

The Principles of Finance and Nuclear New Build

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<http://www.mit.edu/~jparsons/presentations.html>



Introduction and Motivation

- Policy and Principles, Practice and Pedantry
- What's special about nuclear?
 - capital intensity and scale
 - rents and opportunism
 - public choice in electricity markets
 - social choice in re Greenhouse Gases
- Finance matters more than usual.
 - Cost of capital has a huge impact on valuations.
 - The design of financial contracts shifts large quantities of risk and shapes incentives dramatically. Pricing that risk matters a lot. Evaluating incentives is key.
- The discussion about risk and value in nuclear is muddled.
 - I will illustrate that common, fundamental mistakes in the financial analysis have big consequences for the numbers. I believe these mistakes undermine the quality of public policymaking.
 - Sound analysis can make a contribution to the public discussion.

The Price of Risk versus the Value of Risk

A cynic is a man who knows the price of everything and the value of nothing.

in Oscar Wilde's Lady Windermere's Fan

- Since this lecture serves simultaneously as the introduction for a short course on financing investments, and as a seminar paper on the problem of financing nuclear new builds, I have organized it to focus on the fundamental errors in applying finance theory to public policy in the nuclear arena.
- I will start with an outline of a two-step approach to theorizing about finance issues. Then I will illustrate the relevance of this approach using 4 examples from the public policy debates.
- The two-step approach is organized around the distinction between price and value of risk.

The Market Price of Risk

- determined in a robust capital market; well diversified investors;
- only some risk matters—non-diversifiable risk
 - classic model is the Capital Asset Pricing Model (CAPM) where non-diversifiable risk is measured as Beta
 - alternatives to the CAPM exhibit the same insights, just in a different format
- required return is proportional to non-diversifiable risk
- the market price of risk is the same for all companies; i
 - idiosyncracies that make one company more or less averse to risks belong in the category of the value of risk;
 - investors evaluate all cash flows from the company to them using the market price of risk;
 - a company may be able to take a given risky cash flow, and transform it into a higher or lower valued risky cash flow as a result of frictions, incentives, etc; this is where value separates from risk, just as price and value are distinct in all other domains of economics;

Step 1: When Value=Price

- Modigliani-Miller world. Frictionless capital markets.
- One-way model of value and risk: assets determine the value and risk of the liabilities, not vica versa.
- Separation of investment and financing decisions.
- Finance is about dividing the pie, not about the size of the pie.
 - Measure risk correctly, understand the tradeoff between risk and return; understand how different financial structures repackage the asset risk, but without increasing the value.
 - Irrelevance theorems: corporation is a pass through.
 - ✓ No value to hedging. No value to risk shifting. No value to finance, in general.
 - But it's still important to understand how the pie is being cut.
- Strict, clean accounting principles for value, risk and return.
 - Make's it easy to compare the different slices of the pie. Fidelity to these principles is critical for sound financial analysis and clear communication.
- Not a completely realistic picture of the world. But a useful starting point for analysis. You skip this step at your peril.

Step 2 : When Value \neq Price

- Capital market frictions come in a variety of shapes and sizes and create the possibility for finance to shape investment decisions.
 - Long-term contracts enable parties to sink dedicated investments.
 - Allocation of risk shapes incentives for optimal operating and investment decisions.
 - Hedging enables companies to minimize the costs of raising external capital.
- Price of risk still matters.
 - Just because the pie is bigger, doesn't mean we can ignore how it is being cut. Need to carefully account for the market price of risk as we evaluate the costs and benefits of re-allocating the risk.
 - Building on top of the MM-world foundation. Extending the analysis beyond the MM-world.
- Tools here are less familiar, less universally employed, more ideosyncratic.
 - Need for experimentation. Room for blundering, and some charlatans..
 - Problems are very complex.

Policy Examples

#1. Misuse of the WACC Formula

- Assets are risky, and they pass this risk on to the liabilities of the firm.
 - The WACC formula imputes the observed risk of the liabilities to the assets. But it reads the logic backwards.
- Changing the liabilities does NOT change the risk of the assets.
- Widely used models for calculating the LCOE misuse the WACC formula, applying a cost of capital that is too high, yielding an LCOE that is too high.
 - They fix a cost of debt and a cost of equity.
 - They fix an initial debt-to-equity ratio.
 - They then run out the cash flows using the pro forma financing schedule; this produces a declining debt-to-equity ratio through time.
 - This is ignored, and the same cost of equity is applied throughout. Implicitly this amounts to assuming that the asset risk is growing through time and the discount rate applied is growing as well.
 - This lowers the value of future cash flows, and increases the calculated LCOE.

Significance

- A 2007 study of studies done by Nicolas Osouf
 - Major studies by DGEMP, IEA/NEA, CERI, MIT, Chicago, RAE, Sculley
- Evaluated the role of different inputs on the calculated LCOE. Certainly relevant, but impossible to rationalize the studies by standardizing the inputs.
- Two different implementations of the discounting.
 - The first fixed the risk throughout the life of the project: directly applying a single discount rate, the after-tax WACC, to the unlevered cash flows.
 - The second misused the WACC formula as described above.
- The misuse tended to increase the calculated LCOEs by 14%.
 - In comparisons of LCOE this is a significant discrepancy, especially when it is a simple and fundamental mistake in applying a well established financial model.

study is available at this website:

- globalchange.mit.edu/files/document/Osouf_MS_07.pdf; result appears in Table 10 and surrounding discussion.

Can the web be our savior?

- Although policy reports sometimes describe their methodologies, the description is often brief, usually ambiguous, and sometimes wrong.
- There is no substitute for seeing the numbers calculated.
- Modern technology makes that possible.
- Spreadsheets can be posted!
 - We did that for the MIT 2009 Update on the Cost of Nuclear.
- This should be a requirement for public policy discussions.
 - Separate studies at Harvard and MIT on the economics of nuclear fuel recycling are both available on-line. A new study by the Smith School/Oxford produces results at odds with both the Harvard and the MIT study. Why isn't the Oxford study available on-line?
 - Who you gonna trust?
- Differences will be quickly crystallized.

#2. Underestimating the Cost of Loan Guarantees

- The US loan guarantee program is a major tool for supporting both renewables and nuclear
 - in tandem with production tax credits
- Illusion about the true costs of a guarantee
 - long history; NEI thinks this is not a subsidy
 - Federal Credit Reform Act, 1990 requires that guarantees be paid for
 - In the law, the cost of guarantee is calculated using the Treasury rate; but the companies with debt being guaranteed are not as safe as the Treasury; the correct rate to use is higher.
- Mismeasurement of the cost of risk in loan guarantees yields an underestimate of the subsidy value.
 - Negotiations between the government and industry on the guarantees become skewed by the unspoken true subsidy value.
 - The unspoken true subsidy value is so large (getting step #1 wrong), it almost certainly swamps any extra value specific to the nature of a loan guarantee, i.e. due to step #2 over step #1.

The cost of market risk

A common view is that the government has a lower cost of capital than private financial institutions because it can borrow at Treasury rates. Treasury rates are low, however, because holders of Treasury bonds are protected against losses by taxpayers who absorb the risk of the government's activities. ... when the government provides such a guarantee, it is effectively shifting financial risk to taxpayers who, like investors in a financial institution, are averse to bearing that risk. From that perspective, market risk is a cost to taxpayers that is not included in budget estimates.

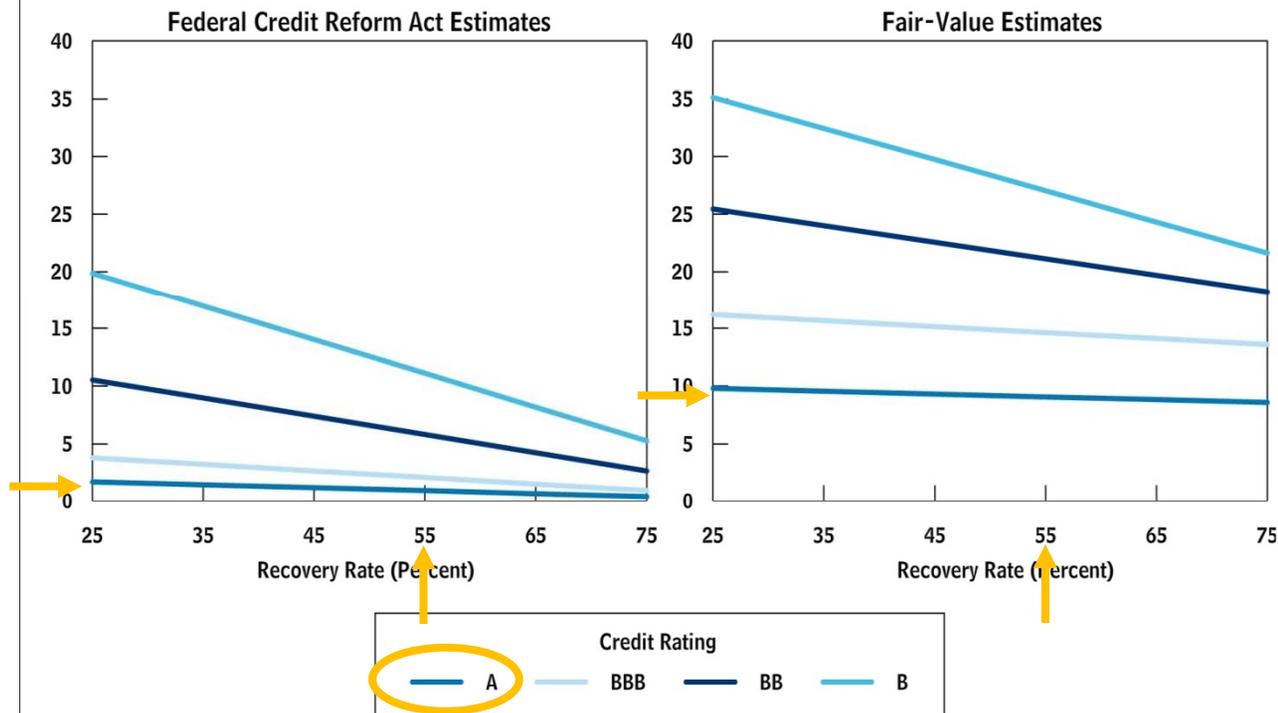
*CBO Report, August 2011, Federal Loan Guarantees
for the Construction of Nuclear Power Plants*

CBO Report quantifies the hidden subsidy

Figure 1.

Variations in the Estimated Cost of Loan Guarantees, by Credit Rating and Recovery Rate, as Measured Under the Federal Credit Reform Act and on a Fair-Value Basis

(Guarantee costs as a percentage of loan principal)



- LHS figure shows budgetary cost calculated per FCRA rules discounting using Treasury rates.

- RHS figure shows fair value cost calculated using discount rates that recognize the cost of market risk.

- In a case with a 55% recovery rate and an A-rated company...
 - FCRA cost = 1% of loan
 - Fair value = 9%

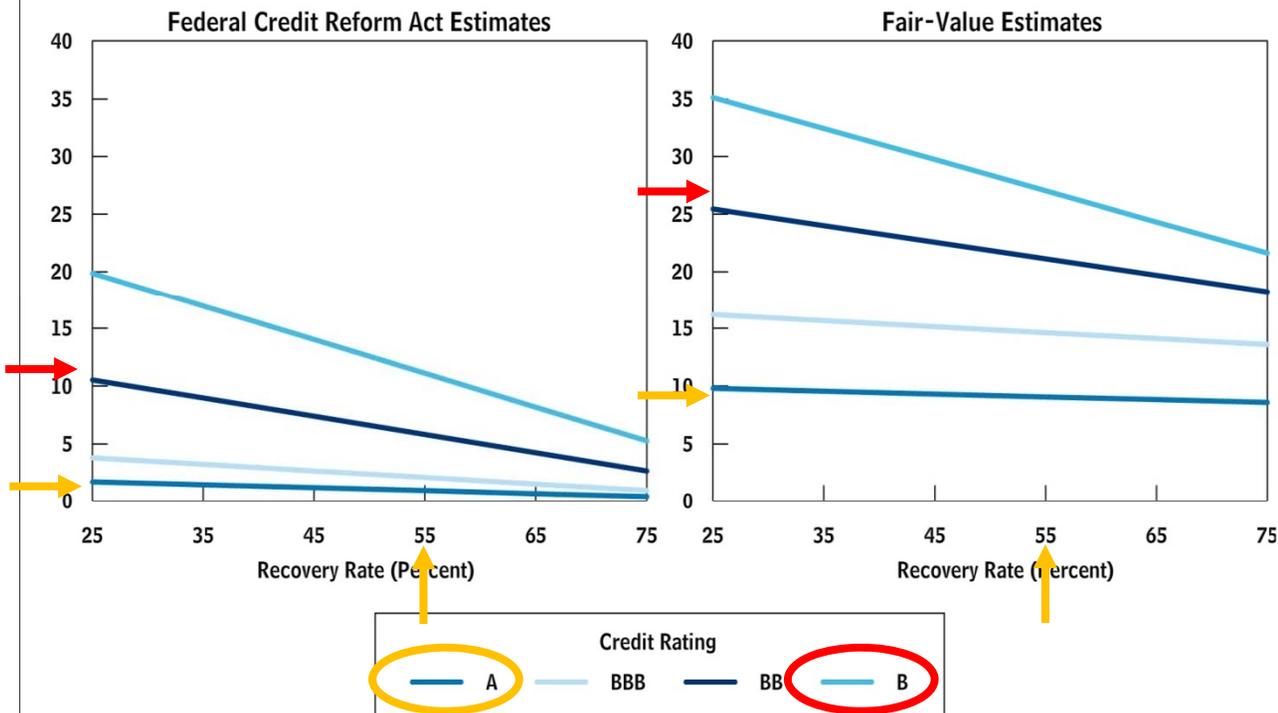
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- LHS figure shows budgetary cost calculated per FCRA rules discounting using Treasury rates.
- RHS figure shows fair value cost calculated using discount rates that recognize the cost of market risk.
- In a case with a 55% recovery rate and an A-rated company...
 - FCRA cost = 1% of loan
 - Fair value = 9%
- or, with a B-rated company
 - FCRA cost = 11%
 - Fair value = 27%

CBO Report, August 2011, Federal Loan Guarantees for the Construction of Nuclear Power Plants

Significance

- At Georgia Power's new units for the Vogtle plant...
- e.g. \$8 billion in debt to be guaranteed
- FCRA cost = \$80 million
- Fair value = \$720 million
- Difference = \$640 million



#3. The UK's Electricity Market Reform's support for nuclear and wind

Two components.

- Traditional electricity market design improvements.
 - solve capacity problems – e.g. with capacity markets
 - solve liquidity problems – e.g. with mandated sales into a pool
 - etc.
- Advancing the decarbonization of the UK electricity system.
 - raising the carbon price
 - emissions performance standard... banning traditional coal
 - power purchase commitments to low-carbon generation... especially wind + nuclear
 - reducing the risk of low-carbon generation
 - carbon floor price
 - contracts for differences... i.e. wholesale electricity price derivatives to low C generators

One word—RISK—covers many very different problems

- Long-term investments and decision making under uncertainty
- Coordination, commitment and the risk of ex post opportunism
- Investors, market risks and the cost of capital

The Real Issues for Carbon and Nuclear

- Long-term investments and decision making under uncertainty
- Coordination, commitment and the risk of ex post opportunism
- Investors, market risks and the cost of capital

In particular, on the second one, there is a place for intelligent financial contracts and other economic policies and instruments to add value. Poor contracts and institutions add risks to the system, undermining the value of wise investments. Fixing this could add value..

The Muddle

- Long-term investments and decision making under uncertainty
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This is an entirely different thing. To a first approximation, I think this is a red herring. In an MM world, there is conservation of risk. Risk is shifted, but not eliminated. Risk is shifted at a price. Low risk activities earn a low return. High risk activities earn a high return. Shifting from one to the other leaves value unchanged. There is no direct value to hedging.

Policy makers mean point #2, but academics are modeling point #3. For the academics to get the result (a positive value to financial contracting) they want with the tools they've chosen (hedging ala point #3), it is necessary to get the finance wrong.

UK Carbon Strategy Claims that by Shifting Risk it can Lower Costs

Carbon Price Floor:

“To make the very large investment decisions needed in low-carbon generation capacity, investors require some certainty about future revenues. Carbon price certainty is particularly important given the long life of low-carbon generation investments. If there is more certainty over future carbon prices, developers should include this as part of their investment appraisals. High levels of uncertainty over future profitability and rates of return could increase the cost of capital for investors and deter investment altogether. If uncertainty is too great, investment will either not go ahead or capital could be diverted to less risky forms of generation.”

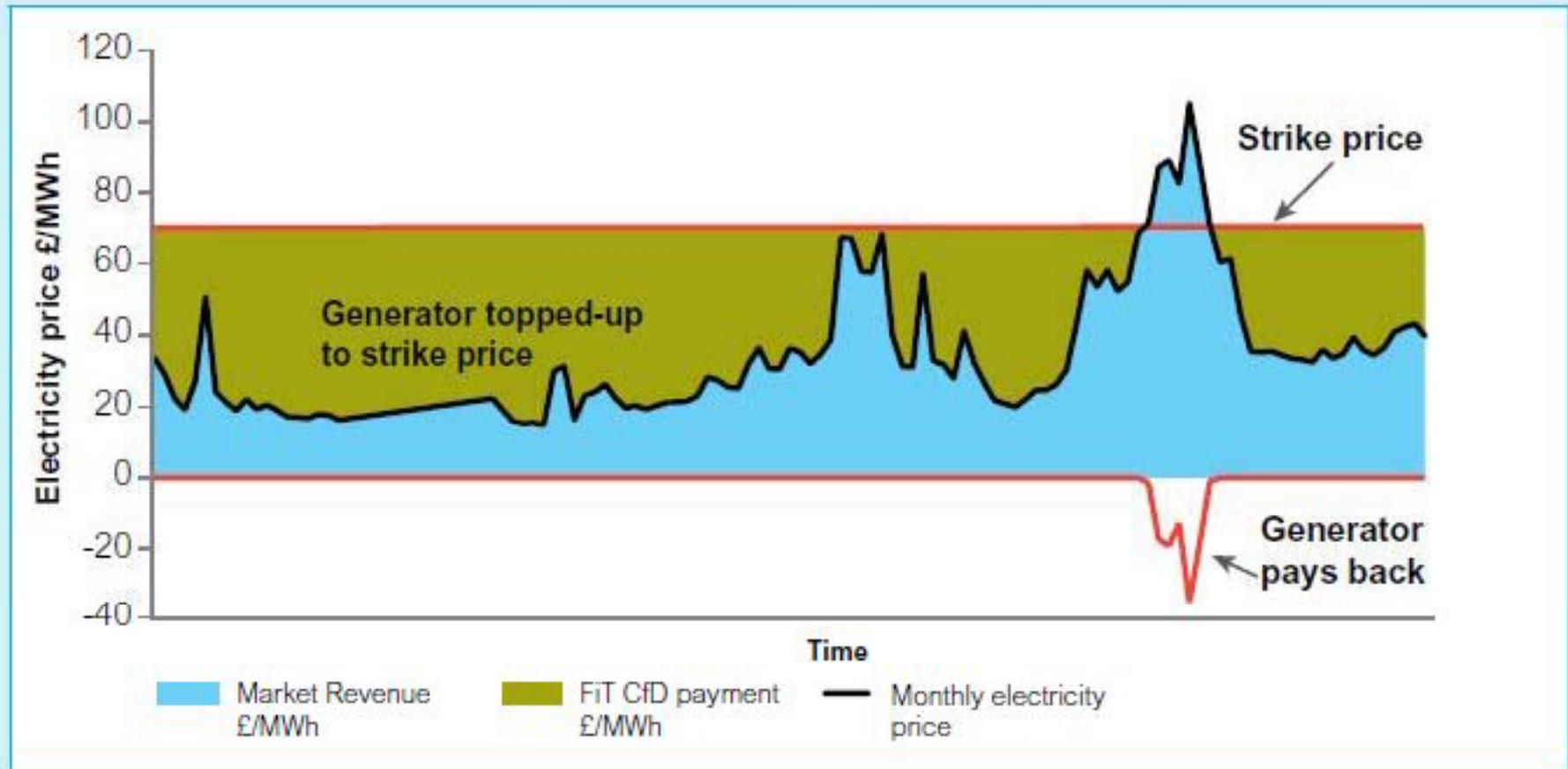
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Contracts-for-Differences to low C generators:

“Each of the low-carbon technologies the Government is considering differs materially from this standard investment choice. In particular, low-carbon generation typically has high construction (capital) costs and low operating costs, and as a result low-carbon plants are wholesale price takers. It is therefore difficult to make an investment case for them in a market where wholesale electricity prices are predominantly set by the short-run marginal costs¹⁸ of unabated gas and coal plant, even if the carbon price was high enough for their levelised costs to be similar.”

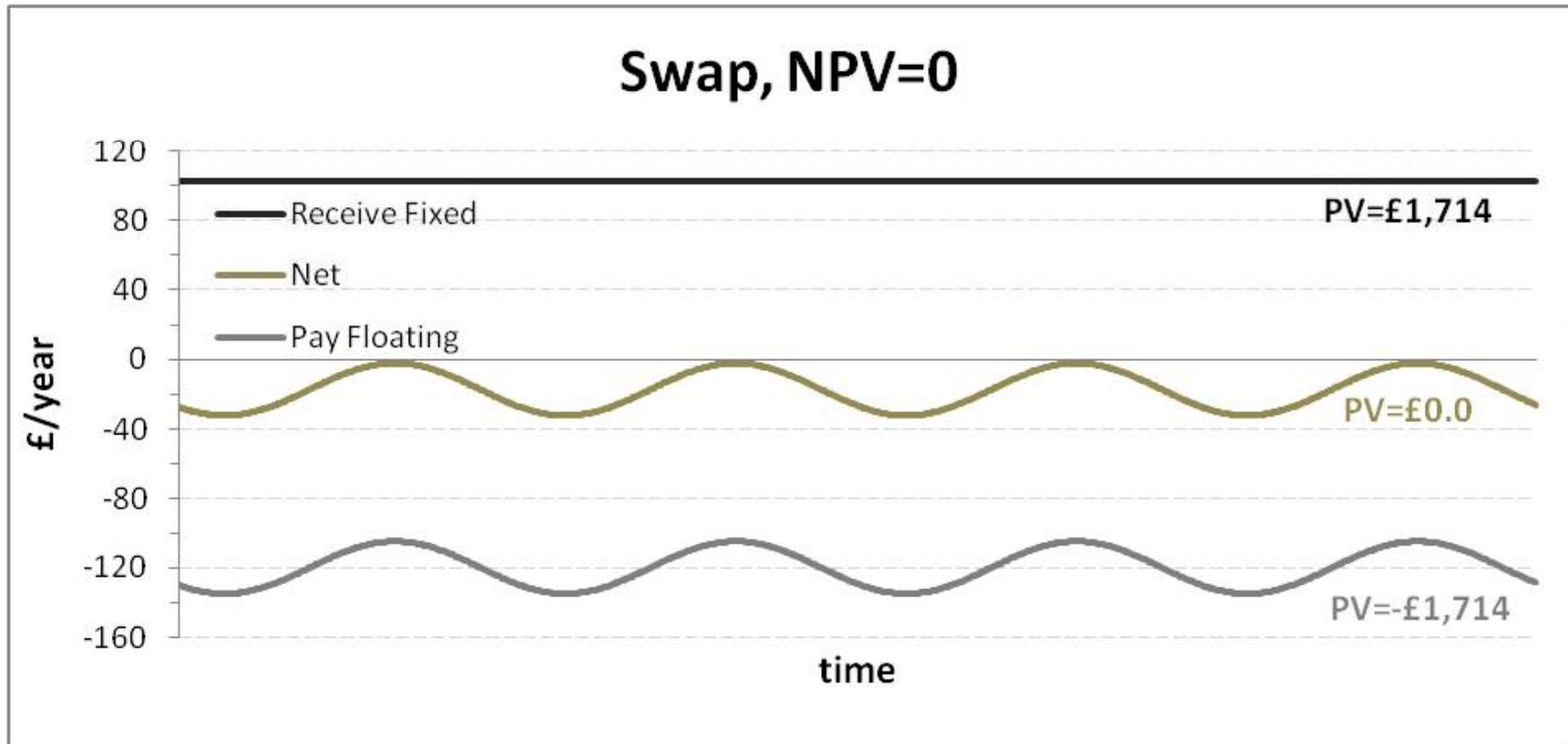
Contracts for Differences

Figure 5: The operation of an intermittent Feed-in Tariff with Contract for Difference



Source: UK Electricity Market Reform White Paper.

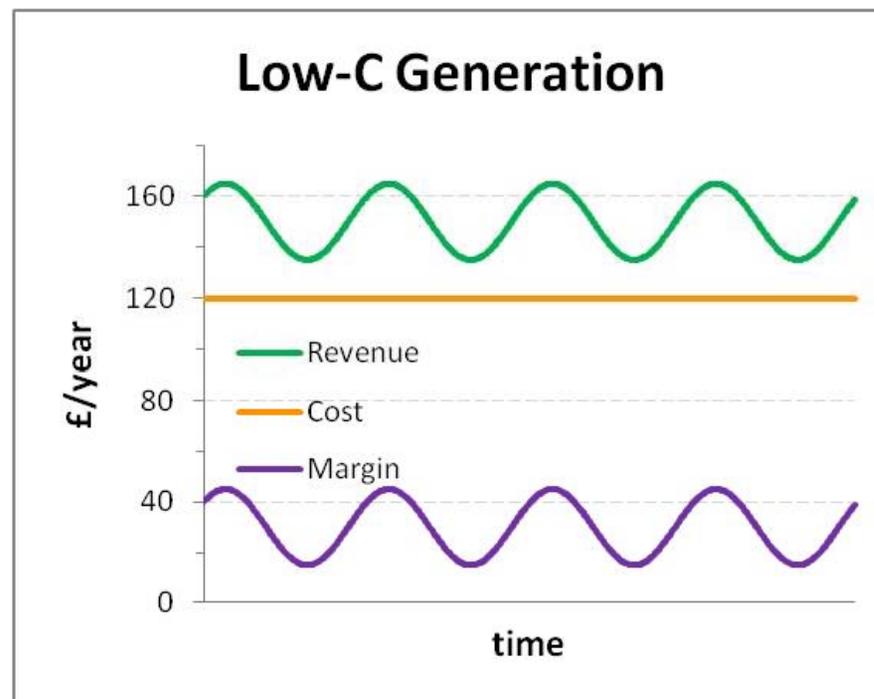
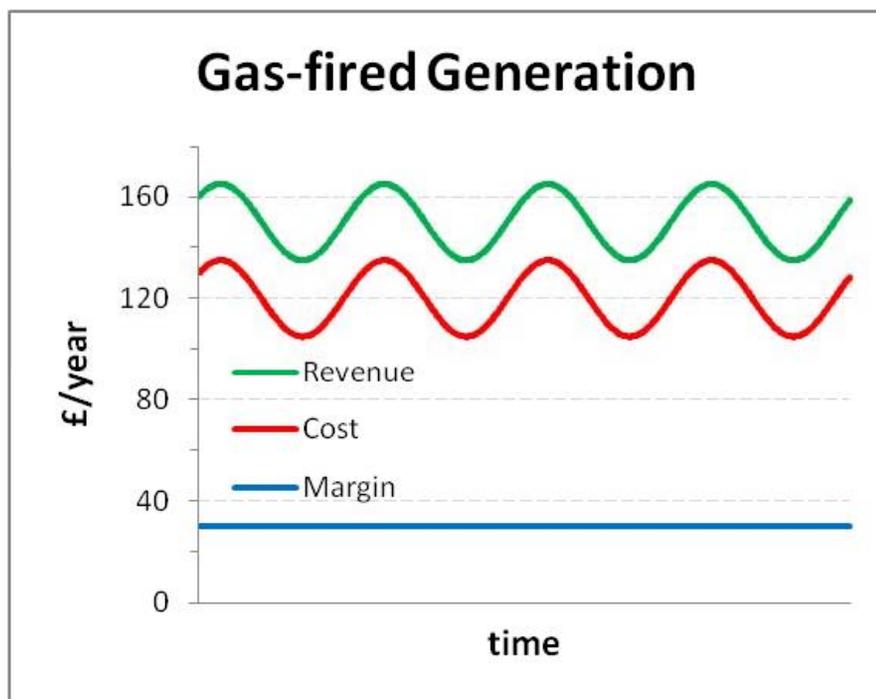
Swap



The Muddle Dissected

- The next couple of slides present the academic case behind the UK EMR.
- I then show that this case is in direct conflict with the principles of finance assuming the Modigliani-Miller framework of step #1.

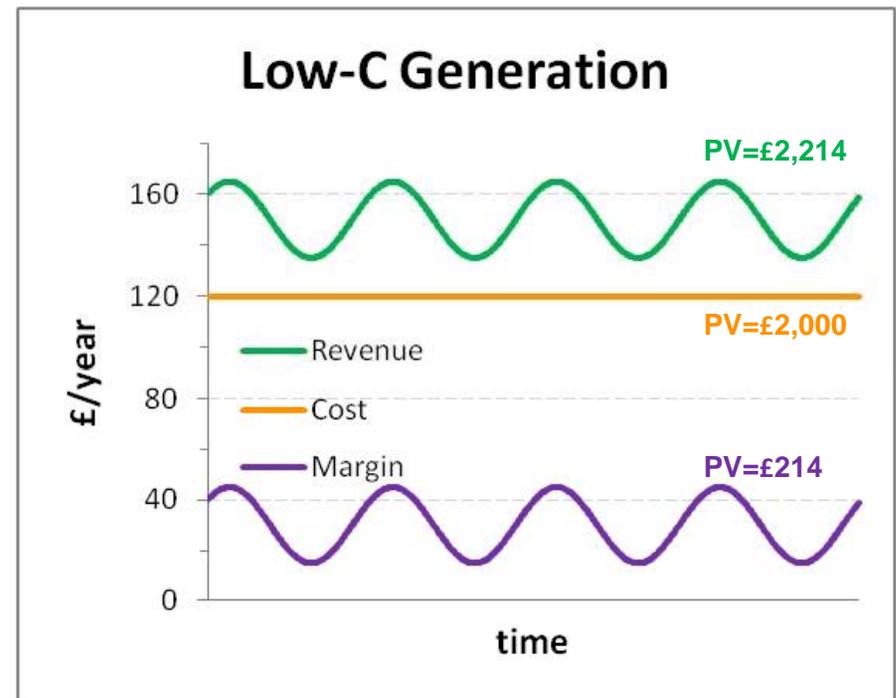
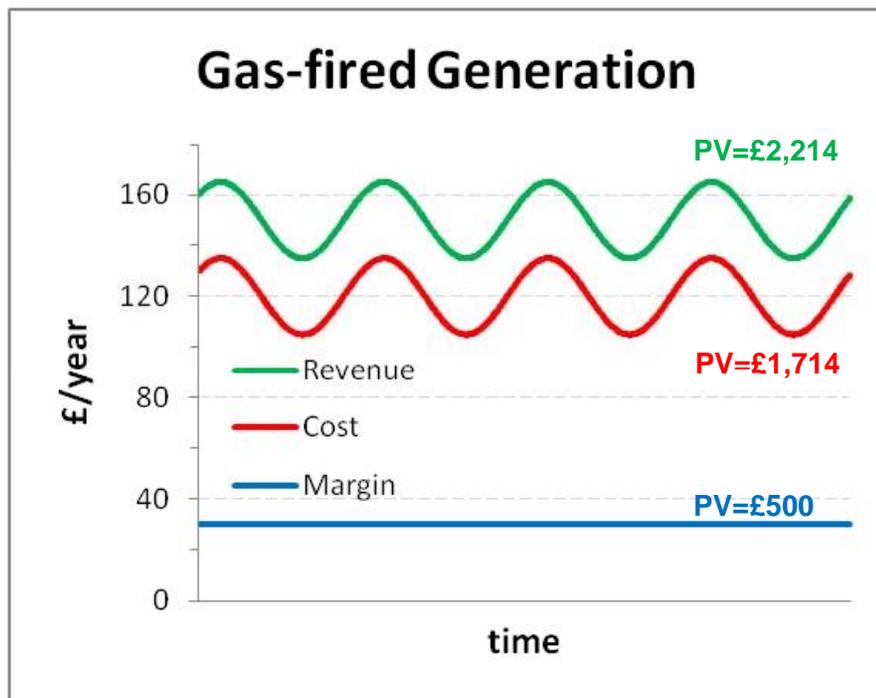
The Rationale for CfDs



Source: David Newbery, The impact of risk in electricity markets on nuclear new build, Nuclear Industry Forum, June 24, 2008.

- Key assumption is that the natural gas price determines the wholesale electricity price.
- Therefore, the gas-fired generator is naturally hedged.
- The low-C generator is exposed to the risk of the wholesale electricity price.
- 2 claims seem to follow...
 1. cost of electricity is approx same, but
 2. investors will choose to build gas.

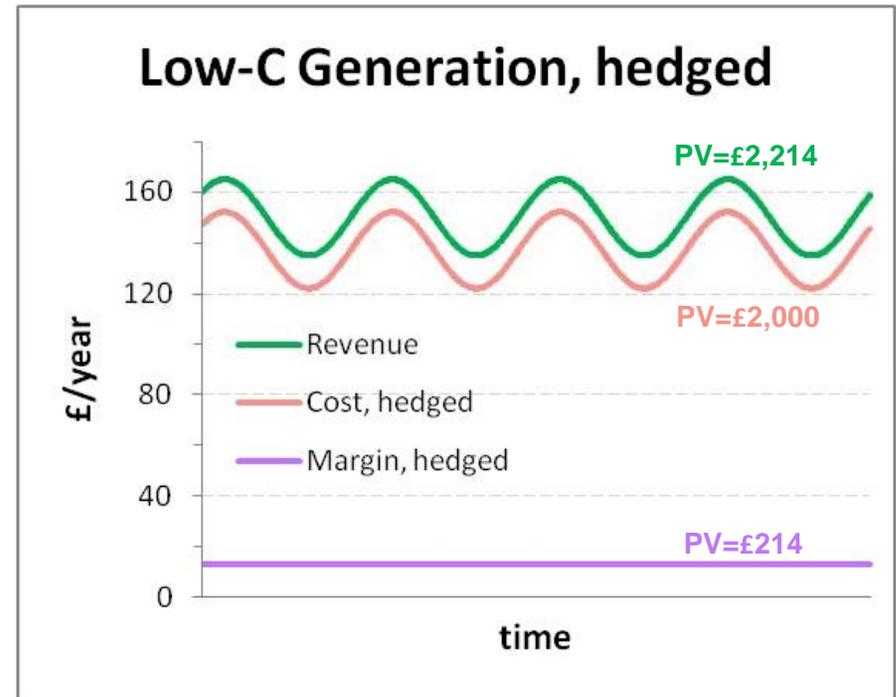
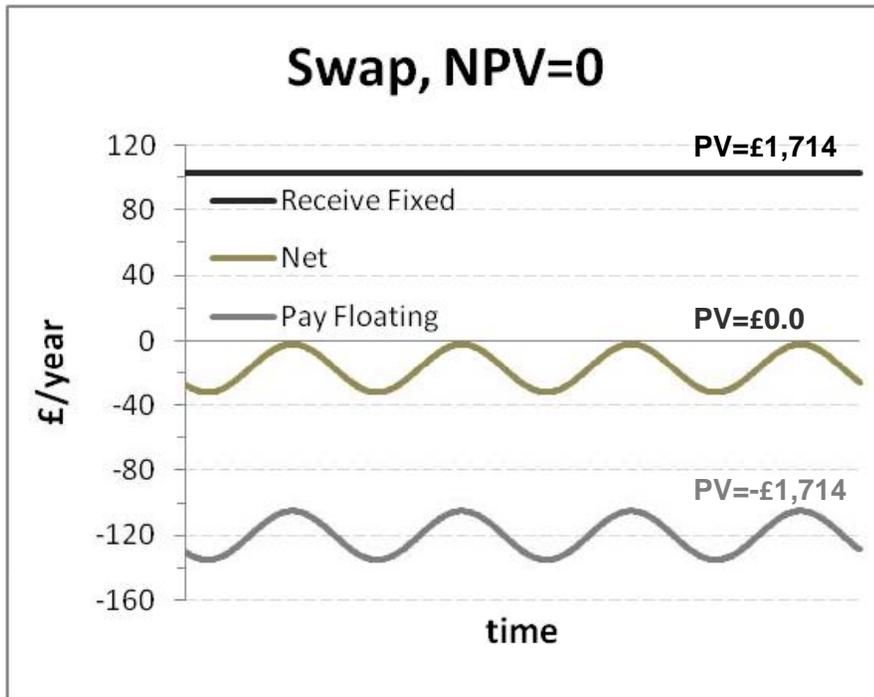
Whoops. Let's put numbers on the graphs.



Source: David Newbery, The impact of risk in electricity markets on nuclear new build, Nuclear Industry Forum, June 24, 2008.
Present values not in the original.

- My assumption: capital markets define a unique price for each risk. Specific values come from a CAPM model, but that is not critical. Any model will do.
- Claim 1 is not true. The LCOE is greater for Low-C Generation.
- Claims 1 & 2 cannot be true at the same time, if my assumption holds.
- LCOE is adjusted for risk, too.

Impact of a Hedge: first order, none.



- Hedge sells the volatile electricity wholesale price risk (calibrated at the level of the gas generator), and receives a fixed payment of equivalent value.
- Key assumption is that the risk in the swap cash flows is priced identically to the risk in the generator's cash flows.
- Low C generator's hedged cost is above the Gas-fired generator's hedged cost. Low-C generator's hedged profit margin is below the Gas-fired generator's hedged profit margin.

Fictitious Savings

- **Sample White Paper claim:**
“These long-term contracts, Feed-in Tariffs with Contracts for Difference (FiT CfDs), which stabilise revenues, should increase the rate of investment and lower the cost of capital, thereby reducing costs to consumers. In our central scenario, the FiT CfD reduces the cost of decarbonisation to 2030 by £2.5 billion compared to using the Premium Feed-in Tariff (PFiT) to deliver the same investment.”
- Calculations supporting this are entirely ad hoc. They are based on a custom built model that is, in design, at odds with the principles of modern finance theory, and constructed with parameters for which there is no empirical foundation.

Figure 79 Simulated earnings risk



Source: Electricity Market Reform Analysis of policy options. A report by Redpoint Energy in association with Trilemma UK. December 2010.

The Real Issues

- Long-term investments and decision making under uncertainty
- Coordination, commitment and the risk of ex post opportunism
- Investors, market risks and the cost of capital

- ✓ Is the carbon price high enough?
- ✓ Is the government's *long-term* commitment to a stated policy sufficient for making a major capital investment today?

These are important issues involving complicated problems of uncertainty and risk over time, and difficult policy challenges. But they are different from issues of exogenous market risks and investor cost of capital.

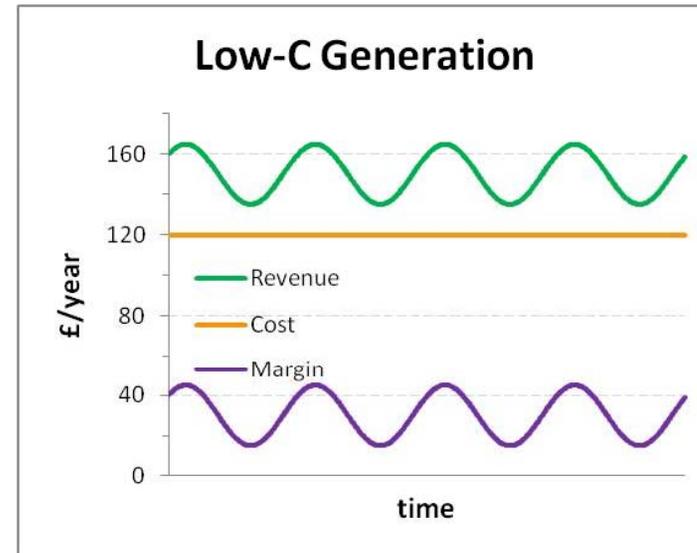
The models used to justify the carbon price floor and CfDs and to quantify the benefits are not constructed to measure the issues raised under these categories.

Dangers Ahead

- The UK's new carbon policy undermines the EU-ETS and abrogates the prior policy of creating a common EU carbon market. Surely one can see irony in providing investors long-term certainty via this route.
- Promises, promises.
 - The floor is not a floor. There is nothing binding about the floor.
 - CfDs only work if, under certain circumstances, they provide revenue above the competitive level. Should that happen, will the UK public understand the deal that was cut on its behalf?
 - Ask owners of German nuclear plants about long-term commitments. ...and about taxes on nuclear fuel.
- Crafting a long-term strategy for carbon in the face of massive uncertainty about the future is a very, very difficult task. Some long-term investments choices do have to be made now. Society does have to make some commitments.
- But there is also no getting around the need for flexibility over time. Society must keep its options open to respond to contingencies and new information. There is serious danger in pretending to being able to lock-in a long-term path today.
- Managing long-term expectations with realism both about the flexibility that must be preserved and about the commitments that are believable is a difficult political task.

Risk and Risk

- Short-run v. Long-run
- Exogenous v. Endogenous
- Key risk facing low-C investors is the long run social commitment to carbon reduction and to specific policies.
- The UK EMR's risk reduction policies are targeted, in part, to short-run fluctuations in price independent of social commitment. This is a red herring.



#4 The Value of Long-Term Contracts as a Strategic Commitment Device

#4 The Value of Long-Term Contracts as a Strategic Commitment Device

- One feature of liberalized energy markets has been proscriptions of various forms against long-term power purchase contracts.
 - US Load Serving Entities are limited in the percent of power they can contract for long-term.
 - EU Commission Oct. 07 decision against Distrigas in Belgium forcing it to reduce the volumes tied to long-term contracts. New contracts with gas resellers will not exceed two years, with electricity generators five years.
 - Bundeskartellamt 2006 decision against E.ON/Ruhrgas to stop writing contracts with distributors that cover more than 50% of demand for more than four years and 80% for two years.
- Contracts are not obviously at odds with liberalization.
 - The issue is a trade-off with monopoly power and entrenched incumbents.
 - Indeed, it is the proscription that is at odds with liberalization. Does this proscription have a cost?
- Can the right baseload generation be built without the benefit of long-term power purchase contracts? Financiers look to long-term power purchase contracts to provide the necessary security that makes low-cost capital available.

Traditional Focus

- Long-term contracts are a common feature for large-scale natural gas development; especially in remote locations where major dedicated infrastructure facilities are to be constructed. LNG gasification facilities and transport infrastructure.
- Long-term contracts had been a common feature of the development of mine-mouth coal fired power plants – see Joskow (1985).
- Project finance for infrastructure development.

Why Long-Term Contracts?

- Remember, long-term contracts for output is not the norm in most industries, for most goods!
 - But it is used for some.
 - Long-term contracts are a common feature for large-scale natural gas development; especially in remote locations where major dedicated infrastructure facilities are to be constructed. LNG gasification facilities and transport infrastructure.
 - Long-term contracts had been a common feature of the development of mine-mouth coal fired power plants – see Joskow (1985).
 - Project finance for infrastructure development
- But, long-term contracts make the financing possible.
 - This begs the question.
- What about risk-sharing, risk-shifting.
 - Where does the risk go? Who gets the hot potato?
 - Are we just burdening consumers, hiding the cost of risk and declaring victory?
 - A subsidy by another name, or a meaningful institutional reform? What is the capital market failure that long-term contracts are meant to treat?

Why Long-Term Contracts? (cont.)

- What exactly is the security that the contract gives? How does it lower the cost of capital? We need to explicitly model the way that finance and investment interact, and then be able to quantify it. Need to identify a clear objective, well specified; need to identify the non-zero sum gain made uniquely possible by this contract form.
- Numbers. Where are the numbers?
 - The numbers should clearly be identified with the targeted objective.
 - Results should vary based on circumstances. Contracts should sometime be better and sometimes not. Hence the need for calibration, for numbers.
 - Choices change, and for some reason: Algeria's recent decision to market its natural gas short-term. Entergy's desire to sell nuclear power spot.

Outline of Research

- This is an example of how to execute step #2 in the research paradigm described earlier. The result is an identification of structural issues in which the financing matters.
- This is based on thesis work by Raphael Berger.
 - Original thesis is available here: dspace.mit.edu/handle/1721.1/34519?show=full
 - A slide show of the research results is available here:
<http://www.mit.edu/~jparsons/Presentations/Contract%20Value%20w%20Berger.pdf>
- The research analyzes the competition between two different generation technologies
 - One is lower cost, but takes a long time to build.
 - The other is higher cost, but can be built quickly.
- Load growth is uncertain. Capacity must be added periodically, but in the face of uncertainty about load growth. Explicit model.
 - In expectation, it is best to build the low cost technology.
 - But occasionally, growth will be unexpectedly fast, and it is valuable to quickly use the high cost technology to satisfy demand.

Outline of Research (cont.)

- A proscription on long-term contracts induces a different game between the two technologies.
 - Occasionally, the evolution of load growth is such that...
 - society would prefer to build the low cost technology, but
 - the high cost technology can jump in and benefit from the spot market now and in the future;
 - this discourages the low cost technology from being built, pre-emption.
- Without long term contracting,
 - society builds more than the optimal amount of the high cost technology
 - pays on average a higher price for electricity.
- In this case finance matters. The contracts that are available for commitment about future cash flows change the competitive game between technologies. Finance is not just a zero sum game.