Room for Improvement:
Increasing the Value of Economic Modeling for Climate and Energy Policy Analysis*

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Energy and Economic Policy Models: A Reexamination of Some Fundamental Issues

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***Adapted and expanded from Laitner (2006)**

Acknowledgments

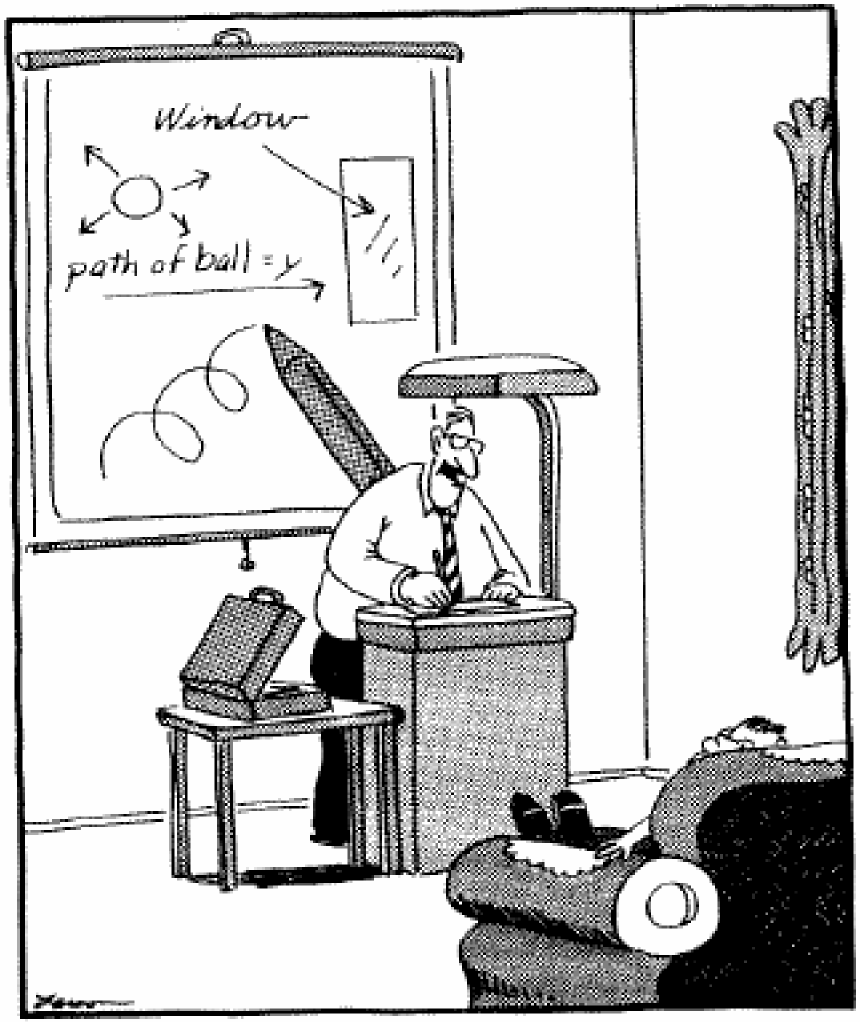
- This presentation draws on the many ideas that have evolved over the years from wide-ranging discussions with a variety of amazing friends, colleagues, and collaborators. I want to acknowledge in particular the special contributions of three of my colleagues here today: Steve DeCanio, Don Hanson, and Neal Elliott.
- But I would also like to acknowledge the many invaluable insights and thoughts from a much broader community, including: Steve Bernow, Fatih Birol, Bruce Biewald, Marilyn Brown, George Burmeister, Penelope Canan, Tom Casten, Ken Colburn, Ruth Schwartz Cowan, Laura Cozzi, Jerry Dion, Therese Dorigan, Andrew Fanara, Lorna Greening, Alan Heeger, John Hoffman, Tina Kaarsberg, Jon Koomey, Amber Leonard, Irving Mintzer, Lynn Price, Wendy Reed, Art Rosenfeld, Matthias Ruth, Alan Sanstad, Suzanne Watson, Elizabeth Wilson, and Ernst Worrell.
- I would also like to extend my deep appreciation to ACEEE's own Steve Nadel and Bill Prindle who encouraged me to rejoin the research community after an absence of more than a decade; and to those of you here today who have come together to explore critical ideas that will make this forum a very real and important contribution to the dialogue. Finally, I want to thank Maggie Eldridge who hung in there with me every step of the way to make this workshop a success.

An Observation With Four Areas of Suggested Improvements

- News stories this week highlight US reluctance to ratify the Kyoto Protocol because of its alleged cost to the US economy.
- My own observations since the 1992 Rio Summit suggest that, among the causes for US reluctance, have been what I believe to be inappropriate modeling exercises which have preempted the review of a more robust set of energy and climate policy initiatives.
- In my review here today, I suggest four areas of needed improvement in our modeling practices:
    1) Technology characterization that is often limited or even inappropriate – for both the demand and the supply-side of the equation;
    2) Capital flows that are not sufficiently disaggregated to provide meaningful policy assessments;
    3) Modeling assumptions about consumers and firms which may be unrealistic and which may also give misleading insights about policy options; and
    4) An economic accounting of investments and technology choices that are limited or poorly represented
- In the limited time here today, I will focus on items one and three.

The Good News About Energy Efficiency Investments and Climate Change Policies

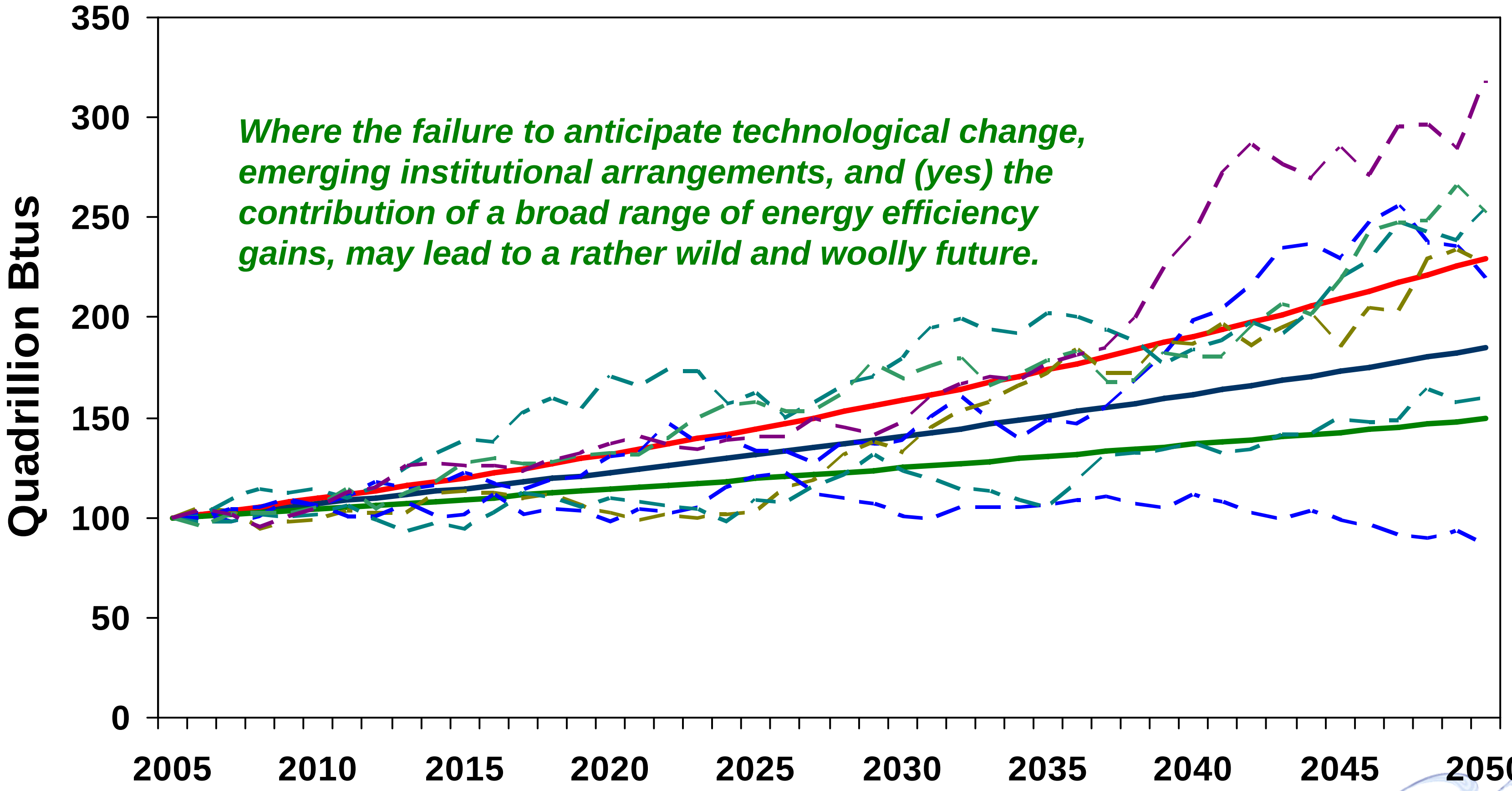
- It is does not have to be about ratcheting down our economy (Laitner et al. 2005);
- Rather, it can be all about:
  - using innovation and our technological leadership;
  - investing in more productive technologies (including both existing and new technologies); and
  - developing new ways to make things, and new ways to get where we want to go, where we want to work, and where we want to play.
- ***But again, most economic models appear to assume the former.***



Eventually, Billy came to dread his father's lectures over all other forms of punishment.

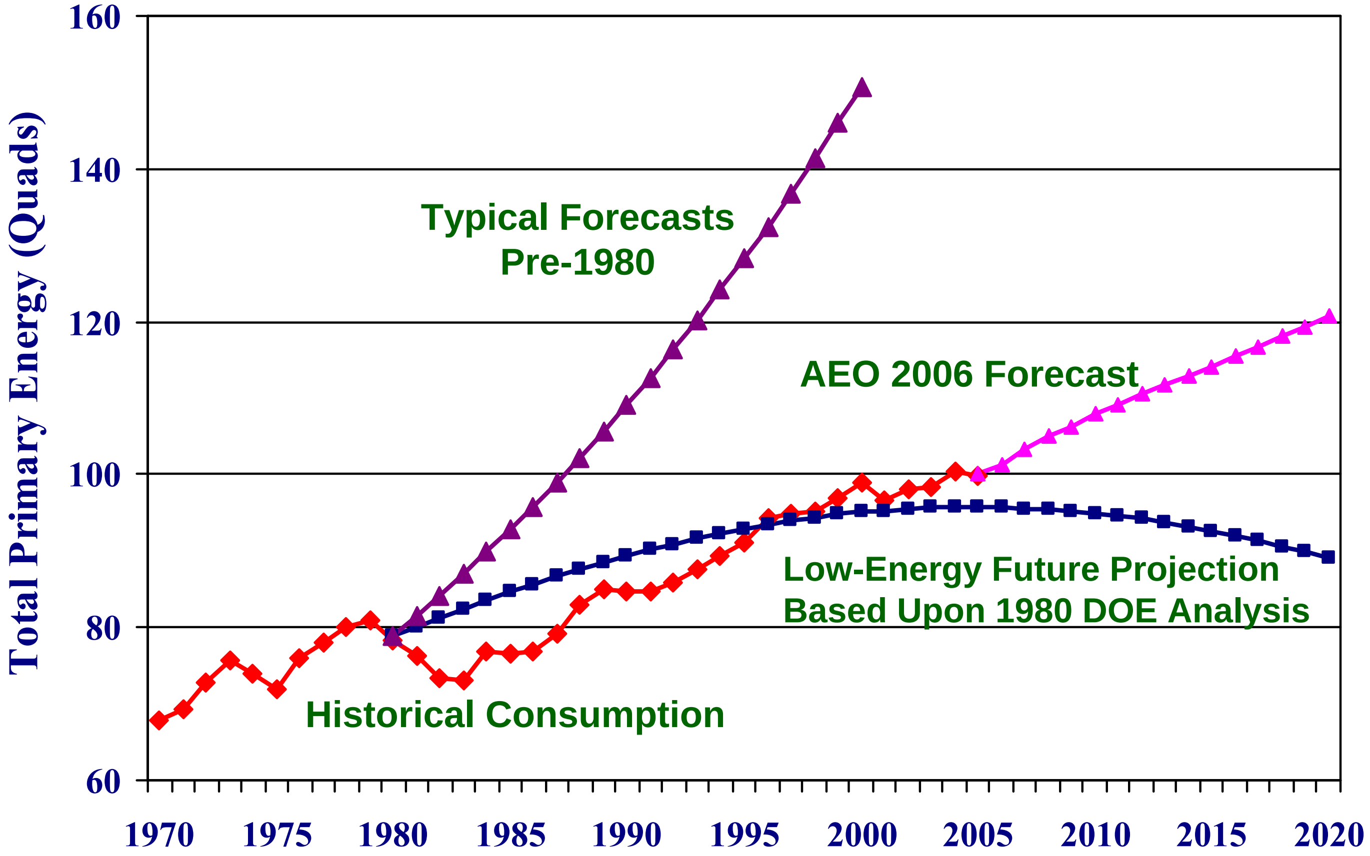
I'm hoping, of course, to avoid this same (or at least a similar) outcome here today. . . .

A Reminder that the Past is Consistent with Many Different Futures*

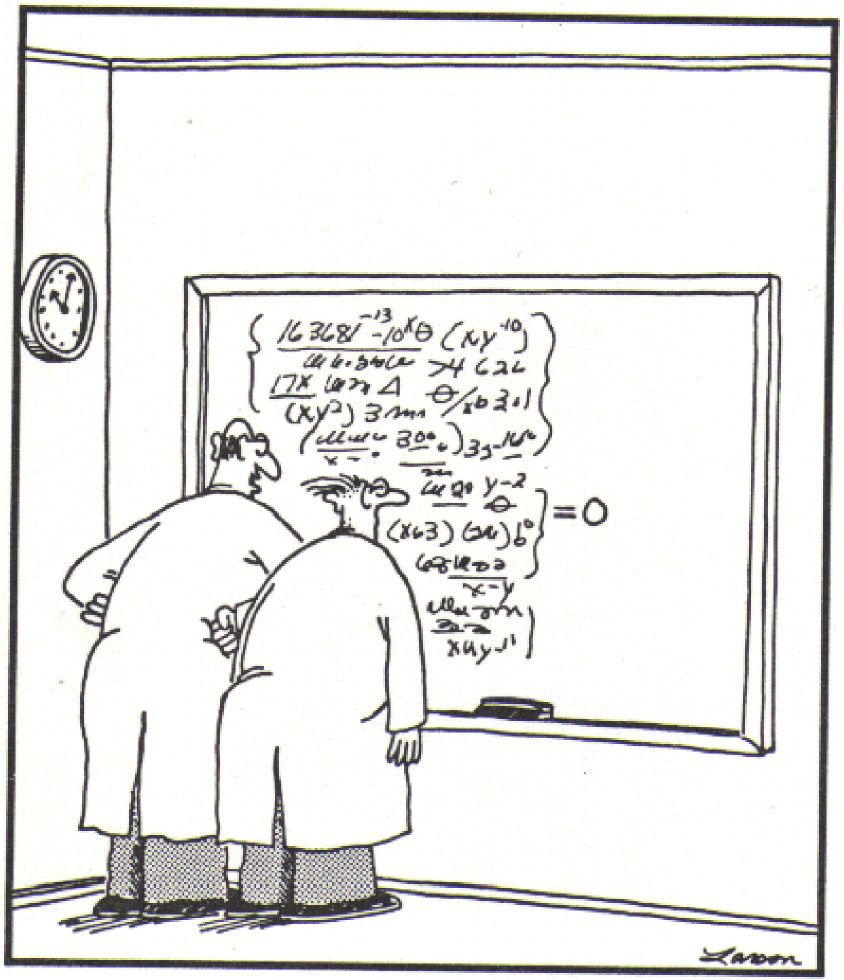


** Adapted from articles by and discussions with Rob Lempert.*

Comparison of U.S. Energy Projections:
Again a Difference in Technology Assumptions



Source: AEO 2006, ACEEE estimates 2006, and 1980 DOE Policy Analysis



"No doubt about it, Ellington—we've mathematically expressed the purpose of the universe. God, how I love the thrill of scientific discovery!"

Although $< \infty$, the future contribution of energy efficiency to the world economy is $>>> 0$. And policy models should be able to help us explore both the size and cost-effectiveness of that resource potential.

Recall this Accounting Identity

GDP = Investment + PCE + Gvt + NetExports

Hence, if we can envision a policy that:
(1) Increases overall productive investment;
(2) Generates a net savings for consumers and businesses;
(3) Benefits from smart government spending patterns; and
(4) Contributes to a net positive export balance. . . .

Then we should expect economic policy models to reflect this set of impacts. If not, then those models may not properly map the correct set of economic assumptions.

Comparing Model Assessments of Kyoto*

Models and Scenarios	Market Reform and Technology Programs	Tax Shift	International Flexibility	Inclusion Other Gases	Air Quality Co-Benefits	Realization of Kyoto Target	Percent Change in GDP For 2010
EIA Domestic Only	No	No	No	No	No	100%	-4.2%
EIA International	No	YES	YES	No	No	100%	-0.8%
EMF-16 Global Trading	No	No	YES	YES	No	100%	-0.2%
CEA Best-case Trading	No	No	YES	YES	No	100%	-0.07%
IWG Domestic Only	YES	No	No	No	No	58%	0.1%
IWG International*	YES	YES	YES	No	No	100%	0.0%
AMIGA Domestic Only	YES	No	No	No	No	52%	0.6%
AMIGA International*	YES	YES	YES	No	No	100%	0.4%
IPSEP	YES	YES	YES	YES	YES	100%	0.5%

*Adapted from Laitner et al (2003).

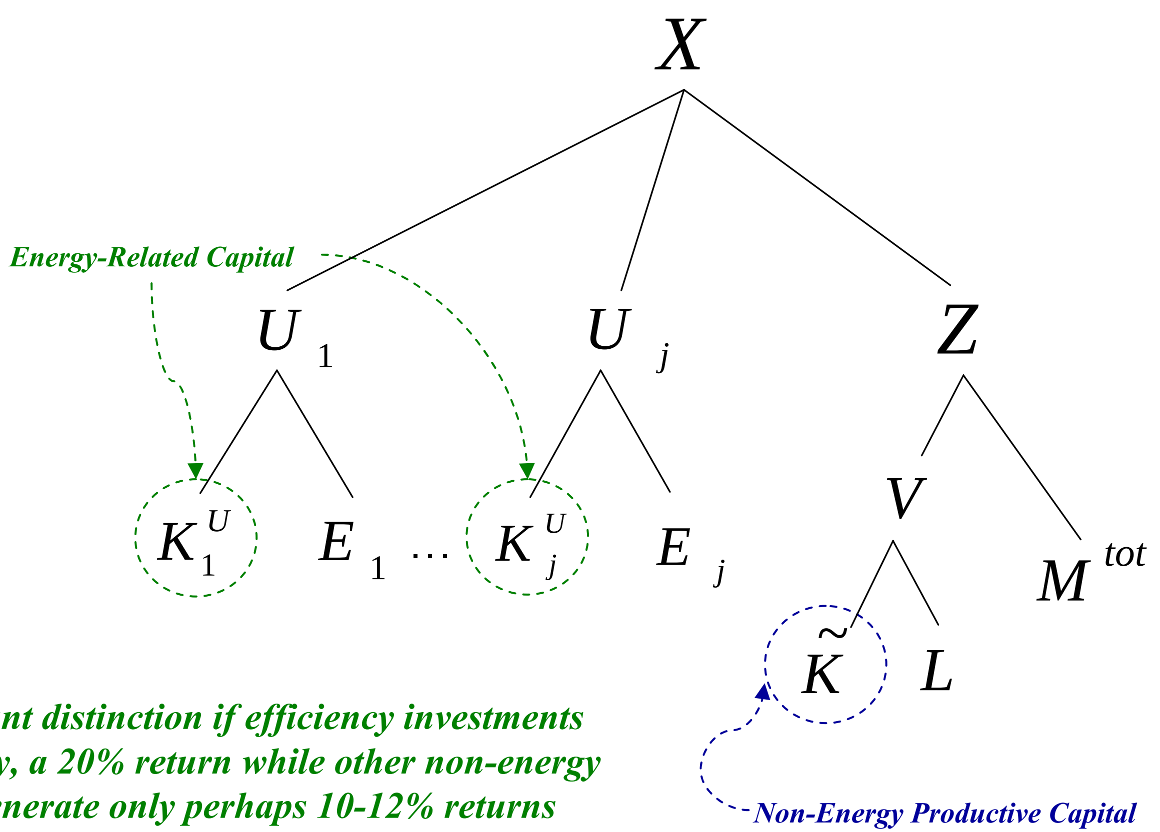
A More Egregious Example of (at least) Five Models Which Use Some Form of the Following Characterization of Potential GDP Impacts

$$GDP_t = GDP_0 * GrowthRate * \left(\frac{P_{new}}{P_{old}} \right)^{-Elasticity}$$

So that no matter how cost-effective the policies or the technologies, if there is any kind of net price increase from a given policy initiative, the macroeconomic impacts (by definition) must be negative.

Given today's understanding of returns on technology and market dynamics, this is not an acceptable characterization.

A Useful Hierarchy for Evaluating Efficiency Investments within a Production Function

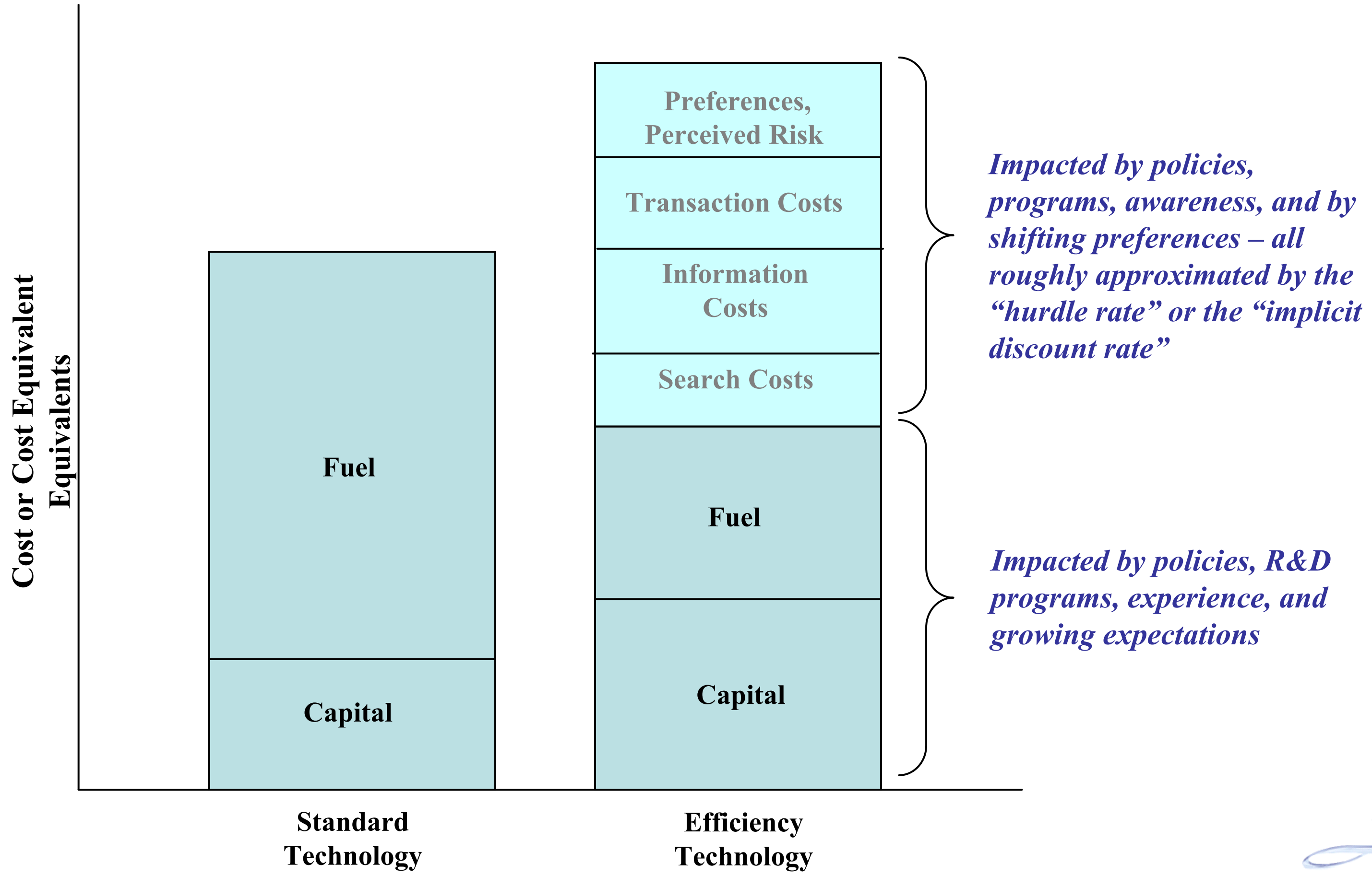


An important distinction if efficiency investments generate, say, a 20% return while other non-energy capital generate only perhaps 10-12% returns

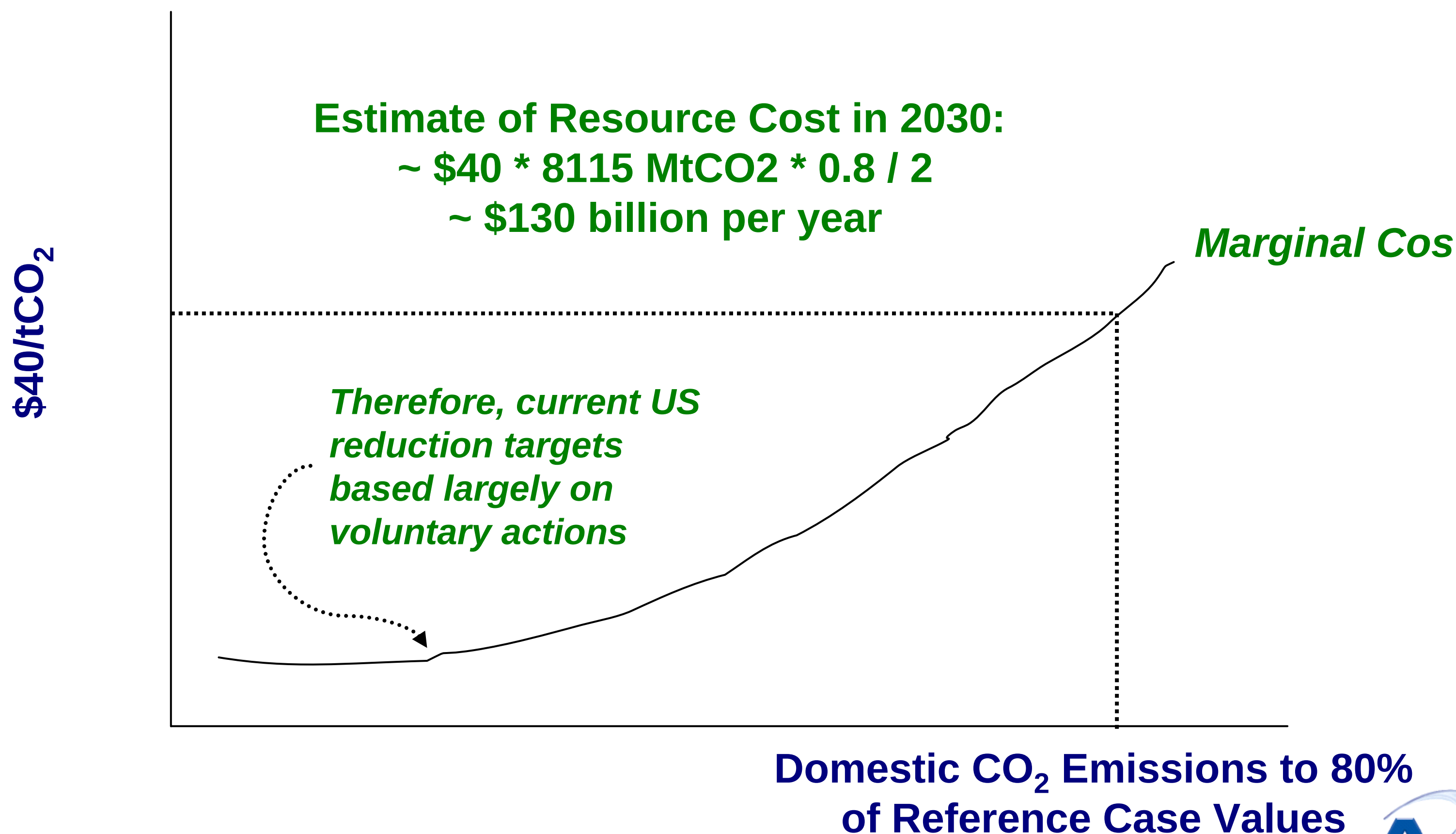
Economics Science Has Not Solved. . . .

- Its first problem – namely, what determines the price of a commodity? (Robinson 1947)
- Among things that can influence commodity prices:
  - Belief
  - Value
  - Habit
  - Alternatives
  - Necessity
  - Income
- All of which can be shaped by changed perceptions, clear and persistent policy signals, as well as new or expanding programs (Brown 2001).

Comparing Hardware and Energy Costs with "Soft" Search and Transaction Costs



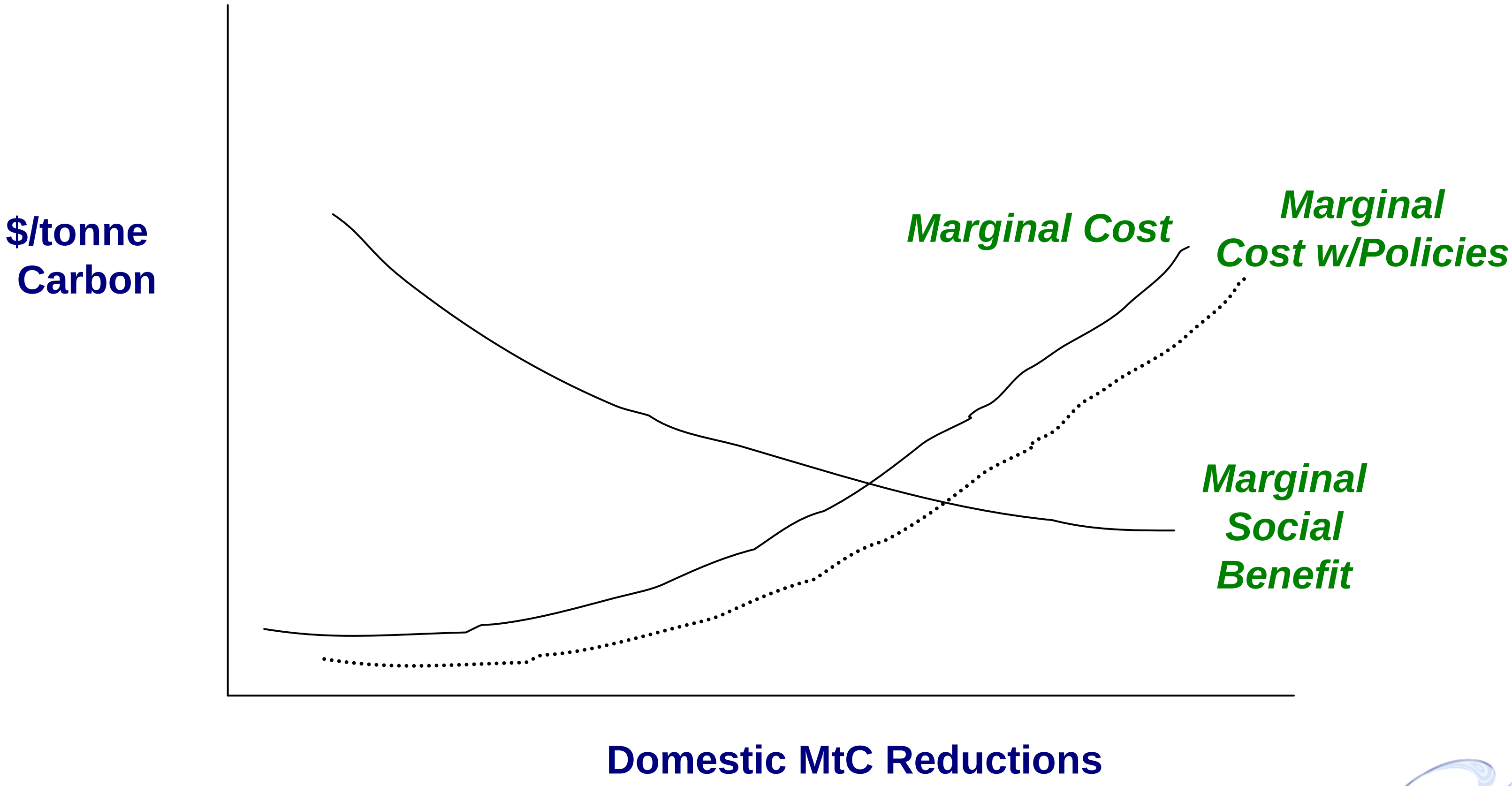
Re-examining the Conventional Marginal Abatement Cost Curve



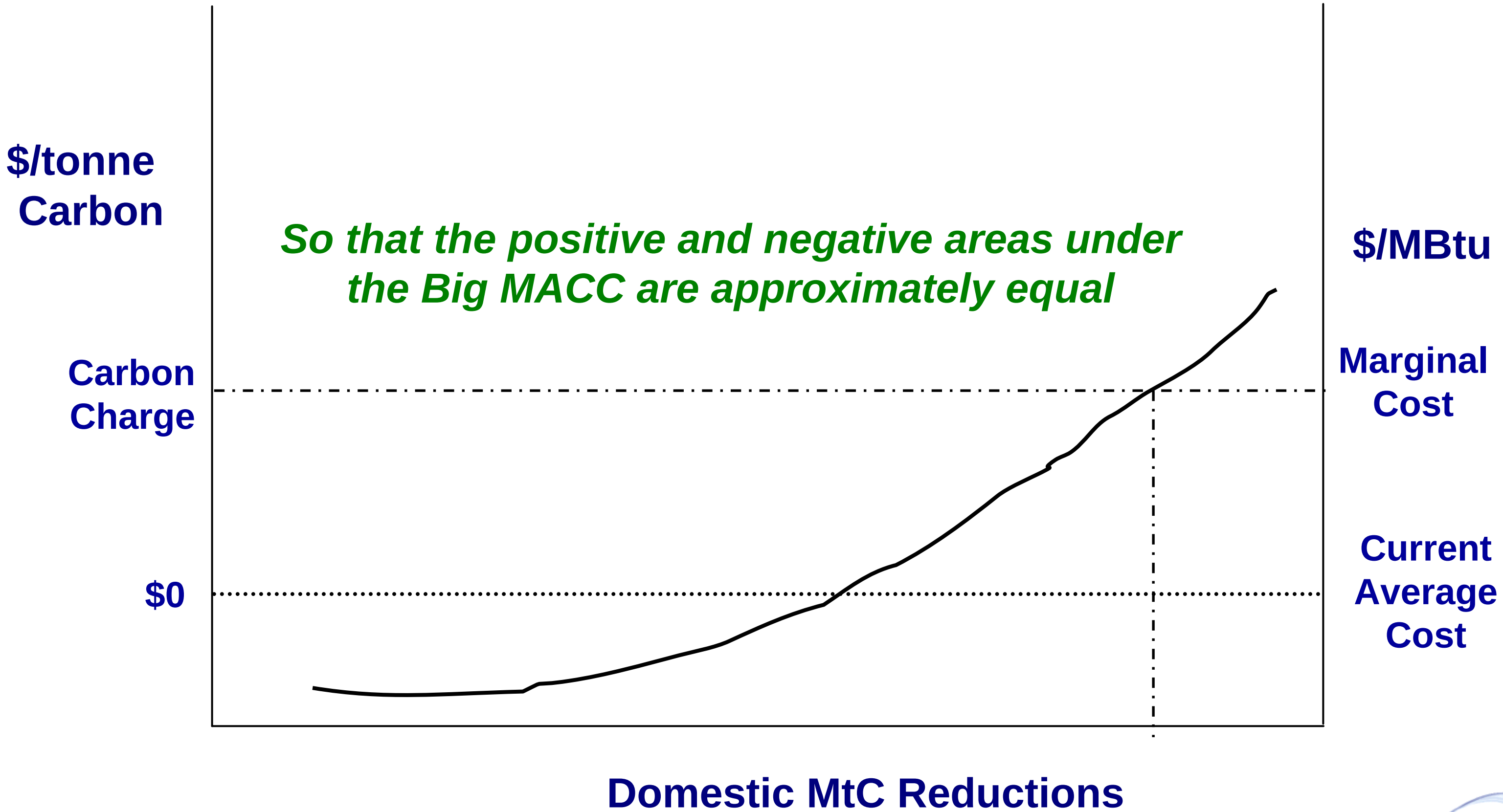
But What If. . . .

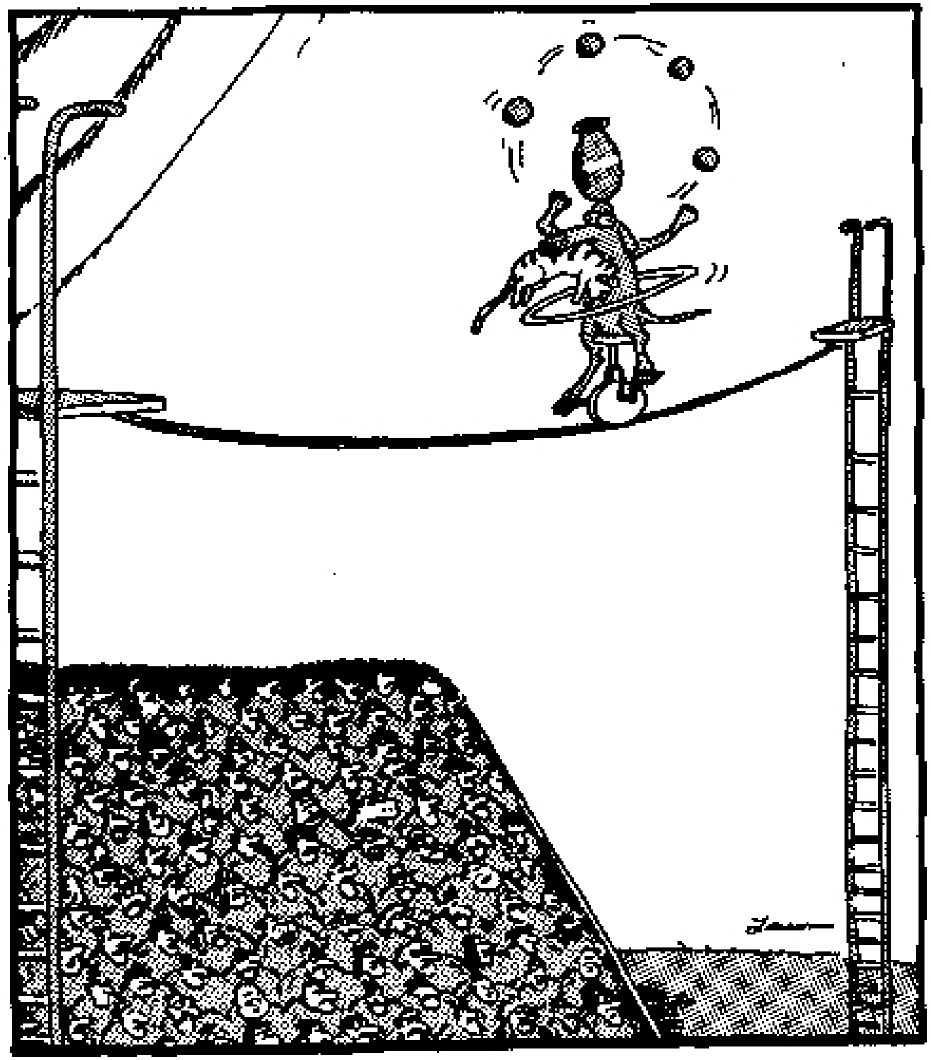
- The price signal, in this case, \$40/tCO_2 is not a highly accurate estimate of resource costs, but only a signal that changes behavior and patterns and investments?
- What if the 20% reductions were energy bill savings:
  - generated through productive efficiency investments that had (on-average) a 5-year energy payback
  - Lowered the non-carbon portion of energy prices by 10%, and
  - Stimulated other productivity innovations?
- Then a negative \$130 billion resource cost might become a \$227 billion net savings – not at all a free lunch, but a significant return on more productive pattern of investments.

So, a Different Result Emerges Using Both Costs and Benefits in the Analysis



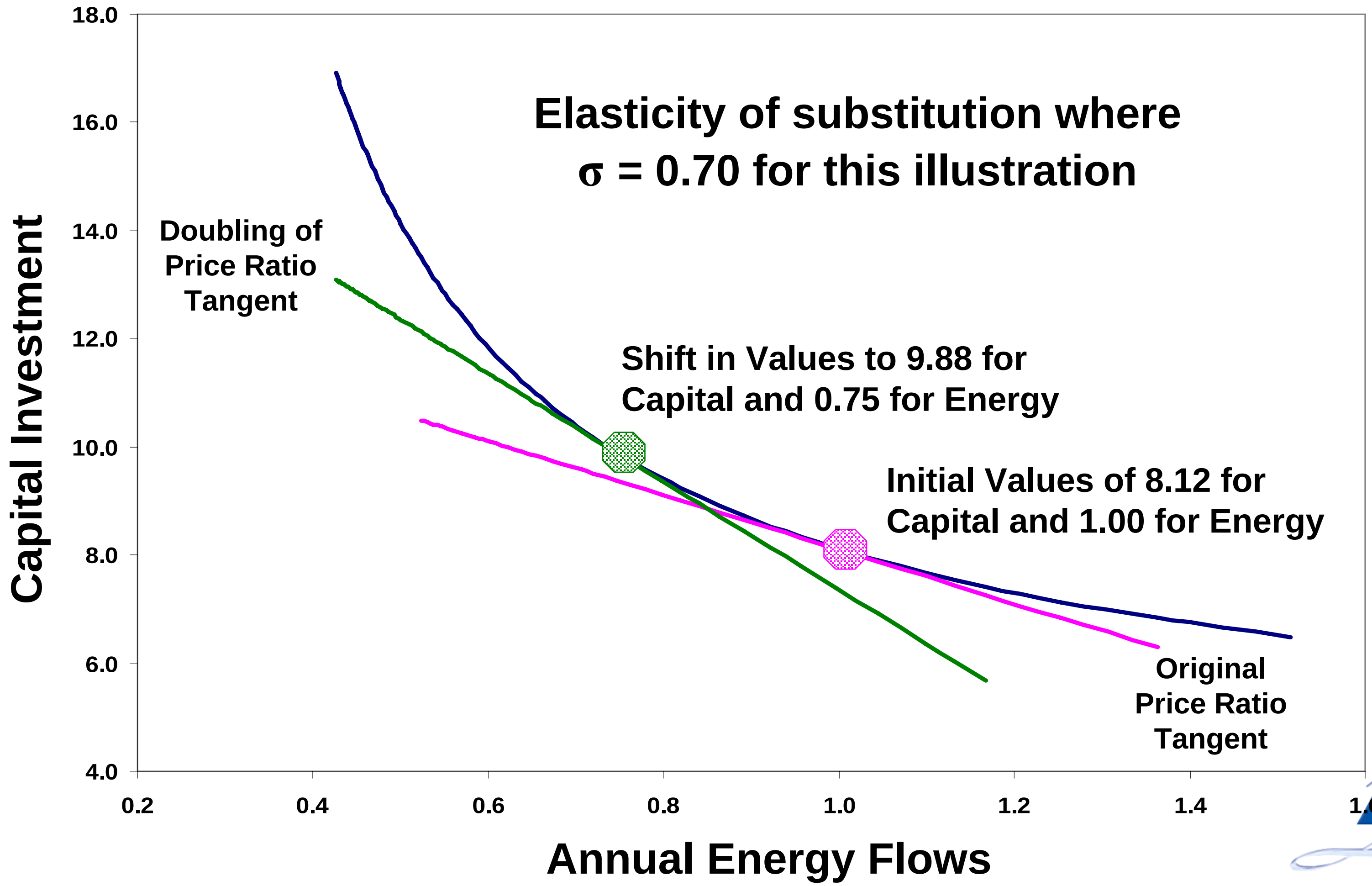
Or More Conventionally, a Different Result Emerges with Better Metrics





High above the hushed crowd, Rex tried to remain focused. Still, he couldn't shake one nagging thought: He was an old dog and this was a new trick.

An Isoquant of Energy Services Showing Relationship Between Capital, Energy, Price Ratio

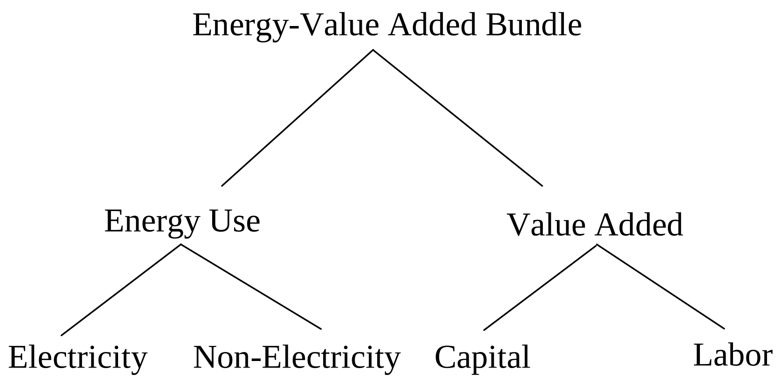


Changes in Capital and Energy as a Result of Doubling the Energy Price Ratio

- Under the assumption that
  - energy prices increase by 50%
  - while hurdle rates decrease from 20% to 15%
- the price ratio will double
  - from 1.00 / 0.20 which equals 5.0
  - to 1.50 / 0.15 which equals 10.0
- In this case
  - Capital investment will increase from 8.12 to 9.88 (22%)
  - Annual energy flow will decrease from 1.00 to 0.75 (-25%)
- Project payback will be
  - (9.88 - 8.12) / 0.25 = 7.04 years under the old energy prices
  - (9.88 - 8.12) / (0.25 * 1.50) = 4.69 years with the new energy prices

Comparing CES Technology Representation

Typical CGE Representation



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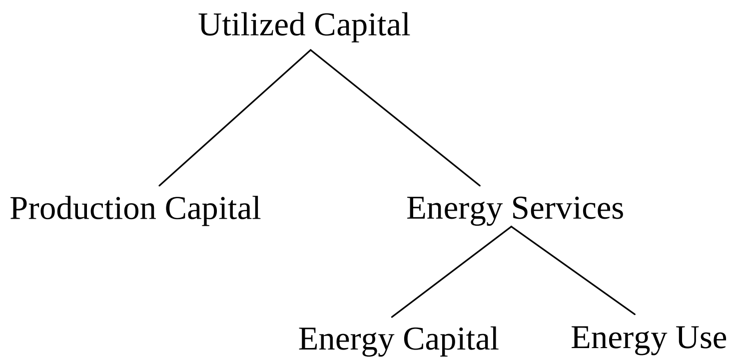
Technology-Based Representation

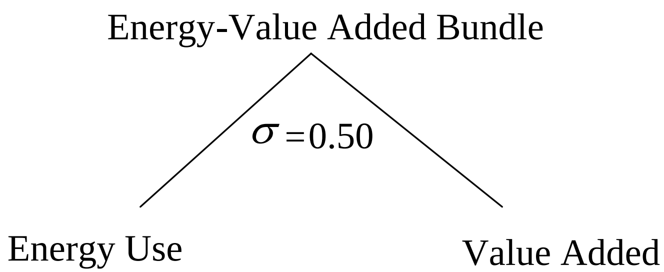


The conventional CGE representation may generate an inappropriate characterization for two reasons: (1) the base of value-added (which includes both capital and labor costs) is much larger than the actual capital costs anticipated in a meaningful technology characterization, and this forces a larger investment than may be actually needed to achieve a given reduction in energy use; and (2) industries show significantly different elasticities across fuel types than the single elasticity which is generally assumed in standard CES production functions.

Comparing CES Technology Representation

Drawing from the LIEF Model (Cleetus 2003) and 2001 Census data for the pulp and paper industry, let us assume that a doubling of the energy price ratio leads to a 12 percent savings of fossil fuels. Let us further assume the following CES functions: (a) The conventional CGE models which impose a substitution elasticity of 0.50 regardless of sector or fuel type; and (b) an actual technology-based representation which suggests an elasticity of 0.38:

Conventional CGE Representation



Capital required is $6.56 billion
Simple payback is 6.91 years

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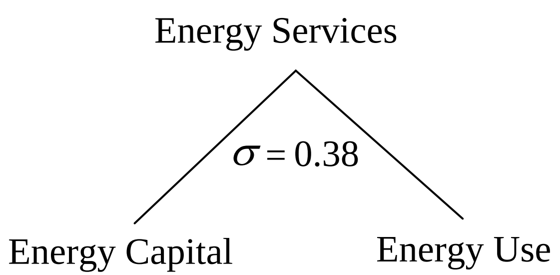
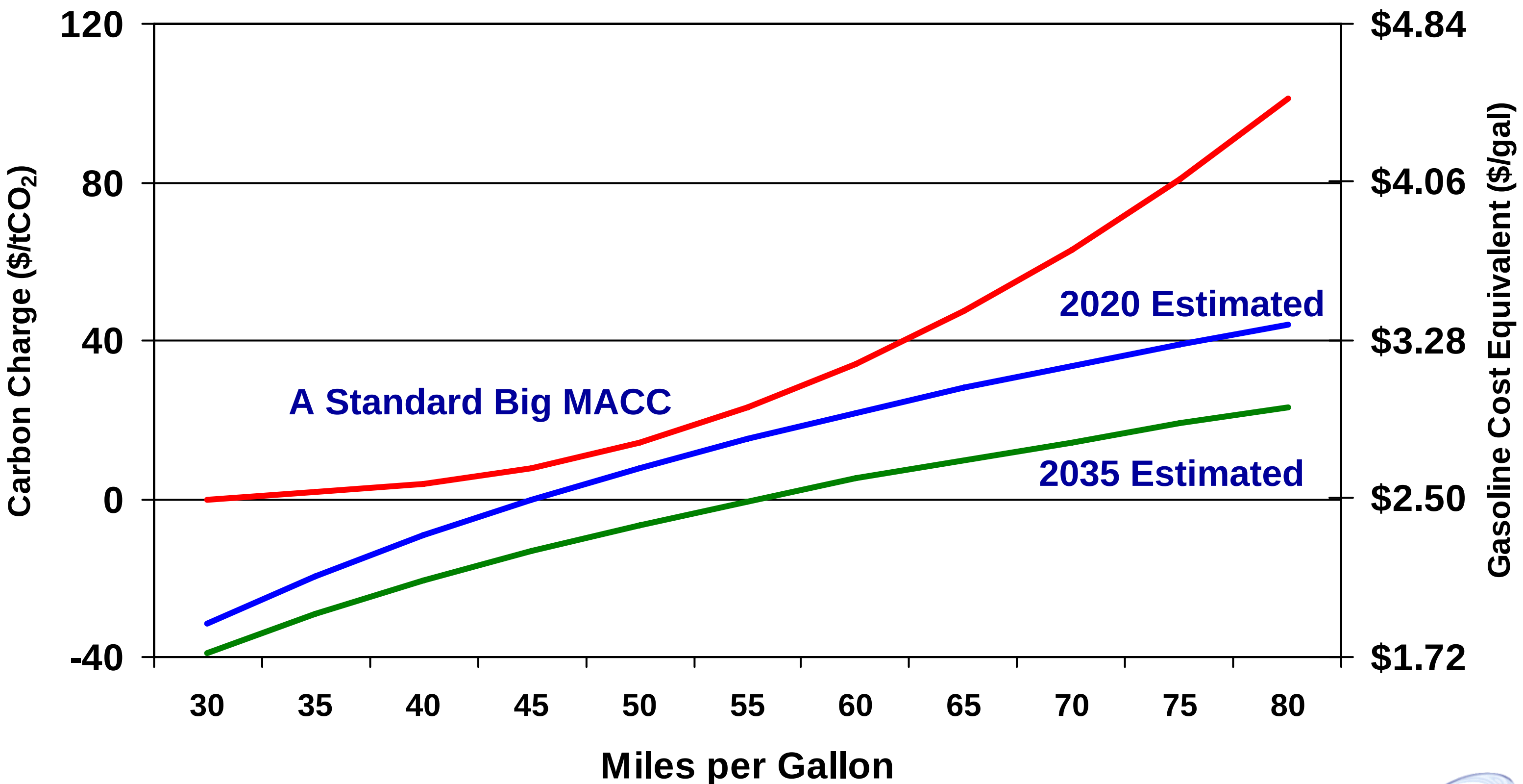
Technology-Based Representation



Capital required is $1.35 billion
Simple payback is 1.42 years

Note: For the documentation that underpins this review and the full set of preliminary results, see Laitner (2006) soon to be circulated for comment.

Different Characterizations of Marginal Abatement Cost Curves for Mid-Sized LDV



When contrasted to actual data, the standard representation may provide a less-than-satisfying technology characterization.

The Importance of Technology Detail: An Illustration of Impacts at $100/tC

- Let's examine what might happen at the microeconomic level with a price signal of $100/tC (~$27/tCO_2)
  - With gasoline prices starting at, say, $2.50/gallon, they would increase to about $2.74/gallon (reflecting the $100/tC carbon charge).
  - Suppose the price of a new car increases from $26,400 to $27,800, to achieve 35 miles per gallon rather than 25 mpg.
  - Assuming "the consumer" drives 14,000 miles each year, the gasoline savings would be 160 gallons annually.
  - With a consumer hurdle rate of 30% (a typical weight attributed to the importance of fuel economy), the decision will switch from buying the 25 mpg car to buying the 35 mpg car as a result of the gasoline price increase.
  - See Table 1 for details.

The Importance of Technology Detail: Table 1. An Illustration of Vehicle Choice

Variable or Impact	**Base Car**	**Greater Fuel Economy**	**Difference**
Initial Assumptions			
Price of New Car	$26,400	$27,800	$1,400
Fuel Economy (MPG)	25	35	10
Annual fuel use (Gallons/year)	560	400	-160
Gasoline Price Case #1: $2.50/gallon			
Annual Fuel Expenditures	$1,400	$1,000	-$400
Internal Rate of Return			28.6%
Gasoline Price Case #2: $2.74			
Annual Fuel Expenditures	$1,537	$1,098	-$439
Internal Rate of Return			31.4%

The Importance of Technology Detail: The Rate of Substitution and Payback

- This example illustrates several important concepts
  - The technology-based slope of the substitution curve
  - The payback on the incremental investment, evaluated at a given energy price
  - Under this example, a ~9.8% increase in energy prices reduced energy use by about 29% with a 5% higher capital cost. The implied substitution elasticity is about 3.2.
  - See Table 2 for details.
- However, this example does not illustrate the shifting curvature of the substitution function
  - We can fit the parameters of a CES production function to produce isoquants, the factor substitution curves.

The Importance of Technology Detail: Table 2. An Illustration of Substitution Rate

	Difference	
Price of New Car, ***dK***	$1,400	Incremental capital cost
Efficiency Improvement	10	miles per gallon
Annual fuel savings, ***dE***	160	gallons per year
Substitution Slope, ***dK/dE***	$8.75	First cost per annual gallon saved
Simple Payback		
for gasoline price of: $2.50/gallon	3.5	Years
for gasoline price of: $2.74/gallon	3.2	Years

The Importance of Technology Detail: Further Discussion

- Imposing a carbon price will increase the penetration of measures that reduce carbon emissions, in this case with a carbon price of $100/tC;
- But many models go a step further and assume that the area under a carbon reduction curve represents a simple textbook pure resource cost.
- Yet, this will not hold in general in a market with multiple policy instruments, diverse decision makers, a distribution of penetration rates for advanced vehicles, and dynamic accounting for flows of investment goods, energy supply costs avoided, and output potential changes.
- In this example, it is cheaper to save energy through fuel economy increases than to produce or import fuel.

The Importance of Technology Detail: An Illustration of Benefits at $100/tC

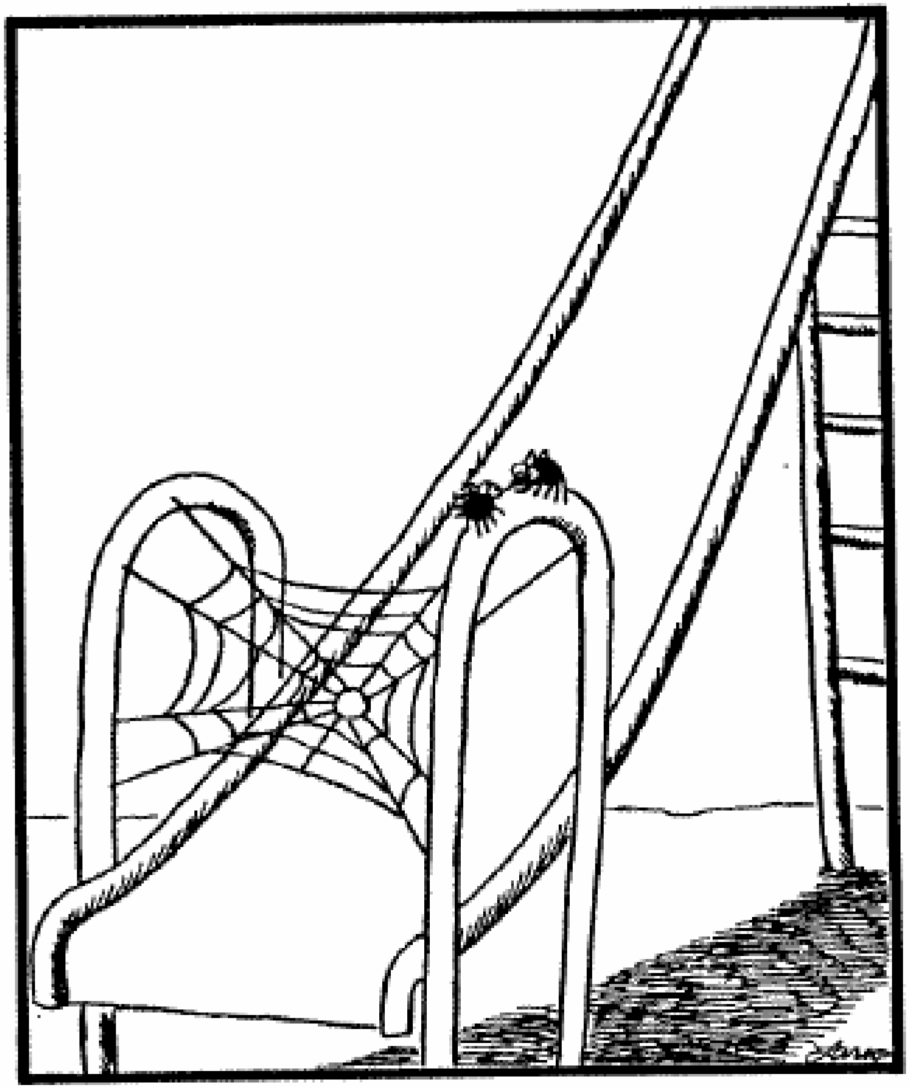
- At these efficiencies and annual travel, the purchase of 2.6 fuel-efficient cars would reduce carbon emissions by 1 tC.
- An associated $100 carbon price, if it truly reflected average cost, would impose a $100 cost on the economy. Instead, we show, in this example, the possibility of net economic gain.
- Associated with this economic gain would be the following changes in consumer spending and economic activities:
  - **Spending for consumer durables is up by about $3,600**
  - **Additional business in the banking or financial sectors from annual loan repayments of about $700 dollars**
  - **Annual gasoline savings of about $1026 per year**
  - **Lower national oil import bills (with increased energy security)**
  - **$100/tC in carbon transfer payments available for revenue offsets or other uses**
  - **Increased real spending potential in the household sector (-$493 in year 1, +$225 in year 2, and +$926 in year 6 and the all following years depending on degradation in performance)**

Emerging Insights on the Importance of Technology Detail

- Although a useful signal to encourage consumers to reduce carbon emissions, the carbon price does not generally measure resource costs; when multiple policy instruments are available, resource costs depend on the set of policies employed.
- Investment in more fuel-efficient automobiles triggers a round of spending changes with net social costs differing significantly from cost estimates based on the carbon price signal.
- Consumer decisions and energy use will be impacted not only by energy prices, but also by changes in the cost of new cars, changes in vehicle miles traveled, changes in weights on vehicle attributes, and changes in fuel economy technology, and changes in consumer preferences.
- While economists may disagree about the amount of carbon savings induced by any of these considerations, or about the overall magnitude of "no-regrets" and low-cost opportunities, omitting specific technological representations may result in an inaccurate estimate of cost to the economy, especially at low to moderate reduction strategies.

Concluding Thoughts and Next Steps

- Unlike the conclusions drawn from a number of previous modeling exercises, there are many cost-effective technologies (and technology policies) that can strengthen economic activity as well as improve environmental quality.
- More work is needed – in effect, a return to the economic fundamentals and best modeling practices – to ensure economic modeling assessments that are appropriate to real world policy concerns.
- Toward that end there is also a critical need for greater data and systematic information as well as a collaborative approach in these and other critical modeling issues – with an eye toward a major national policy modeling conference in 2007. Feedback, comments, and suggestions are greatly encouraged.



"If we pull this off, we'll eat like kings."

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