms per field falls
- Concentration is local, on treated fields Non-EOR null

Field-Level: Ownership Concentrates in Treated Fields

Back

Dep. variable	Share of Operator (1)	Top 1 (2)	Top 3 (3)
Norway × EOR × Post	0.273*	0.291**	0.404**
	(0.141)	(0.147)	(0.196)
EOR × Post	−0.024	−0.020	0.021
	(0.053)	(0.054)	(0.089)
Avg. dep. var.	0.335	0.360	0.642
Country-Year FE	Yes	Yes	Yes
Field FE	Yes	Yes	Yes
Observations	1,988	1,988	1,988
R-squared	0.59	0.47	0.46

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the field level.

- Triple-difference (country × EOR-eligibility × post) with country-by-year FE
- Operator share, top-1, top-3 all rise; number of firms per field falls
- Concentration is local, on treated fields Non-EOR null

Field-Level: Ownership Concentrates in Treated Fields

Back

	Share of			HHI
Dep. variable	Operator	Top 1	Top 3	Standard
	(1)	(2)	(3)	(4)
Norway × EOR × Post	0.273*	0.291**	0.404**	0.204*
	(0.141)	(0.147)	(0.196)	(0.115)
EOR × Post	−0.024	−0.020	0.021	−0.019
	(0.053)	(0.054)	(0.089)	(0.048)
Avg. dep. var.	0.335	0.360	0.642	0.306
Country-Year FE	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes
Observations	1,988	1,988	1,988	1,988
R-squared	0.59	0.47	0.46	0.64

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the field level.

- Triple-difference (country × EOR-eligibility × post) with country-by-year FE
- Operator share, top-1, top-3 all rise; number of firms per field falls
- Concentration is local, on treated fields Non-EOR null

Field-Level: Ownership Concentrates in Treated Fields

Back

	Share of			HHI	
Dep. variable	Operator	Top 1	Top 3	Standard	Normalized
	(1)	(2)	(3)	(4)	(5)
Norway × EOR × Post	0.273*	0.291**	0.404**	0.204*	0.249*
	(0.141)	(0.147)	(0.196)	(0.115)	(0.141)
EOR × Post	−0.024	−0.020	0.021	−0.019	0.023
	(0.053)	(0.054)	(0.089)	(0.048)	(0.067)
Avg. dep. var.	0.335	0.360	0.642	0.306	−0.030
Country-Year FE	Yes	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes	Yes
Observations	1,988	1,988	1,988	1,988	1,781
R-squared	0.59	0.47	0.46	0.64	0.52

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the field level.

- Triple-difference (country × EOR-eligibility × post) with country-by-year FE
- Operator share, top-1, top-3 all rise; number of firms per field falls
- Concentration is local, on treated fields Non-EOR null

Field-Level: Ownership Concentrates in Treated Fields

Back

	Share of			HHI		Nb. Firms
Dep. variable	Operator	Top 1	Top 3	Standard	Normalized	per Field
	(1)	(2)	(3)	(4)	(5)	(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)
Avg. dep. var.	0.335	0.360	0.642	0.306	−0.030	4.33
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Field FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,988	1,988	1,988	1,988	1,781	1,988
R-squared	0.59	0.47	0.46	0.64	0.52	0.96

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. SE clustered at the field level.

- Triple-difference (country × EOR-eligibility × post) with country-by-year FE
- Operator share, top-1, top-3 all rise; number of firms per field falls
- Concentration is local, on treated fields

Non-EOR null

Non-EOR-Eligible Fields: Null Effects

Back

	Production and Costs				Market Share	
Dept. var.	$\ln(1+\text{prod}_{it})$	$\ln(1+\text{OPEX}_{it})$	$\ln(1+\text{cum. CAPEX}_{it})$	prod_{it} / OPEX_{it}	All	Positive
	(1)	(2)	(3)	(4)	(5)	(6)
Panel (a): Non-EOR, Deep Well Fields (Deep)						
Share Deep Norway × Post	0.789	0.118	0.403	0.157	0.013	0.008
	(0.841)	(0.791)	(0.561)	(0.140)	(0.018)	(0.023)
Share Deep × Post	-0.050	-0.321	0.097	-0.176	0.001	0.005*
	(0.304)	(0.431)	(0.237)	(0.130)	(0.003)	(0.003)
Observations	1406	1402	1406	1406	1406	1232
R-squared	0.84	0.84	0.93	0.41	0.82	0.84
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes

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

- Deep, sour, and other non-EOR Norwegian fields show **no gains**

Market Shares: Know-How Only

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Dept. var.	Market Share	Number of Fields		
		All Fields	EOR Eligible	Non-EOR Eligible
	(1)	(2)	(3)	(4)
K-H × Share EOR Norway × Post	0.108***	33.812***	9.655***	24.157***
	(0.035)	(10.635)	(2.966)	(8.820)
Share EOR Norway × Post	0.009**	5.148	4.059*	1.089
	(0.004)	(3.248)	(2.135)	(1.327)
Observations	1377	1377	1377	1377
R-square	0.89	0.85	0.82	0.84
Share EOR × Post	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Average dependent variable	0.012	5.216	2.116	3.100

Market Shares: State Ownership Only

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Dept. var.	Market Share	Number of Fields		
		All Fields	EOR Eligible	Non-EOR Eligible
	(1)	(2)	(3)	(4)
S-O × Share EOR Norway × Post	0.129***	25.463**	8.690***	16.773**
	(0.025)	(9.968)	(2.757)	(7.910)
Share EOR Norway × Post	0.011**	7.127*	4.482**	2.645
	(0.005)	(3.981)	(2.192)	(2.045)
Observations	1377	1377	1377	1377
R-squared	0.88	0.82	0.81	0.80
Share EOR × Post	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Average dependent variable	0.012	5.216	2.116	3.100

Other Upstream Technologies

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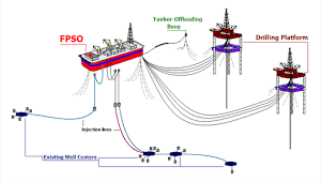
FPSO

Floating Production, Storage & Offloading



- Designed to be **relocated**

→ Low irreversibility

Drilling Rigs

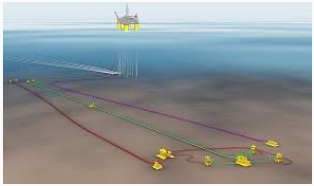
Jackups, semisubs, drillships

- Rented from contractors

→ Low asset specificity

Subsea Tiebacks

Pipelines to existing platforms



- Payback 3–5 years

→ Short payback

⇒ None of these satisfies all three Williamson hold-up conditions like EOR