

Value of Biogen's existing products

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- Biogen had two commercial products (a drug to treat Hepatitis B and Intron) at the time of this valuation that it had licensed to other pharmaceutical firms.
- The license fees on these products were expected to generate \$ 50 million in after-tax cash flows each year for the next 12 years.
- To value these cash flows, which were guaranteed contractually, the pre-tax cost of debt of the guarantors was used:

$$\begin{aligned}\text{Present Value of License Fees} &= \$ 50 \text{ million } (1 - (1.07)^{-12})/.07 \\ &= \$ 397.13 \text{ million}\end{aligned}$$

Value of Biogen's Future R&D

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- Biogen continued to fund research into new products, spending about \$ 100 million on R&D in the most recent year. These R&D expenses were expected to grow 20% a year for the next 10 years, and 5% thereafter.
- It was assumed that every dollar invested in research would create \$ 1.25 in value in patents (valued using the option pricing model described above) for the next 10 years, and break even after that (i.e., generate \$ 1 in patent value for every \$ 1 invested in R&D).
- There was a significant amount of risk associated with this component and the cost of capital was estimated to be 15%.

Value of Future R&D

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Yr	Value of Patents	R&D Cost	Excess Value	PV (at 15%)
1	\$ 150.00	\$ 120.00	\$ 30.00	\$ 26.09
2	\$ 180.00	\$ 144.00	\$ 36.00	\$ 27.22
3	\$ 216.00	\$ 172.80	\$ 43.20	\$ 28.40
4	\$ 259.20	\$ 207.36	\$ 51.84	\$ 29.64
5	\$ 311.04	\$ 248.83	\$ 62.21	\$ 30.93
6	\$ 373.25	\$ 298.60	\$ 74.65	\$ 32.27
7	\$ 447.90	\$ 358.32	\$ 89.58	\$ 33.68
8	\$ 537.48	\$ 429.98	\$ 107.50	\$ 35.14
9	\$ 644.97	\$ 515.98	\$ 128.99	\$ 36.67
10	\$ 773.97	\$ 619.17	\$ 154.79	\$ 38.26
				\$ 318.30

Value of Biogen

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- The value of Biogen as a firm is the sum of all three components – the present value of cash flows from existing products, the value of Avonex (as an option) and the value created by new research:

$$\begin{aligned}\text{Value} &= \text{Existing products} + \text{Existing Patents} + \text{Value: Future R\&D} \\ &= \$ 397.13 \text{ million} + \$ 907 \text{ million} + \$ 318.30 \text{ million} \\ &= \$1622.43 \text{ million}\end{aligned}$$

- Since Biogen had no debt outstanding, this value was divided by the number of shares outstanding (35.50 million) to arrive at a value per share:

- ▣ Value per share = \$ 1,622.43 million / 35.5 = \$ 45.70

The Real Options Test: Patents and Technology

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- The Option Test:
 - ▣ Underlying Asset: Product that would be generated by the patent
 - ▣ Contingency:
 - If PV of CFs from development > Cost of development: $PV - \text{Cost}$
 - If PV of CFs from development < Cost of development: 0
- The Exclusivity Test:
 - ▣ Patents restrict competitors from developing similar products
 - ▣ Patents do not restrict competitors from developing other products to treat the same disease.
- The Pricing Test
 - ▣ Underlying Asset: Patents are not traded. Not only do you therefore have to estimate the present values and volatilities yourself, you cannot construct replicating positions or do arbitrage.
 - ▣ Option: Patents are bought and sold, though not as frequently as oil reserves or mines.
 - ▣ Cost of Exercising the Option: This is the cost of converting the patent for commercial production. Here, experience does help and drug firms can make fairly precise estimates of the cost.
- Conclusion: You can estimate the value of the real option but the quality of your estimate will be a direct function of the quality of your capital budgeting. It works best if you are valuing a publicly traded firm that generates most of its value from one or a few patents - you can use the market value of the firm and the variance in that value then in your option pricing model.

Example 2: Valuing Natural Resource Options

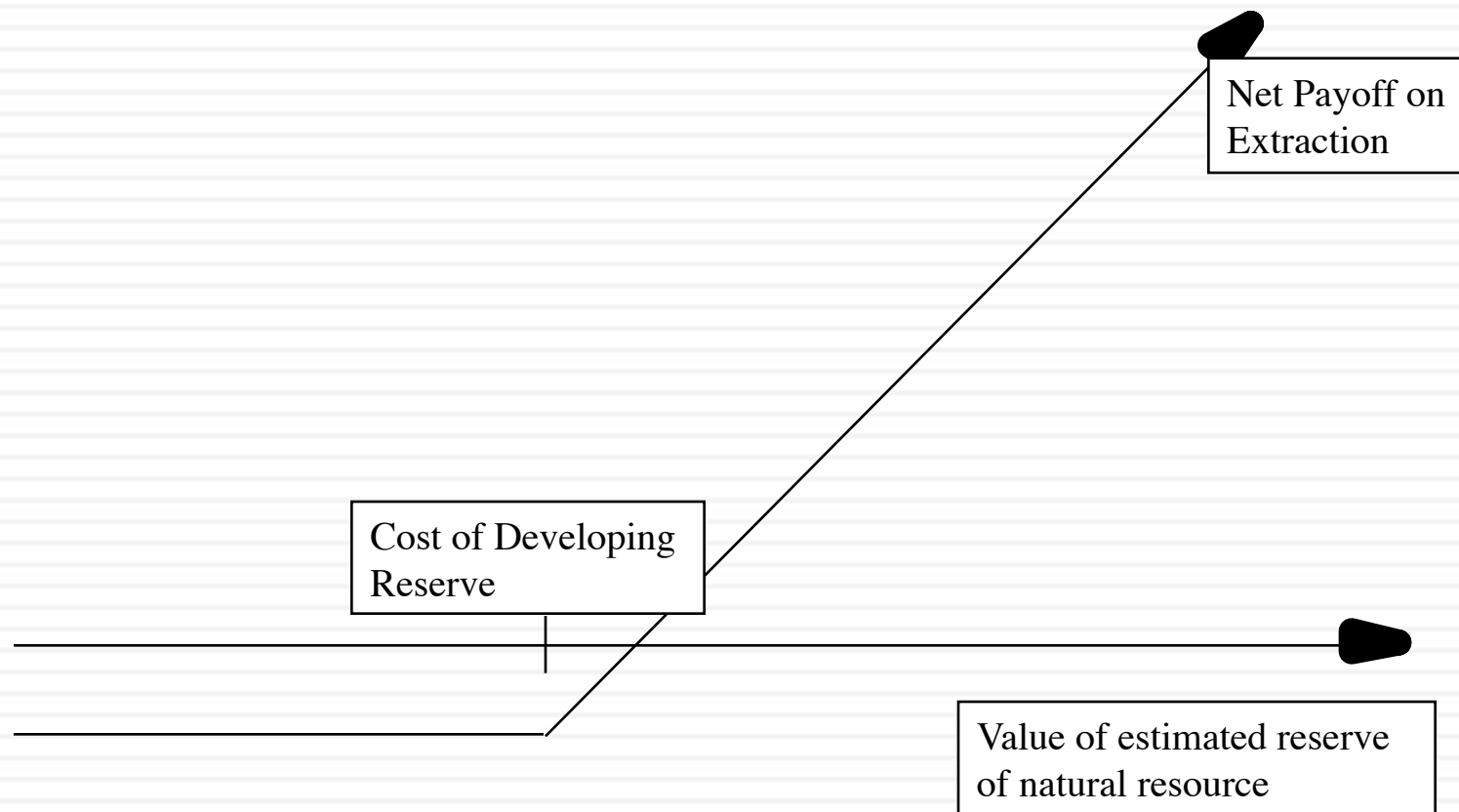
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- In a natural resource investment, the underlying asset is the resource and the value of the asset is based upon two variables - the quantity of the resource that is available in the investment and the price of the resource.
- In most such investments, there is a cost associated with developing the resource, and the difference between the value of the asset extracted and the cost of the development is the profit to the owner of the resource.
- Defining the cost of development as X , and the estimated value of the resource as V , the potential payoffs on a natural resource option can be written as follows:

$$\begin{aligned}\text{Payoff on natural resource investment} &= V - X && \text{if } V > X \\ &= 0 && \text{if } V \leq X\end{aligned}$$

Payoff Diagram on Natural Resource Firms

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Estimating Inputs for Natural Resource Options

Input	Estimation Process
1. Value of Available Reserves of the Resource	<ul style="list-style-type: none">• Expert estimates (Geologists for oil.); The present value of the after-tax cash flows from the resource are then estimated.
2. Cost of Developing Reserve (Strike Price)	<ul style="list-style-type: none">• Past costs and the specifics of the investment
3. Time to Expiration	<ul style="list-style-type: none">• Relinquishment Period: if asset has to be relinquished at a point in time.• Time to exhaust inventory - based upon inventory and capacity output.
4. Variance in value of underlying asset	<ul style="list-style-type: none">• based upon variability of the price of the resources and variability of available reserves.
5. Net Production Revenue (Dividend Yield)	<ul style="list-style-type: none">• Net production revenue every year as percent of market value.
6. Development Lag	<ul style="list-style-type: none">• Calculate present value of reserve based upon the lag.

Valuing Gulf Oil

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- Gulf Oil was the target of a takeover in early 1984 at \$70 per share (It had 165.30 million shares outstanding, and total debt of \$9.9 billion).
 - It had estimated reserves of 3038 million barrels of oil and the average cost of developing these reserves was estimated to be \$10 a barrel in present value dollars (The development lag is approximately two years).
 - The average relinquishment life of the reserves is 12 years.
 - The price of oil was \$22.38 per barrel, and the production cost, taxes and royalties were estimated at \$7 per barrel.
 - The bond rate at the time of the analysis was 9.00%.
 - Gulf was expected to have net production revenues each year of approximately 5% of the value of the developed reserves. The variance in oil prices is 0.03.

Valuing Undeveloped Reserves

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- Inputs for valuing undeveloped reserves
 - ▣ Value of underlying asset = Value of estimated reserves discounted back for period of development lag = $3038 * (\$22.38 - \$7) / 1.05^2 = \$42,380.44$
 - ▣ Exercise price = Estimated development cost of reserves = $3038 * \$10 = \$30,380$ million
 - ▣ Time to expiration = Average length of relinquishment option = 12 years
 - ▣ Variance in value of asset = Variance in oil prices = 0.03
 - ▣ Riskless interest rate = 9%
 - ▣ Dividend yield = Net production revenue / Value of developed reserves = 5%
- Based upon these inputs, the Black-Scholes model provides the following value for the call:
 - $d1 = 1.6548 \quad N(d1) = 0.9510$
 - $d2 = 1.0548 \quad N(d2) = 0.8542$
 - Call Value = $42,380.44 \exp^{(-0.05)(12)} (0.9510) - 30,380 (\exp^{(-0.09)(12)} (0.8542))$
= \$ 13,306 million

Valuing Gulf Oil

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- In addition, Gulf Oil had free cashflows to the firm from its oil and gas production of \$915 million from already developed reserves and these cashflows are likely to continue for ten years (the remaining lifetime of developed reserves).
- The present value of these developed reserves, discounted at the weighted average cost of capital of 12.5%, yields:
 - Value of already developed reserves = $915 (1 - 1.125^{-10})/.125 = \5065.83
- Adding the value of the developed and undeveloped reserves

Value of undeveloped reserves	= \$ 13,306 million
Value of production in place	= \$ 5,066 million
Total value of firm	= \$ 18,372 million
Less Outstanding Debt	= \$ 9,900 million
Value of Equity	= \$ 8,472 million
Value per share	= \$ 8,472/165.3 = \$51.25

Putting Natural Resource Options to the Test

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- The Option Test:
 - ▣ Underlying Asset: Oil or gold in reserve
 - ▣ Contingency: If value > Cost of development: Value - Dev Cost
 - ▣ If value < Cost of development: 0
- The Exclusivity Test:
 - ▣ Natural resource reserves are limited (at least for the short term)
 - ▣ It takes time and resources to develop new reserves
- The Option Pricing Test
 - ▣ Underlying Asset: While the reserve or mine may not be traded, the commodity is. If we assume that we know the quantity with a fair degree of certainty, you can trade the underlying asset
 - ▣ Option: Oil companies buy and sell reserves from each other regularly.
 - ▣ Cost of Exercising the Option: This is the cost of developing a reserve. Given the experience that commodity companies have with this, they can estimate this cost with a fair degree of precision.
- Real option pricing models work well with natural resource options.

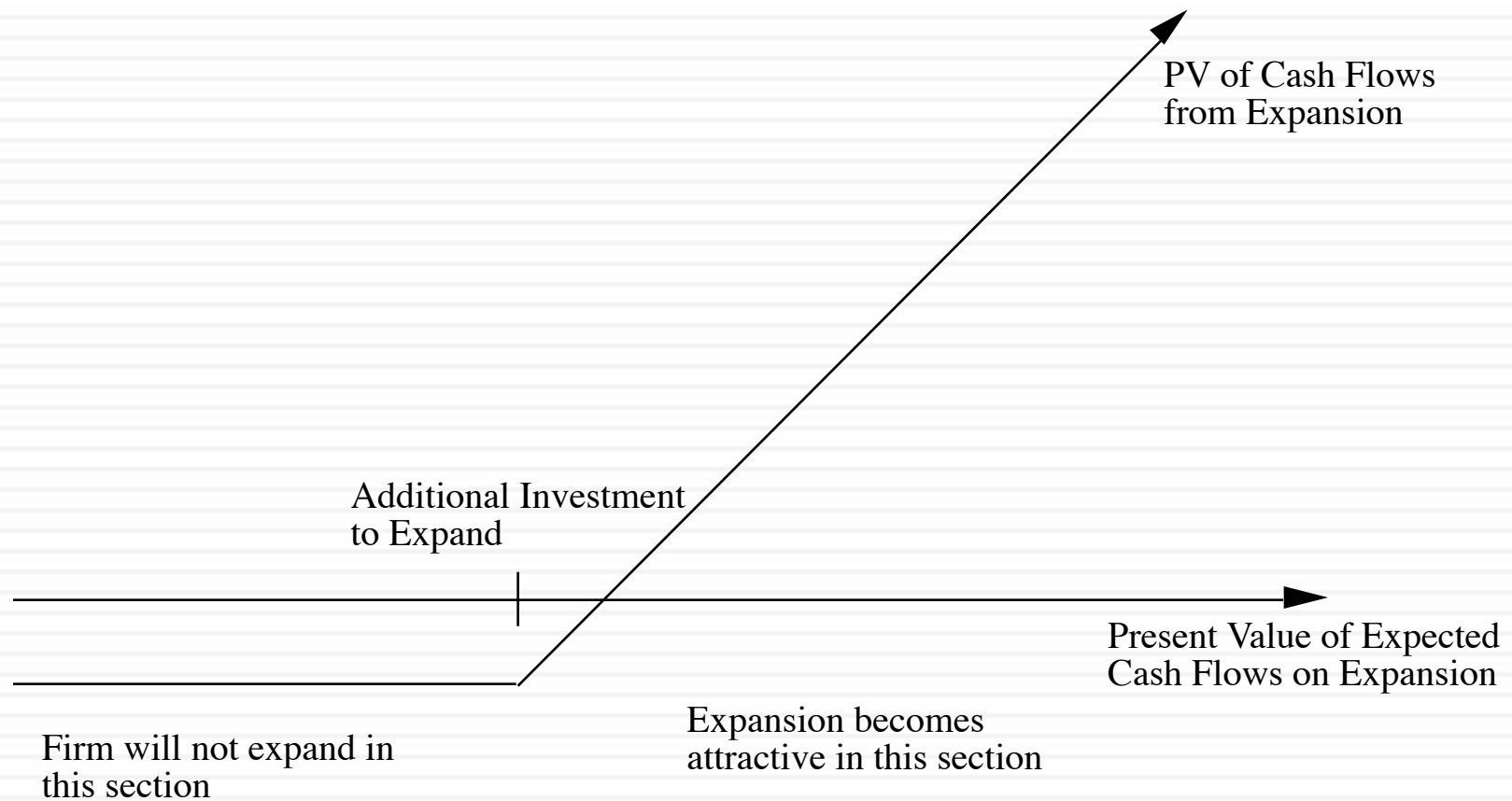
The Option to Expand/Take Other Projects

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- Taking a project today may allow a firm to consider and take other valuable projects in the future.
- Thus, even though a project may have a negative NPV, it may be a project worth taking if the option it provides the firm (to take other projects in the future) provides a more-than-compensating value.
- These are the options that firms often call “strategic options” and use as a rationale for taking on “negative NPV” or even “negative return” projects.

B. The Option to Expand

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The option to expand: Valuing a young, start-up company

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- You have complete a DCF valuation of a small anti-virus software company, Secure Mail, and estimated a value of \$115 million.
- Assume that there is the possibility that the company could use the customer base that it develops for the anti-virus software and the technology on which the software is based to create a database software program sometime in the next 5 years.
 - It will cost Secure Mail about \$500 million to develop a new database program, if they decided to do it today.
 - Based upon the information you have now on the potential for a database program, the company can expect to generate about \$ 40 million a year in after-tax cashflows for ten years. The cost of capital for private companies that provide database software is 12%.
 - The annualized standard deviation in firm value at publicly traded database companies is 50%.
 - The five-year treasury bond rate is 3%.

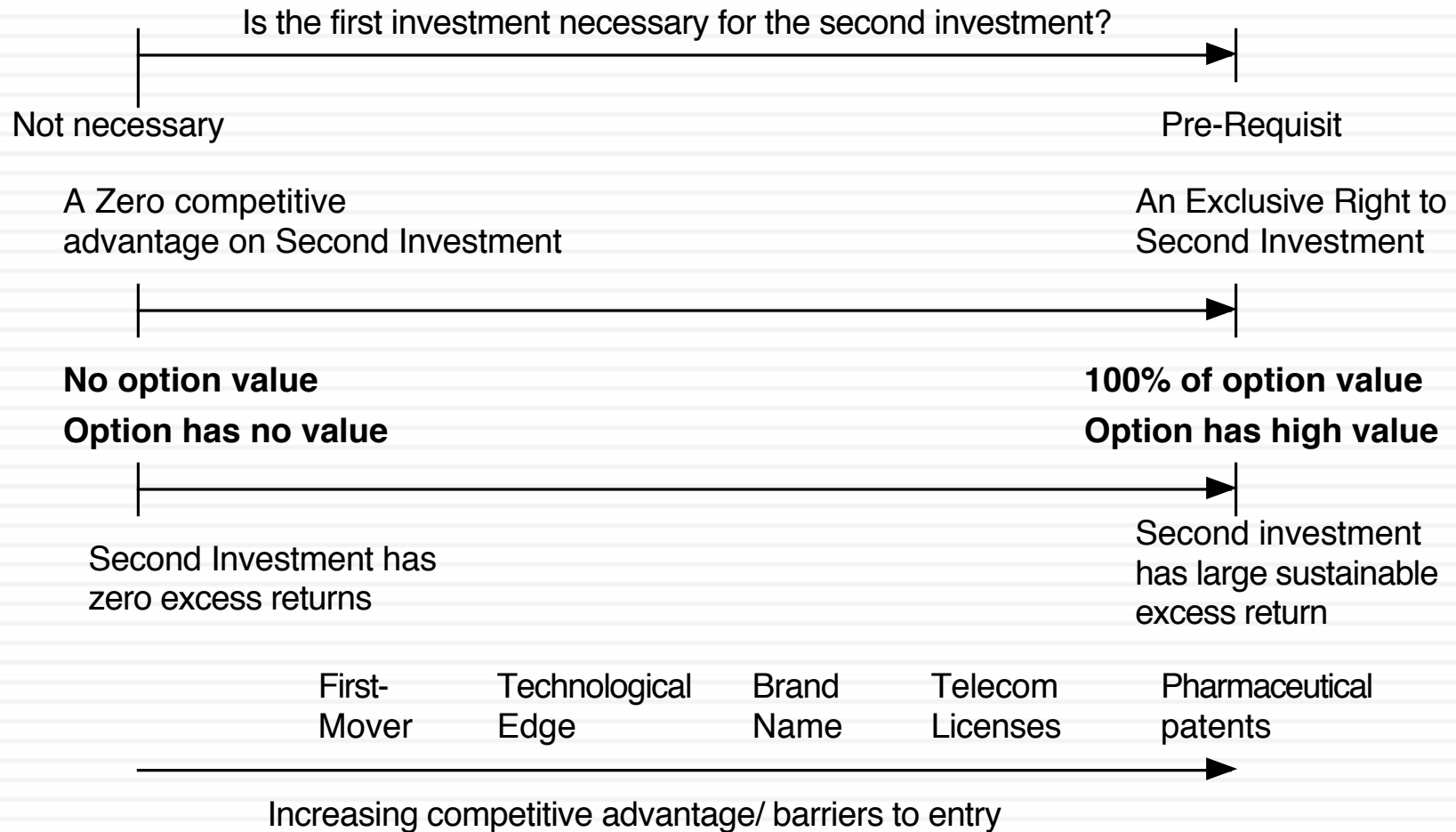
Valuing the Expansion Option

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- S = Value of entering the database software market
= PV of \$40 million for 10 years @12% = \$226 million
- K = Exercise price
= Cost of entering the database software market = \$ 500 million
= Period over which you have the right to enter the market
= 5 years
- s = Standard deviation of stock prices of database firms = 50%
- r = Riskless rate = 3%
- Call Value= \$ 56 Million
- DCF valuation of the firm = \$ 115 million
- Value of Option to Expand to Database market = \$ 56 million
- Value of the company with option to expand = \$ 171 million

A note of caution: Opportunities are not options...

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The Real Options Test for Expansion Options

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- The Options Test
 - ▣ Underlying Asset: Expansion Project
 - ▣ Contingency
 - ▣ If PV of CF from expansion > Expansion Cost: $PV - \text{Expansion Cost}$
 - ▣ If PV of CF from expansion < Expansion Cost: 0
- The Exclusivity Test
 - ▣ Barriers may range from strong (exclusive licenses granted by the government) to weaker (brand name, knowledge of the market) to weakest (first mover).
- The Pricing Test
 - ▣ Underlying Asset: As with patents, there is no trading in the underlying asset and you have to estimate value and volatility.
 - ▣ Option: Licenses are sometimes bought and sold, but more diffuse expansion options are not.
 - ▣ Cost of Exercising the Option: Not known with any precision and may itself evolve over time as the market evolves.
- Using option pricing models to value expansion options will not only yield extremely noisy estimates, but may attach inappropriate premiums to discounted cashflow estimates.