# Real Options and Regulation

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# A Car Leasing Puzzle

- Why are daily rental rates for a car from a rental agency like Hertz significantly greater than the per diem equivalent of the monthly rate?
- Someone renting a car on a daily basis has the flexibility of only having to rent the car when and where it is needed. This flexibility option is valuable, so the renter is willing to pay a higher daily rate.

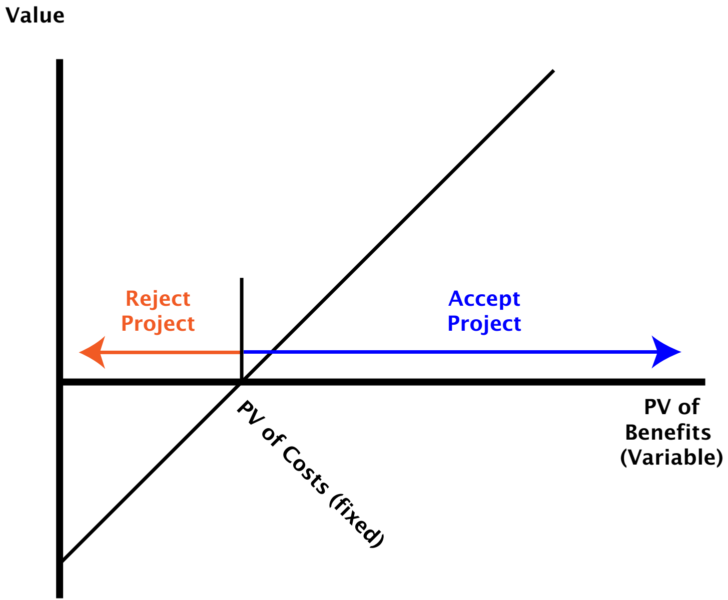
# The Fama-French Puzzle

- Fama and French found that the Capital Asset Pricing Model (CAPM) beta had no explanatory power in cross-sectional share returns.
- But, they found significant return premia for size and market-to-book, even though CAPM provides no theoretical basis for this.
- Small firms and firms with low market-to-book ratios usually have a lot of growth options. Options have a great deal of operating leverage.
- The operating leverage causes their betas to vary inversely with their market value, but the CAPM tests assume their betas are constant.
- Thus, the Fama-French factors are merely good proxies for the time-varying betas of firms with real options.

# Another Puzzle: The NPV Investment Policy

- The NPV of a project is the present value (PV) of projected benefits net of costs.
- The NPV rule says “Go ahead with a capital project if and only if it has a positive NPV”.

# The NPV Rule


Value
Reject
Project
Accept
Project
PV of Costs (fixed)
PV of
Benefits
(Variable)

# Theory vs Application

- The theory says we should accept a project with a \$1 billion capital cost if it has an NPV of \$1.
- Why don't firms accept such projects?
- A bond trader will often do a round trip transaction that earns 10 basis points. That is, they would transact \$1 million of bonds to earn an NPV of \$1000.
- But, most companies would reject a \$1 million capital project that only has an NPV of \$10,000 or even \$100,000.

# Real Options

Real options arise when the decision maker has flexibility or optionality in investment decisions. The real option decision to invest generally involves a tradeoff:

**Risk** gives incentives to defer a project. The real option separates upside potential from downside risk. The manager waits to collect more information, so when there is more risk, there is more delay.

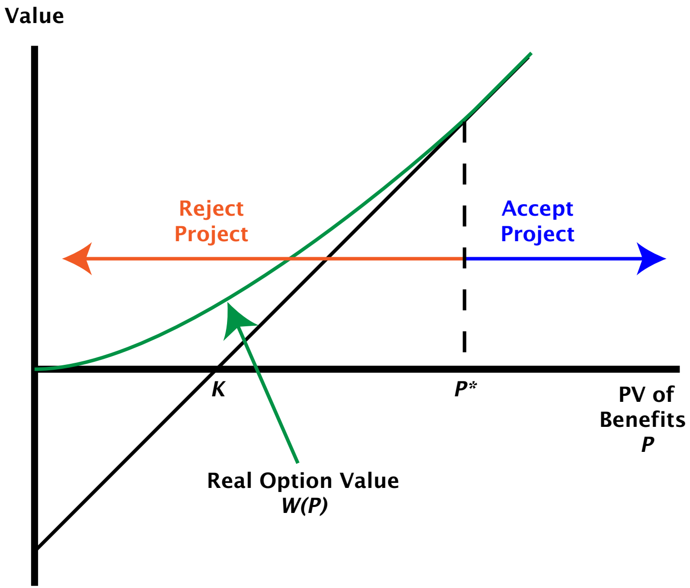
**Dividends** provide an incentive to develop a project early. Measuring dividends in a real option setting can be complex, but in many real options, it is the free cash flow payout from a developed project.

# Analyzing Real Options

Suppose the real option has an underlying asset of value PV of Benefits $\equiv P$, which follows a stochastic process. Real option value $W(P)$ depends on two things:

1. Terminal conditions for the value of the real option when the underlying risk driver $P$ assumes specific values, such as $0, \infty$ or an exercise (development) point.
2. Some methodology for extending option values to all possible values of $P$:
   - Lattice or tree models.
   - Solution of the fundamental valuation PDE from asset pricing theory.
   - Monte Carlo methods, extended to least squares Monte Carlo methods if the option can be exercised early.

# The Real Options Investment Decision



# The Real Options Investment Decision

- The real options model determines a hurdle value $P*$ and the decision rule is to defer development as long as $P$ is below $P*$.
- The optimal time for development is the first time that $P$ rises above $P*$.

# Terminal Conditions: Criteria Defining the Hurdle $P^*$

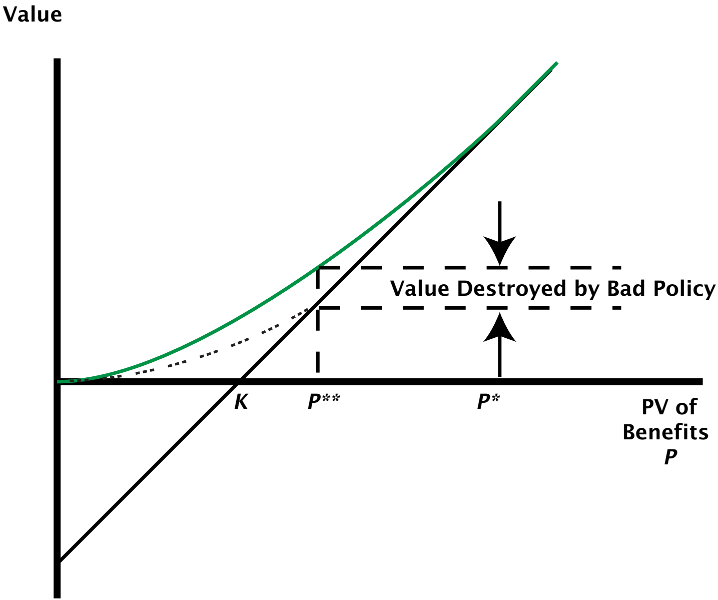
**Value Matching** The real option value equals the NPV when $P = P^*$. The real option gains its value from the fact that at some point, the real option will be exercised and the project will be developed.

**Smooth Pasting** The real option graph is tangent to the NPV graph at $P^*$. This tangency criterion is similar to the criteria in other constrained optimization problems whereby an optimum is characterized by the tangency between the contours of the objective function and the contours of the constraint function — Kuhn Tucker or Lagrange multipliers.

# Real Option Value vs NPV

- The real options hurdle price is higher than the NPV hurdle: $P^* > K$. Thus, projects are optimally developed later under the real options rule.
- The real option value exceeds NPV.
- The real option value is non-negative. The real option protects its owner from achieving a negative value.
- In effect, the real option separates upside potential from downside risk by deferring development until the underlying PV of Benefits is sufficiently above the development cost to greatly reduce the potential for loss.

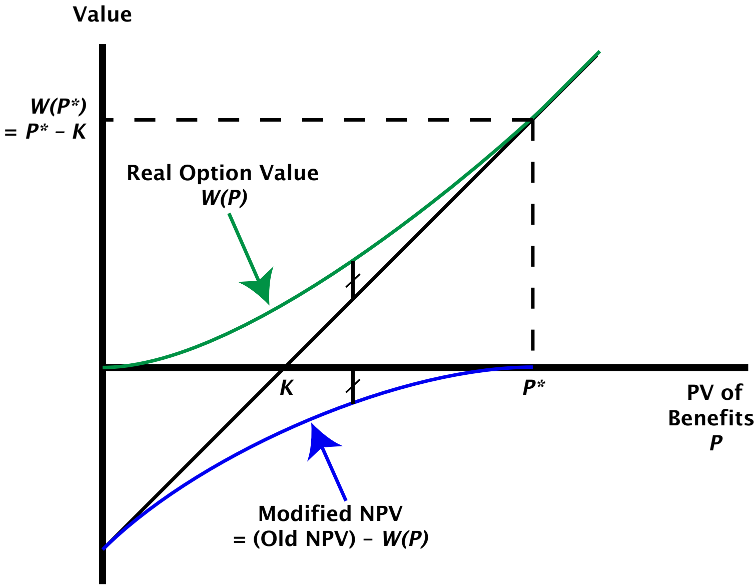
# Value Lost by Investing Too Early



# Value Lost by Investing Too Early

- Suppose the firm adopts a decision rule that it will develop as soon as the PV of Benefits, $P$, equals $P^{**}$ where $K < P^{**} < P^{*}$.
- The value matching condition holds because the real option value is anchored to the NPV value at the time of development.
- But, the smooth pasting tangency criterion for optimality does not hold.
- The resulting value function lies below the optimal real option value, but above the NPV graph.

# Modifying the NPV Rule to Include Opportunity Cost of Extinguishing a Real Option



# Modifying the NPV Rule to Reflect the Opportunity Cost of Extinguishing a Real Option

- If we charge the opportunity cost of the extinguished real option against the NPV calculation, we get the Modified NPV rule shown in the blue curve, which shows Old NPV $- W(P)$.
- Including this opportunity cost allows us to return to the decision rule "Invest as soon as the Modified NPV rises to 0 from a negative value".

# Book Value and Market Value

Consider a firm (or division) that has a single asset, namely the real option.

- Market value is formed from market assumptions of the behaviour of the managers in their dynamic development policies. If the market has reason to believe that management cannot or will not follow the optimal development policy, it will bid down the market value.
- Accounting principles do not allow the firm to book the value accruing from a prospective dynamic strategy. Thus, book value is based on past decisions only, and not future strategy.

# Book Values are Related to the NPV Rule

- Prior to development ($P < P^*$), the book value of the division is 0, but the market value is the value of the real option, $W(P) > 0$.
- Development requires an injection of capital in the amount $K$.
  Immediately after development ($P = P^*$), the book value is the invested capital, $K$, and the market value is $P = P^*$.
- Thus, at the time of development, the Market-to-Book Ratio is $\frac{P^*}{K} >> 1$.

# Market-to-book Ratios and Tobin's $Q$ Ratio

- In this simple model, the replacement cost of the assets after development is $K$, so the Market-to-book ratio equals Tobin's $Q$ ratio.
- Thus, firms that have a lot of real (growth) options have a high $Q$, where $Q >> 1$.

# Economic Rent and Real Options

- Economic rent also generates conditions where $Q > 1$.
- Thus, firms that own real growth options have some appearance of earning economic rent.
- This becomes an important issue if a regulated entity has real options: how should tariffs be set?

# Setting Tariffs in the Presence of Real Options

- In the development option above, the replacement cost of the assets and the book value of the assets is $K$, but the investment requires the owner to extinguish a real option that had a value of $W(P^*) = P^* - K$ at the time of development.
- Logically, any tariff for use of the developed asset should include compensation for the value of the extinguished option.
- One approach is to include the value of the option in the cost base for the tariff. Thus, the cost base would be $P^* = P^* - K + K$, rather than replacement cost $K$.
- Another approach is to increase the allowable rate of return on the lower cost base of $K$. This is consistent with the fact that unregulated corporations have internal rates of return that are significantly higher than their weighted average cost of capital.

# The Regulatory Objective: Avoid Distorting Investment Incentives

- If the regulator only allows the recovery of capital costs $K$ at the cost of capital used to calculate NPV, the regulated entity has no incentive to optimally invest, and perhaps no incentive to invest at all.
- The infrastructure provider would rationally change its behaviour by reducing investment activity if it were to anticipate that it would not be compensated for the real options.
- If investment did occur, but there is no compensation for the value of extinguished real options, a subsidy is given to either the final consumer or access seekers.

# Dividends or Convenience Value

- We have seen that the basic real option to delay investment involves a tradeoff between delaying to resolve risk and investing to capture a dividend payoff.
- Sometimes this dividend is characterized as a convenience dividend. Convenience dividends arise when a good has a high value only if it is available for immediate delivery. The immediacy could arise from a shock to the market that generates larger demand or diminished alternative supply.
- Convenience dividends for commodities can be measured from forward curves when there is backwardation: lower forward prices for longer terms.
- Electric power has very volatile convenience dividends. The owner of a gas-fired power generator captures the convenience value of positive electricity price shocks.

# Excess Capacity as a Real Option

- Convenience value arises from a real option itself.
- The convenience value of a good arises from the real option to use the good when its value rises because of a demand shock. This assumes that the good takes time to build and cannot be instantly supplied in unlimited quantities when a price shock arrives.
- In general, if a capital asset takes time to build and there are shocks to the profit stream it can produce, there are good real-option reasons to invest earlier to generate excess capacity.
- The excess capacity can be used to quickly ramp up production and capture positive shocks to profit, just as the electricity producer captures peaks in electricity prices.

# Facilities Access Regulation

- Facilities access is a system whereby regulation of the allowable consumer prices to be charged by an infrastructure provider is replaced by regulation of the cost of access to the production system. This allows multiple vendors to buy the production and sell it to consumers in a competitive market.
- Facilities access has been used around the world to "deregulate" telecom, electric power, natural gas and other utilities. From a consumer perspective, these industries were deregulated, but in reality, the regulation was transferred from the consumer level to a wholesale level.

# Facilities Access Tariffs and Capacity Options

- We have seen that a non-distorting tariff to be paid to a infrastructure provider who has the option to delay investment must include compensation for the opportunity cost of the real option that is extinguished to make the investment.
- Similarly, it is important to determine a non-distorting access tariff system when there are real options, including options to carry excess or latent capacity.

# Facilities Access Tariffs when Capacity is Finite

- Sometimes there are hard limits to the amount of capacity that can be used.
- For example, a refinery, railway or shipping port has a limited capacity. If access is granted to a seeker, it displaces the ability of the provider to use the excess capacity at a later date for its own real options.
- If this is coupled with a stochastic risk driver that creates real options, the regulator has an extremely difficult task in designing a non-distorting tariff system.

# Facilities Access Tariffs when Capacity is Finite: Single Part Tariff

- Suppose the regulator sets an access tariff that is paid monthly or annually, once access is attained.
- This gives the access seeker a free option to gain access if its product markets achieve high profit margins, but to avoid paying the fixed cost of building capacity if the product markets have low profit margins.
- The infrastructure provider does not know how much excess capacity to build because it does not know whether or not a seeker will actually come to use the capacity.
- Moreover, if the seeker is in the same output market as the provider, the seeker will ask for excess capacity exactly when the infrastructure provider needs it for its own use.

# Facilities Access Tariffs when Capacity is Finite: Single Part Tariff

- Suppose the single part tariff will only be received by the provider when the seeker actually starts to use the capacity. Then, the provider does not receive any compensation at the time it invests in the capacity option, so it has an incentive to underinvest in capacity.
- The regulator could set a high single-part tariff to compensate the provider on an *ex ante* basis for the possibility of access being granted.
- But, there is a limit to how high the tariff can be set without it becoming a deterrent for the seeker to actually demand the capacity.
- Indeed, setting a very high single-part tariff may fail to induce infrastructure investment because the provider anticipates that access will be actually sought only with a very low probability.

# Facilities Access Tariffs when Capacity is Finite: Two Part Tariff

- To address the problems with a single-part tariff, the regulator could set an up-front fee to be paid when the access seeker nominates or reserves capacity.
- In order for the provider to know how much excess capacity to build for a seeker, this up-front fee would have to be paid at the time the provider builds excess capacity. Otherwise, the provider will under-provide excess capacity.
- In this situation, the access is provided to the new capacity, rather than the existing capacity that the infrastructure provider had built for its own use.
- The seeker would still pay an annual fee for capacity used, once it actually gains access to the capacity.

# Regulating Access in the Presence of Real Options is Not an Easy Task

We can see that the regulator faces a significant task in designing a non-distorting facilities access system in the presence of real options.

- It must identify all the real options available to the infrastructure provider and the access seeker.
- It must model and value these real options. Or, it could design a regime where the seeker pays a maximal fee (e.g. all prospective capital costs) up front. But, this could be a significant deterrent to access.
- It must design a system in which tariffs are paid at the points in time when real option decisions are made, in order to provide incentives to build the optimal size and at the optimal time.

- The regulator must set the tariff levels at least to reflect the real option value, which depends on the prospective costs of investment, as well as the stochastic nature of the processes driving the real option.
- To support timely decision making, this analysis needs to be done in a short period of time, despite the fact that it is done in a confrontational regulatory environment.
- A simple cost base and cost of capital system will result in distorted incentives because it is a single-part tariff.
- Building a proper access regulatory system would require methods not yet developed in any jurisdiction.