Heterogeneous oil supply elasticities: indebtedness and production responses to the COVID-19 shock

Sergei Seleznev

INECO CAPITAL LTD

Veronika Selezneva

CERGE-EI

ESEM 2022

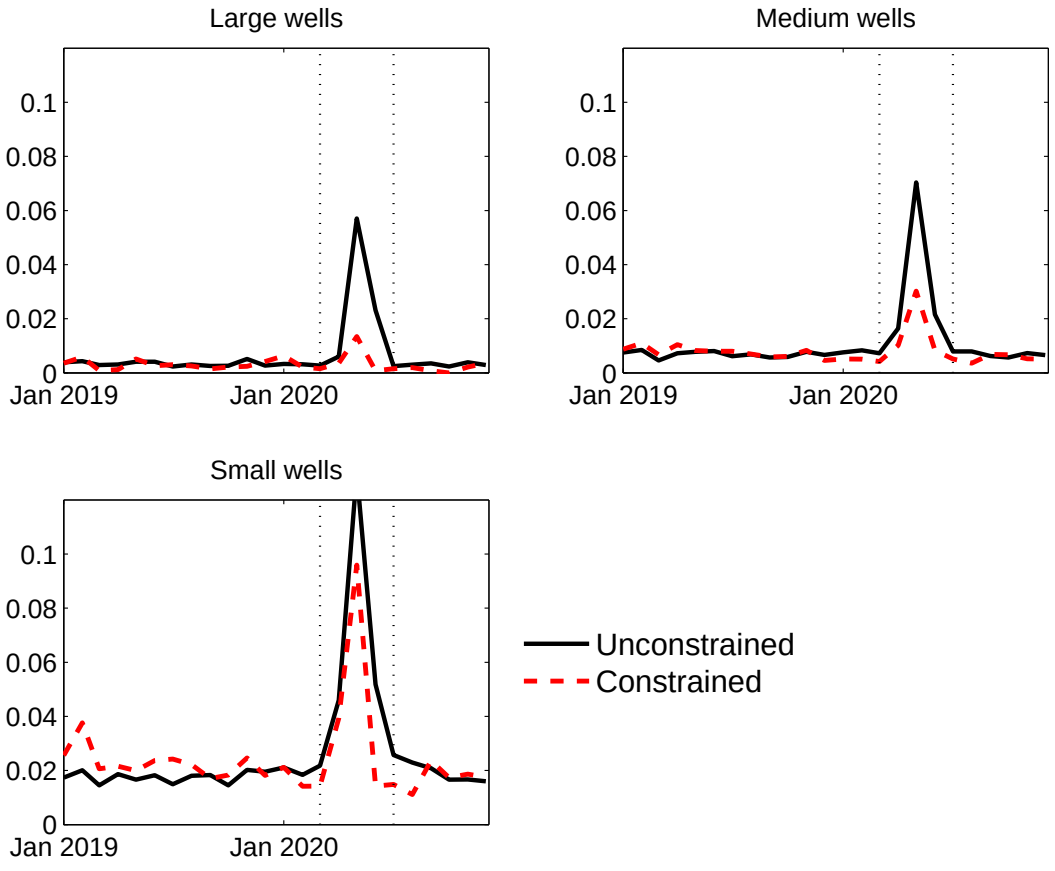
Motivation

- Puzzling resilience of oil production
- Regulatory interventions
  - 2019 - production cap implemented in Alberta, Canada to limit the WCS - WTI price differential
  - 2020 - the Railroad Commission of Texas discussed a state-wide production cap
- Can indebtedness explain oil production resilience?
  - Financially constrained firms make distorted production decisions

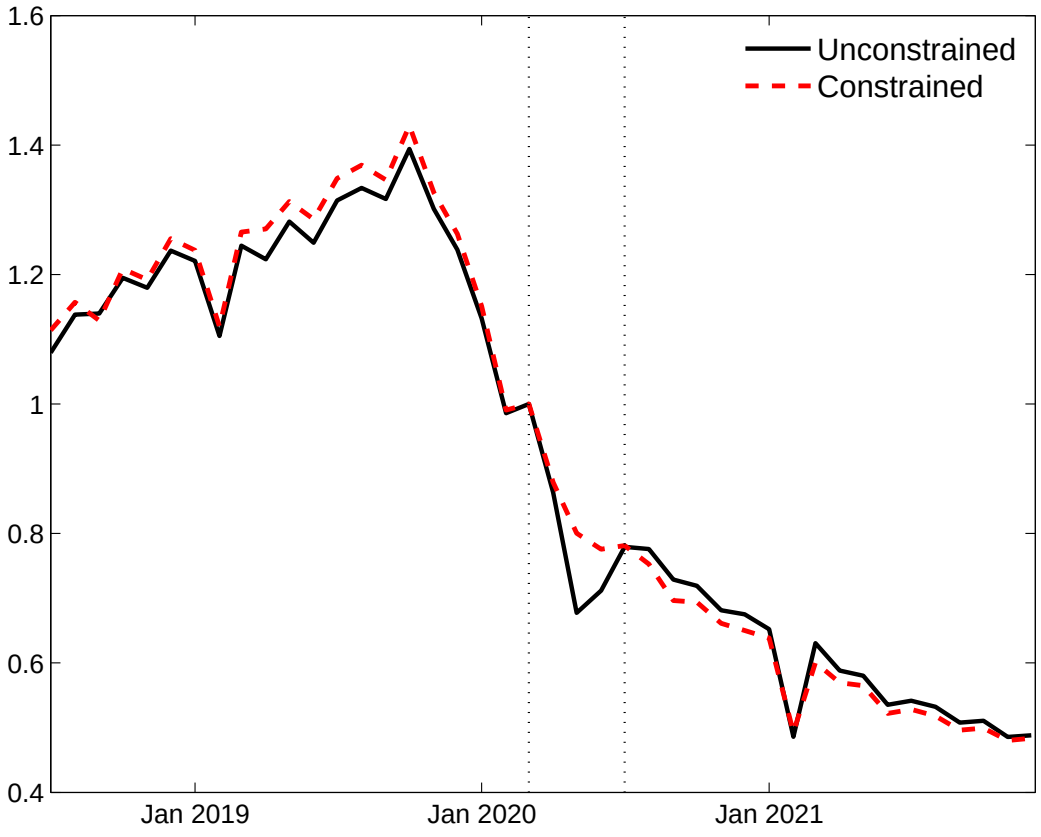
What this paper does

- Use well-level data to document oil production responses to the COVID-19 demand collapse.
- Show that indebtedness matters for oil supply elasticities
  - Financially constrained firms cut production by 10 pp less than unconstrained firms.
- Our well-level approach allows us to control for productivity, pandemic intensity, lockdown measures, refinery utilization rates, availability of storage facilities, benchmarking (see Gilje et al. 2021), and other differences across locations.

Financially constrained firms were less likely to shut in oil wells



Financially constrained firms produced more



Production responses to the COVID-19 shock

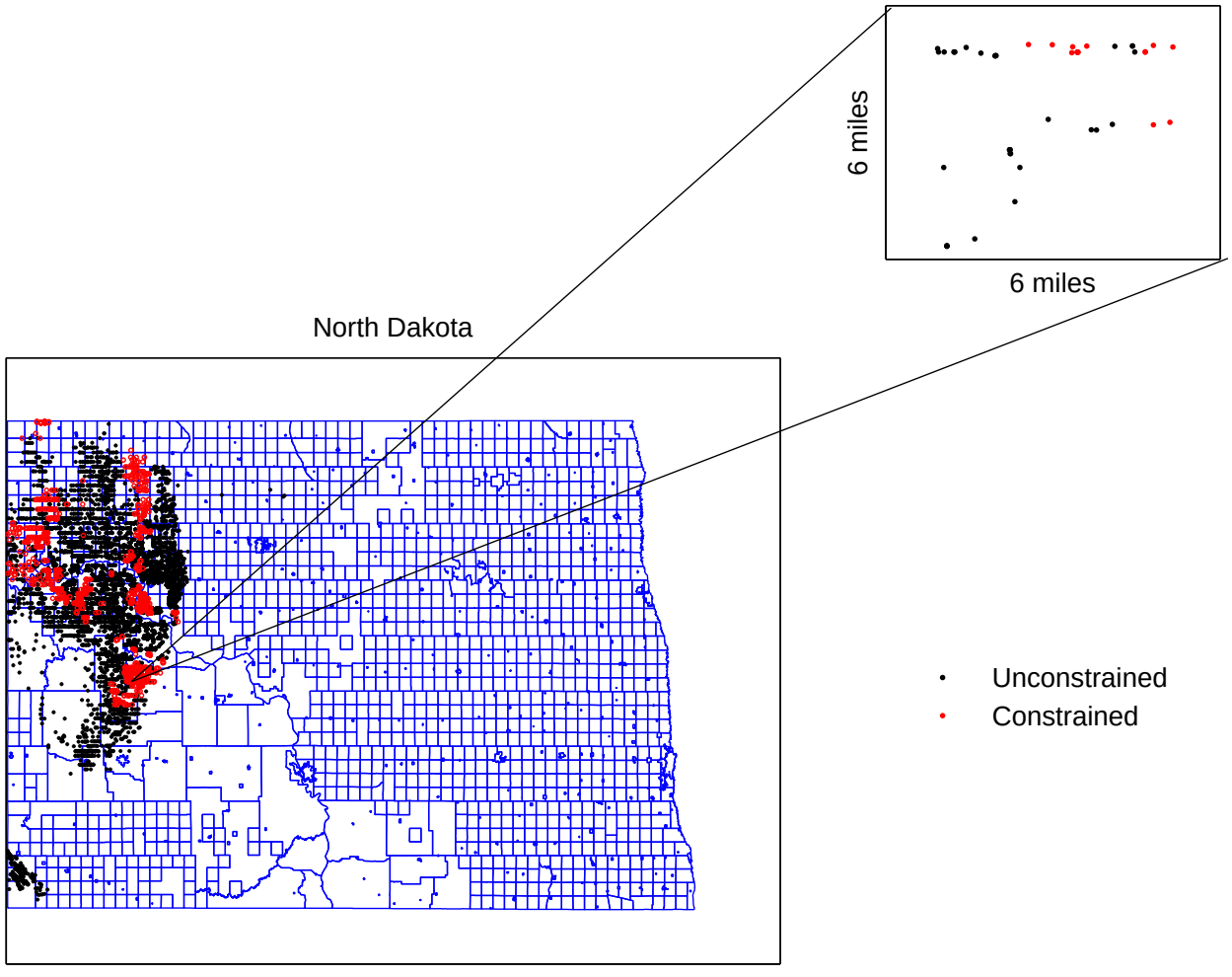
- We estimate the following cross-sectional model:

$$\Delta y_{j,i,s,k} = \delta_s + \gamma_k + \alpha \cdot \mathit{Constrained}_i + \beta_1' X_i + \beta_2' X_j + \varepsilon_j$$

  - unit of observation is a well;
  - $\Delta y_{j,i,s,k}$ is the change in the oil production from March to May 2020 in well j operated by firm i, located in a geographical unit s, of age k;
  - $\mathit{Constrained}_i$ is the indicator variable equal to 1 if firm i is financially constrained.

- The main coefficient of interest is α that measures the extra cut in production that is done by financially constrained operators.
- Controls:
  - granular geographical unit s fixed effects δ_s;
  - well age fixed effects γ_k and X_j well-level controls (horizontal length, productivity, lagged production changes)
  - X_i firm-level controls.

Illustration of our identification strategy



Identifying financially constrained firms

- Three exercises to identify financially constrained firms
  1. Credit Expiry
  2. Access to Credit
  3. Failed Hedging

Identifying financially constrained firms: Credit Expiry

- Idea: A firm with credit agreements that expire in the midst of the pandemic is more financially constrained.
- Problem: Hard to identify payment deadlines on multiple forms of long-term debt
  - credit lines, term loans, notes and bonds etc
- Our solution:
  - Exploit path-dependence and synchronization of debt-related deadlines
- Tendency of multiple forms of long-term debt to be co-issued and co-dependent creates a synchronized/correlated pattern of payment deadlines
  - refinancing activity
  - financing of investment projects
- Hence, we can use the available data on one type of long-term debt to reasonably predict the timing of all other debt-related payment deadlines.

Example

- For example:
  - March 1, 2019, Cimarex Energy completed the acquisition of Resolute Energy Corporation.
  - On February 5, 2019, Cimarex Energy amended its credit agreement and extended the maturity date to February 5, 2024.
  - On March 8, 2019, Cimarex issued $500 million aggregate principal amount of 4.375% senior unsecured notes due March 15, 2029. The interest is payable semiannually on March 15 and September 15.
- Many payments were synchronized to occur in March-February.

Identifying financially constrained firms: Credit Expiry

- Identify firms with payment deadlines likely to occur in the midst of the pandemic
- Use DealScan Create to create $Constrained_i$ indicator for each oil firm i:
  - $Constrained_i = 1$ if the firm i has any data entries with an expiration date scheduled within 4 months from March to June 2020.
  - and 0 if the firm i has at least one data entry with an expiration date after January 2020, and does not have any data entries with an expiration date from March to June 2020.

- Advantages:
  - Past credit expiration dates are exogenous to the timing of the COVID-19 outbreak, and to both the operational and financial performance of the firms.
  - Available for both public and private firms

Data

- Well-data: Enverus (previously Drillinginfo)
  - all horizontal oil wells in the US drilled after 2005 with sufficient production in March 2020
- Financial data: Dealscan + Compustat
- Hand-collected data from 10k forms (as of Dec 31, 2019, and Q1 and Q2 of 2020)
- Sample:
  - 106 public and private operators.

Production Results: Credit Expiry

$$\Delta y_{j,i,s,k} = \delta_s + \gamma_k + \alpha \cdot \textit{Constrained}_i + \beta_1' X_i + \beta_2' X_j + \varepsilon_j$$

	Oil Well Production Response					
	(1)	(2)	(3)	(4)	(5)	(6)
Constrained	0.046**	0.045***	0.041***	0.040***	0.048***	0.036***
	(0.023)	(0.011)	(0.010)	(0.010)	(0.012)	(0.012)
Log Cumulative Production, T=6m			0.008	0.007	0.008	0.008
			(0.005)	(0.005)	(0.005)	(0.006)
Public Status			0.020	0.021		
			(0.019)	(0.020)		
Hedged Volume					0.017	0.025
					(0.023)	(0.025)
Committed Volume						-0.014
						(0.015)
Fraction Oil						0.047
						(0.031)
Fraction Shale						-0.032
						(0.021)
Owns Refinery						-0.042*
						(0.022)
Mean Dep.Var	-0.115	-0.120	-0.116	-0.116	-0.112	-0.108
Number of Wells	14523	12488	11351	11362	10077	9591
Number of Operators	115	106	104	104	47	43
R^2	0.006	0.284	0.295	0.276	0.308	0.302
Geo FE		Y	Y	Y	Y	Y

Extensive robustness checks

1. Similar results for well shut-ins.
2. Placebo test: no effect from March to May of 2019.
3. Similar results for vertical wells
4. Opposite results for Fall Expiration
   - *Fall Expiration*$_i$ that equals 1 if the firm i has any credit data entries with an expiration date scheduled from August to December 2020
5. Results are not driven by
   - shale firms; oil/gas mix;
   - hedging; physical delivery commitments
   - composition of wells
6. Our treatment variable - credit expiry - is orthogonal to all standard firm-level controls and oil-market specific physical measures.
7. Account for spatial correlation.
8. Use different windows for credit expiry

- Our empirical design (well-level analysis + credit expiry) rules out many alternative explanations that are unrelated to our mechanism

Access to credit

- We investigate the effects of access to credit on production responses.
- Many oil and gas producing firms rely on asset-based lending.
- We hand-collected the data on borrowing limits, borrowings outstanding and issued letters of credit as of December 31, 2019, March 31 and June 30, 2020 from SEC filings.
- Oil producers heavily utilize their secured credit facilities.
  - median credit utilization rate increased from 45% to 55% in March, and to 77% in June.
- However, the increase in credit utilization rates was driven mostly by the severe cuts in the borrowing limits
  - the median decrease in the borrowing base was 20%, the first and third quantiles were 11% and 35%.
    Sandridge Energy - 67%, Oasis Petroleum - 53%, Chaparral Energy Inc. - 46%, Contango Oil and Gas - 41%.
- Banks severely limited firms' ability to drawdown on their existing credit lines during the pandemic; consistent with Chodorow-Reich et al. (2021).

Access to credit: Reduction in the Borrowing Base

	Oil Well Production Response			Well Shut-In Indicator		
	(1)	(2)	(3)	(1)	(2)	(3)
Borrowing Base Reduction	-0.168*	-0.211***	-0.184**	0.131	0.086	0.042
	(0.084)	(0.077)	(0.080)	(0.103)	(0.081)	(0.081)
Operating Costs		-0.015*	-0.022		-0.011	-0.004
		(0.008)	(0.014)		(0.012)	(0.013)
Hedged Volume		-0.081***	-0.056		0.035**	-0.083**
		(0.027)	(0.036)		(0.017)	(0.031)
Mean Dep.Var	-0.094	-0.094	-0.094	0.076	0.076	0.080
Number of Wells	7049	7049	6597	7628	7628	7169
Number of Operators	35	35	29	35	35	29
R^2	0.314	0.316	0.315	0.362	0.362	0.377
Geo FE	Y	Y	Y	Y	Y	Y
Well Controls	Y	Y	Y	Y	Y	Y
First Production FE	Y	Y	Y	Y	Y	Y
Operator Controls			Y			Y

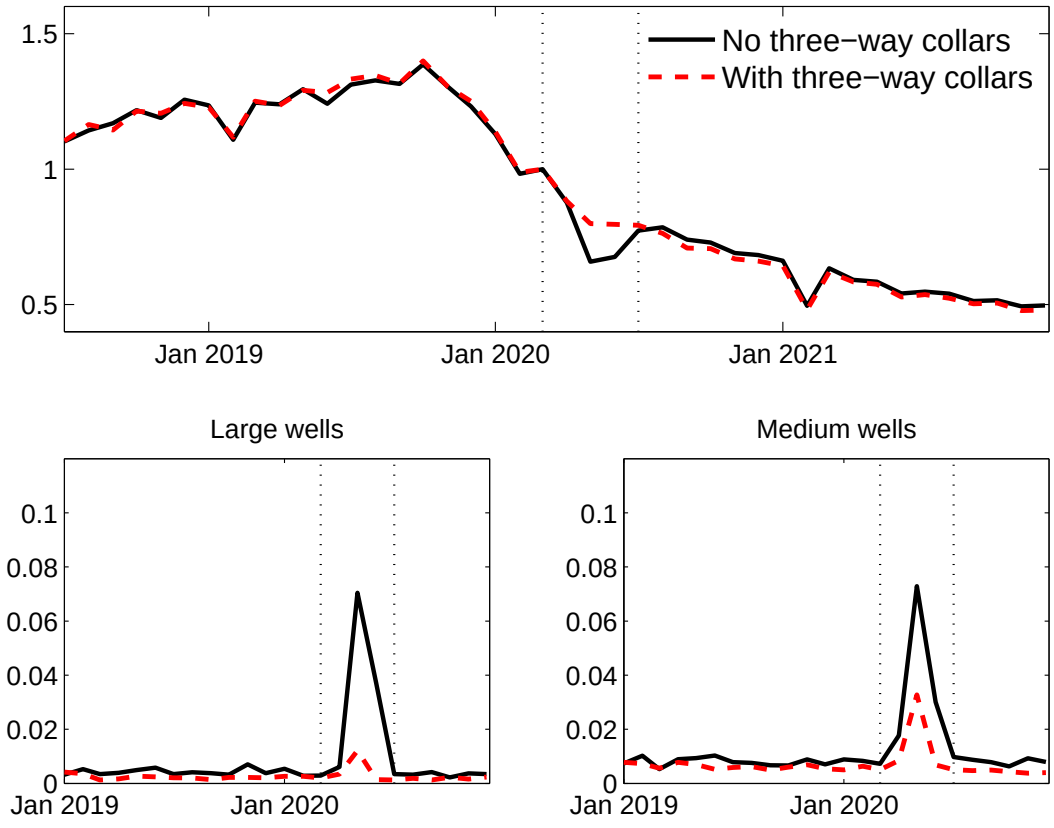
Access to credit: Credit Line Drawdowns

	Oil Well Production Response			Well Shut-In Indicator		
	(1)	(2)	(3)	(1)	(2)	(3)
Credit Line Drawdowns	-0.208*	-0.194*	-0.344**	0.533**	0.509**	0.201
	(0.112)	(0.104)	(0.144)	(0.214)	(0.208)	(0.163)
Operating Costs		-0.006	-0.013		-0.008	-0.006
		(0.007)	(0.009)		(0.010)	(0.012)
Hedged Volume		-0.076**	-0.071*		0.022	-0.073*
		(0.031)	(0.038)		(0.023)	(0.036)
Mean Dep.Var	-0.094	-0.094	-0.094	0.076	0.076	0.080
Number of Wells	7049	7049	6597	7628	7628	7169
Number of Operators	35	35	29	35	35	29
R^2	0.314	0.315	0.316	0.366	0.367	0.377
Geo FE	Y	Y	Y	Y	Y	Y
Well Controls	Y	Y	Y	Y	Y	Y
First Production FE	Y	Y	Y	Y	Y	Y
Operator Controls			Y			Y

Failed Hedging

- We identify the firms that had more acute immediate cash needs than others.
- Exploit variation in hedging practices:
  - typically: collars, futures, swaps
  - three-way collars = typical collar + sale of a further out-of-the-money put option
    - ⋆ makes hedging cheaper,
    - ⋆ but exposes to risk of significant declines in oil prices.
- When oil prices plunged in 2020, the three-way collars failed to pay off.
- Use the fraction of production volume hedged with the three-way collars.
- Result: Firms which used three-way collars more extensively also cut production by less, thus further reinforcing our main conclusions.

Failed Hedging



Cash needs and well completions

- Our channel: immediate cash needs.
- To further test the mechanism, we explore well completion decisions
  - well completions are costly and thus cannot alleviate immediate cash flow needs.
- Alternative channel (highlighted by Gilje et al. 2017): Collateral channel
  - new successful well completions can potentially improve the value of the land and thus the collateral value and facilitate refinancing
- Our approach
  - identify wells that were drilled before the pandemic but not completed (DUCs)
  - create a well completion indicator $WellCompletion_{j,i,s,k}$
    - ⋆ equal to 1 if a well j owned by firm i, spud k months ago, and located in a geographical unit s was *completed* in March or April 2020,
    - ⋆ and equal to 0 if it was completed at a later date or if it has not been completed yet.
  - similar well-level regression

Cash needs and well completions

	Well Completion Indicator			
	(1)	(2)	(3)	(4)
Constrained	-0.279***	-0.258***	-0.241***	-0.218**
	(0.067)	(0.077)	(0.083)	(0.106)
Public Status		-0.114		
		(0.127)		
Hedged Volume			0.070	0.128
			(0.066)	(0.103)
Committed Volume				-0.100
				(0.162)
Fraction Oil				0.254
				(0.192)
Fraction Shale				-0.211
				(0.225)
Owns Refinery				-0.165
				(0.106)
Mean Dep.Var	0.445	0.445	0.424	0.428
Number of Wells	2467	2467	2030	1686
Number of Operators	87	87	43	37
R^2	0.727	0.728	0.730	0.735
Geo FE	Y	Y	Y	Y
Spud Month FE	Y	Y	Y	Y

Alternative ways to identify financially constrained firms

- In the main exercise, we use credit expiry to identify financially constrained firms.

- Next we show that our results are robust to using alternative measures:
  1. Exploit the unexpected failure of OPEC-Russia negotiations in March 2020.
  2. Use a battery of typical measures of financial constraints and financial distress.

Summary and contribution

- Main takeaway: Debt matters for oil supply adjustments to low oil prices.
  - We document heterogeneity in oil supply elasticities.
  - We provide the first large scale empirical evidence of production resilience due to indebtedness.

- Production responses to large negative demand shocks can be nontrivial
  - in contrast, existing empirical papers find short-run production elasticities to be zero (see Anderson et al. 2018, Newell and Prest 2019, and Kilian 2020 for the review).

- Implications: Debt relief rather than production caps?