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Optimal organization in commodity industries

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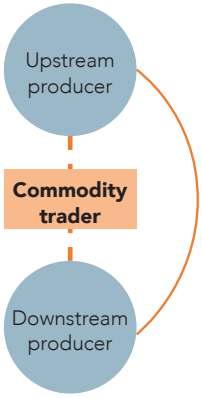
COMMODITY INDUSTRY

- We have observed a global trend toward vertical integration strategies with the commodity super-cycle. Big oil companies capitalized on sky-high prices to extend their production capacities.
- With vertical integration, producers could control the barrels from the exploration to the distribution in order to capture a higher fraction of the value added.
- However, lower prices bring the companies to rationalize their activities. Producers set disintegration strategies to reduce the organizational costs.

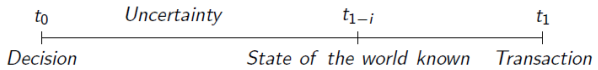


Propositions:

- Transaction costs and risk are connected.
- Price dynamic could determine organization changes.
- The commodity trader is a specific actor of the industry. He can manage price risk for the producers.

TRADE ORGANIZATION

- With non-cooperative producers, the success of an organization depends on the timing:



Market		Firm
Spot contract	Long term contract	Transfer
• Price risk • No counterpart risk • Commission paid to the commodity trader to hedge the price risk	• No price risk • Counterpart risk • Increasing ex ante costs or potential loses to redeploy the transaction on another party	• No price risk • No counterpart risk (no asymetries) • High fixed cost, financed by loans or by mobilizing the stackholders

MODEL

- The demand includes the inventories. We define the speculative stocks and contango stocks.

$$P_t = \varphi \exp(Z_t + Y_t)\,(Q_t^D + S_t^{spec} + S_t^{co})^{\beta}$$
$$S_t^{spec} = Max(A_{spec}\,(P_t^e - P_t), 0)$$
$$S_t^{co} = Max(A_{co}\,(Fut_t - P_t), 0)$$

- Marginal costs are increasing and defined as a function of the production capacities.

$$MC_t = A_{MC} + \frac{\nu}{(Q_{t-1}^{cap} - Q_t^S)^{\psi}}$$

Production capacity is a lagged variable. There is a time mismatch between the investment decision and its consequences on the production.

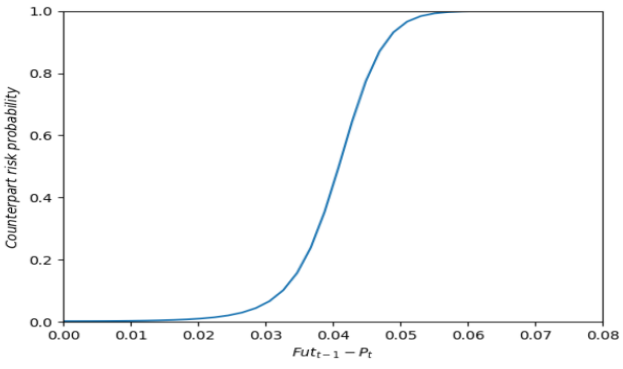
- The decision taken on the investment strategy and the production capacities are based on expectations.

$$Q_t^{D^e} = Q_t^D \exp(z^e)$$
$$P_t^e = \varphi \exp(z_t^e)\,(Q_t^{D^e} + S_t^{spec} + S_t^{co})^{\beta}$$

- The future price is defined by the storage costs per barrel and the convenience yield:

$$sc_t = sc_{min} + \iota\, s_t$$
$$cy_t = \frac{1}{(S_t^{tot})^{\alpha}}$$
$$Fut_t = P_t + sc_t - cy_t$$

- The transaction costs are the costs paid to the commodity trader to hedge the price risk (Spot contract), the organizational costs (Firm) and the counterpart risk (Long term contract):
  - $\pi_t = A_{pr}\,\frac{1}{P_t^2}$
    $\delta_t = A_d\,P_t^2$
  - OC (high and fixed)
  - $CR_t = \frac{1}{1+\exp\,(6 - A_{cr}(Fut_{t-1} - P_t)^2)}$



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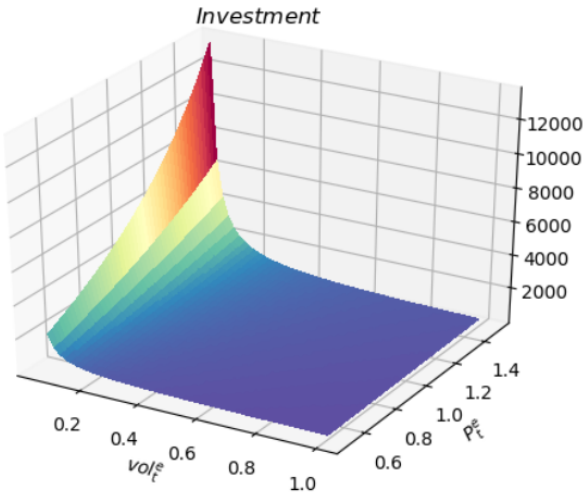
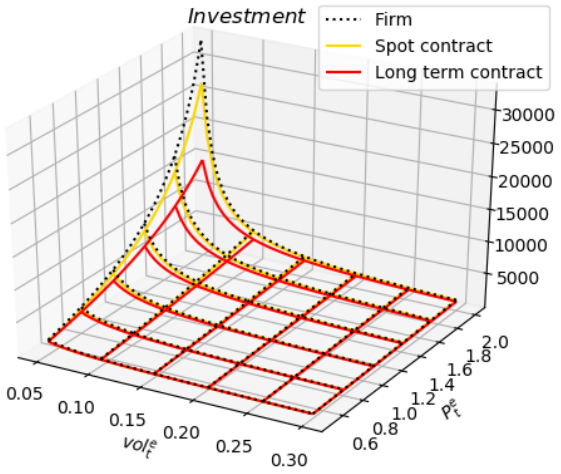
OPTIMAL ORGANIZATION

- Mean-variance equation:

$$Q_t^{cap^i} = Q_{min} + \lambda\ \sigma_t^i$$
$$\eta_t = \tau P_t$$
$$Q_t^{cap}\ P_t^e - A_i\ vol_t^e\ \sigma_t = \eta_t\ \sigma_t$$



- $Q_t^{cap^v}\ P_t^e - A_i\ vol_t^e\ \sigma_t^v = \eta_t\ \sigma_t^v + OC$
- $Q_t^{cap^{ct}}\ (P_t^e - \delta_t) - A_i\ vol_t^e\ \sigma_t^{ct} = \eta_t\ \sigma_t^{ct}$
- $(1 - CR_t)\ (Q_t^{cap^{lt}}\ P_t^e) - A_i\ vol_t^e\ \sigma_t^{lt} = \eta_t\ \sigma_t^{lt}$



$Q = 95,\ \lambda = 0.011727,\ A_i = 0.576121,\ P = 1,\ \tau = 0.0002197,\ OC = 5.279285,\ \delta = 0.1,\ CR = 0.2$

RESULTS

- We use two distinct solvers. One to model the price dynamic, the transaction costs and the expectations in the industry. A second to determine the organization maximizing the production capacities.We simulate different scenarios by modifying the current demand change (z) and the expected demand change (ze) at each period.

Cycle 1	T_1 z = 0.017 ze = 0.02	T_2 z = 0.02 ze = 0.02	T_3 z = 0.03 ze = 0.01	T_4 z = 0.01 ze = 0	T_5 z = 0.005 ze = 0.005	T_6 z = -0.005 ze = -0.02	T_7 z = -0.03 ze = -0.02	T_8 z = -0.02 ze = -0.01	T_9 z = -0.005 ze = -0.005	T_{10} z = -0.02 ze = -0.01
Q_t^D	98,38	100,37	103,42	104,46	104,99	104,46	101,38	99,37	98,87	96,92
Q_t^S	97,96	99,98	102,15	102,20	101,52	102,16	98,90	97,62	98,07	97,99
Q_{t-1}^{cap}	103.77	105,59	107,53	107,54	106,80	107,50	104,50	103,40	103,91	104,04
P_t	1,00	1,09	1,20	1,22	1,26	1,22	1,09	1,01	0,99	0,92
Fut_t	0,98	1,07	1,17	1,18	1,20	1,16	1,01	0,92	0,89	0,83
S_t^{tot}	5509,28	5438,78	5205,28	4791,41	4157,30	3735,44	3281,73	2960,91	2814,37	3010,59
S_t^{spec}	0,75	0,95	0,52	0,00	0,27	-0,99	-0,89	-0,42	-0,21	-0,38
S_t^{co}	-0,19	-0,22	-0,28	-0,40	-0,60	-0,73	-0,88	-0,99	-1,05	-0,98
S_t^{res}	-1,17	-1,33	-1,79	-2,26	-3,73	-2,31	-2,48	-1,75	-0,80	1,07
P_t^e	1,07	1,17	1,25	1,22	1,28	1,13	1,01	0,97	0,97	0,88
vol_t^e	0,21	0,21	0,21	0,22	0,22	0,25	0,24	0,23	0,23	0,23
δ_t	0,05	0,06	0,07	0,07	0,08	0,07	0,06	0,05	0,05	0,04
CR_t	0,05	0,01	0,03	0,02	0,21	0,99	0,64	0,03	0,01	0,99
Q_t^{cap}	105,59	107,53	107,54	106,80	107,50	104,49	103,40	103,91	104,04	102,66
$Q_t^{cap^{ct}}$	-	LTC	LTC	LTC	F	F	F	LTC	LTC	SC

With SC: spot contract, LTC: long term contract, F: the firm (through vertical integration).

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DISCUSSION

- The spot contract is a credible organization for the producers. On the market, the price risk exposure has to be compared to the counterpart risk exposure.
- When we take into account the transaction costs, the firm is not necessary the organization optimizing the investments in the industry. The cost of no risk may exceed the cost of risk exposure.
- We need to notice that the optimal organization may be different for the upstream producer and the downstream producer. As an example, an increase in gasoline demand may bring to a higher crude oil price, but it would be differently managed by gasoline producers and gasoil producers. The crude price dynamic is not sufficient, we should include the spreads between crude and refined products.
- The commodity traders can take part to the vertical integration strategies. First because big oil companies acquired trading subsidiaries. Second because they could take production capacities within the industry.

CONCLUSION

- Price dynamic should be a key variable to determine the transaction costs, explaining why the organization of the industry is changing.
- When the prices are increasing, vertical integration can maximize production capacities for the upstream producer.
- When prices are decreasing, spot contract can be optimal.
- Long term contract is efficient with moderate counterpart risk.
- Major changes comes when the price trend is inverting, especially if the producers did not anticipated it. Misestimate increases the pro-cyclicality of investment strategies.
- There is no spot market without commodity traders. This assumption could be extended in further studies.