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Climate Change - Oil Shock Comparisons

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MEMORANDUM FOR DEPUTY SECRETARY SUMMERS

FROM: Jonathan Gruber
Deputy Assistant Secretary (Economic Policy)

SUBJECT: Would stabilizing U.S. carbon emissions feel like another oil shock?

Before 1973, energy consumption had been rising almost as fast as gdp. The two oil shocks of the 1970s changed that pattern. Between 1973 and 1985, real gdp rose by 40 percent; if total energy consumption had continued to grow at its pre-1973 pace, it would have stood 35 percent higher in 1985 than in 1973. Instead, total energy consumption was about the same in 1985 as in 1973. Energy consumption fell 5 percent after the 1973 oil shock, and 12 percent after the 1979 oil shock, in the wake of dramatically higher prices for imported oil.

Between 1985 and 1995, energy consumption resumed its pre-1973 pattern, rising almost as fast as real gdp. During this decade, energy consumption rose 23 percent, versus 27 percent for gdp. Energy consumption jumped up after the sharp fall in world oil prices in 1986, and, except for the mild recession of 1990-91, rose steadily thereafter.

If the US is required to stabilize at 1990 levels in 2010, energy consumption must fall by 6% between 1995 and 2010. During this time, gdp is forecast to rise by another 40%, according to Administration projections. This will again mean a gap of about 40% between growth in gdp, and growth in energy consumption.

In this sense, stabilizing carbon emissions at 1990 (or 1995) levels by 2010 would resemble the experience of the two oil shocks.

Carbon price vs oil shocks

	baseline quantities quads	baseline prices $/quad	baseline values	w/$100/ton quantities quads	w/$100/ton prices $/quad	w/$100/ton values
coal	22.68	7.6E+08	1.7E+10	14.72242	3.1E+09	4.6E+10
natural gas	28.77	2.0E+09	5.8E+10	25.54706	3.5E+09	8.9E+10
crude petrol	42.24	3.5E+09	1.5E+11	36.97815	5.3E+09	2.0E+11
	total		2.2E+11			3.3E+11

	Laspeyres	Paasche	ideal
denominator	2.2E+11	1.9E+11	
numerator	4.0E+11	3.3E+11	
ratio	1.786591	1.7396	1.762939

Would Stabilizing U.S. Carbon Emissions Feel Like Another 1970's Oil Shock?

Both the '73 and '79 energy price shocks were similar in magnitude to what is projected to result from a policy to stabilize carbon dioxide emissions at 1990 levels by 2010 without trading or joint implementation.

Price Effects of Stabilizing Carbon Emissions

- Government agencies have estimated the implicit price of carbon in fossil fuels that would be implied by a policy to stabilize carbon dioxide emissions at 1990 levels by the year 2010. These estimates presume no trading of emissions reductions among countries and no joint implementation. They are uncertain, and may be too optimistic due to a rosy view of ongoing technological progress. They suggest that the implicit price of a ton of carbon would be about $100 by 2010 and that fuel prices would rise as summarized below:

Fuels	Current Prices	Baseline Prices (2010)	Prices With $100/ton Carbon Price	Increase Over Baseline
Gasoline ($/gallon)	$ 1.14	$ 1.22 to$1.40	$ 1.58	21 %
Coal ($/ton)	$27	$13.80 to $16.90	$79	400 %
Oil ($/barrel)	$17	$20.41 to $21.24	$33	58 %
Natural Gas ($/1000cf)	$ 2.04	$ 2.01 to $2.46	$ 3.7	64%

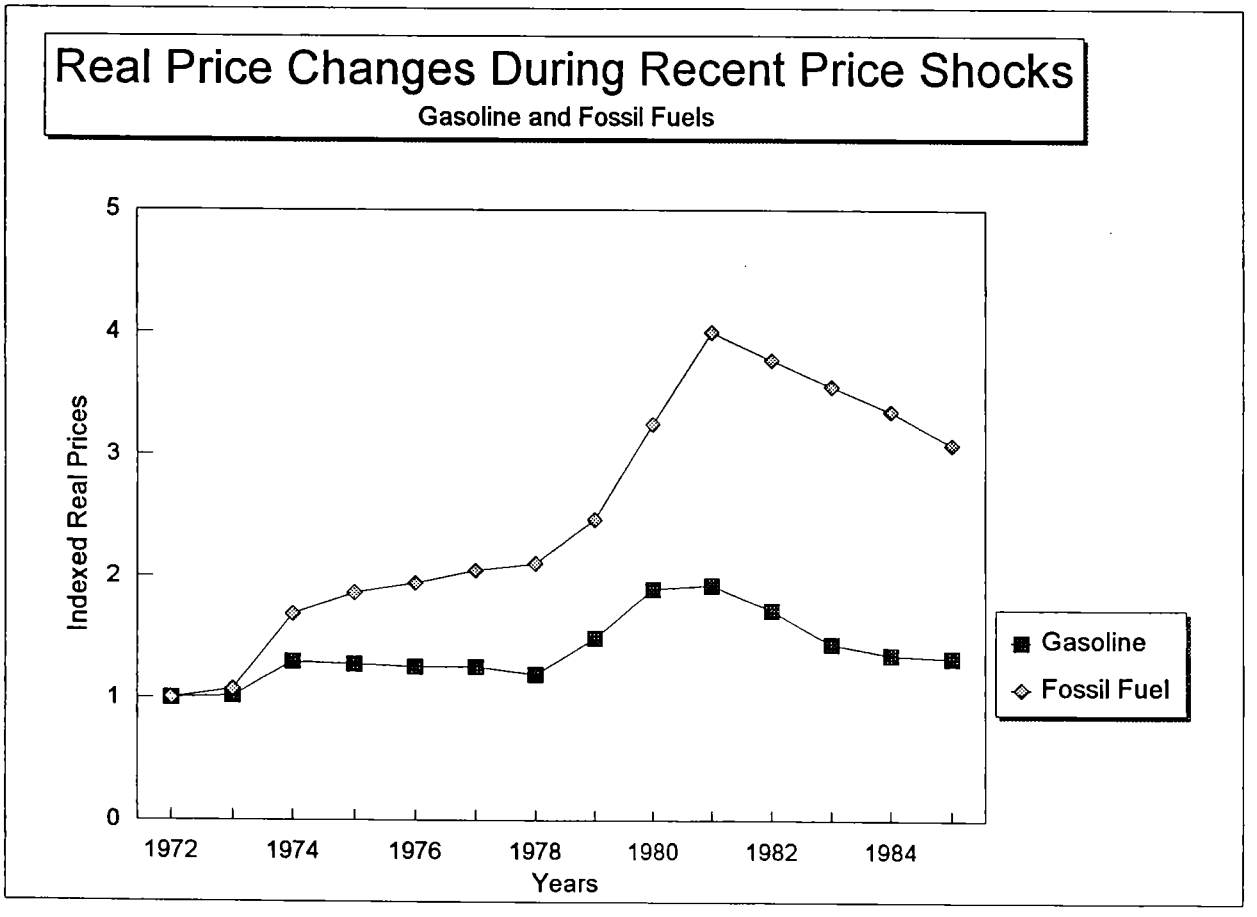
- The price hike would be about 88 % for primary fuels (coal, oil and natural gas).

Price Hikes During the Oil Shocks.

- The oil price shocks of the '70s led to a doubling of fossil fuel prices net of inflation between 1972 and 1975 and another doubling by 1981. See Figure.
- Gasoline prices rose by 30 percent between 1972 and 1974 and by nearly another 50 percent from 1974 to 1981.
- These increases are similar in magnitude to the price increases projected for 2010.

Comparability of These Projections with the 1970s Price Shocks Is Limited

- The shocks were surprises, but a carbon tax would be anticipated.
- The oil shocks affected oil prices directly and other fossil fuels only as substitutes. However, a carbon tax would affect all fuels in proportion to carbon content.


Real Price Changes During Recent Price Shocks
Gasoline and Fossil Fuels
Indexed Real Prices
5
4
3
2
1
0
1972
1974
1976
1978
1980
1982
1984
Years
Gasoline
Fossil Fuel

Would Stabilizing U.S. Carbon Emissions Feel Like Another 1970's Oil Shock?

Macroeconomic Effects of the 1970's Oil Shock

- Hall and Taylor in their textbook report that relative to its normal growth path of 2 percent per year, GNP fell 5.8 percent over the 2 years following the '73 price shock and 1.7 percent over the 2 years following the '79 price shock.

- After the oil shocks aggregate consumption also fell very briefly in absolute terms; it remained below trend for about 3 or 4 years after the shocks.

- Unemployment and inflation both rose in the stagflation episodes shown in the attached Figure.

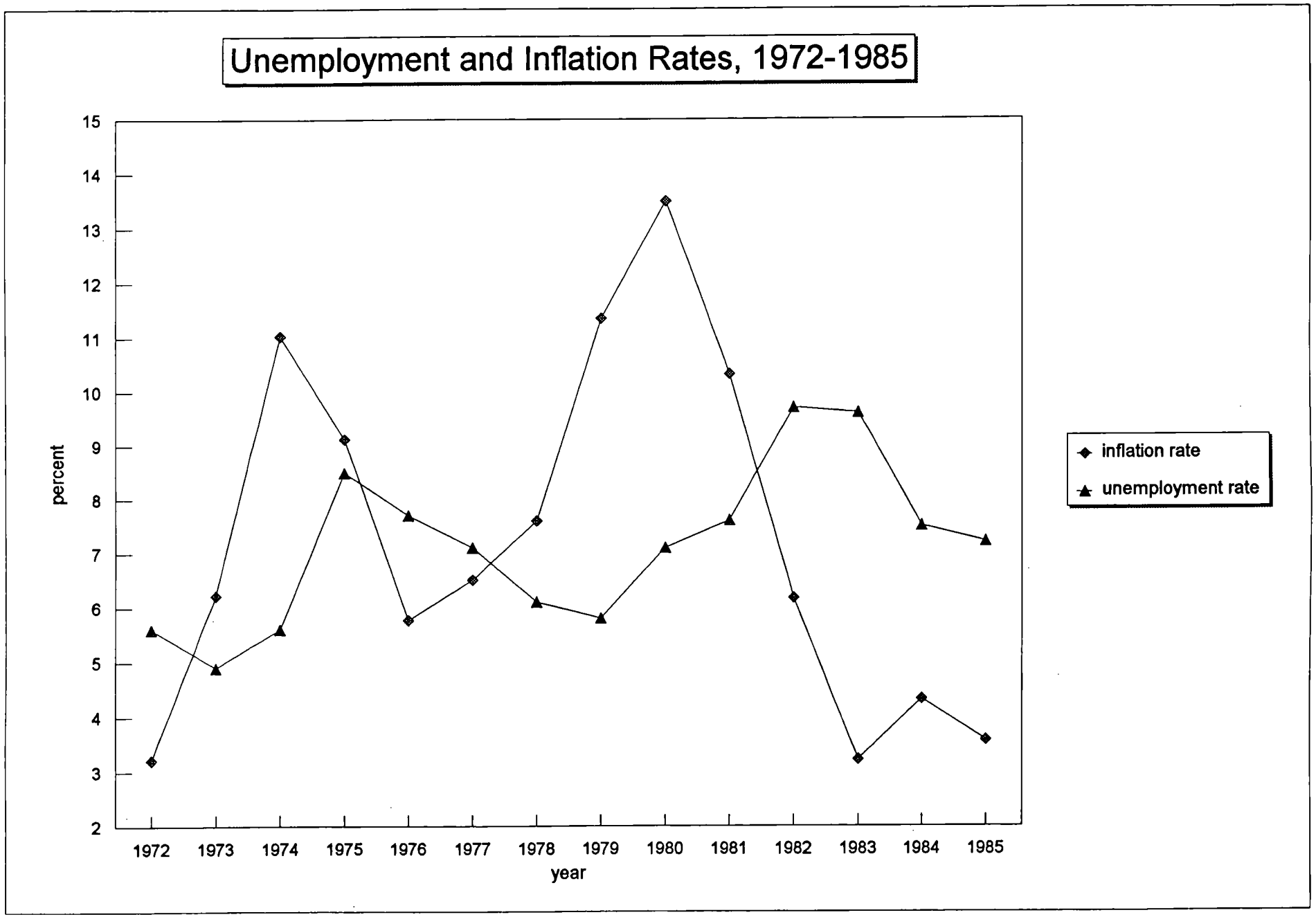
Macroeconomic Effects of Stabilizing Carbon Emissions

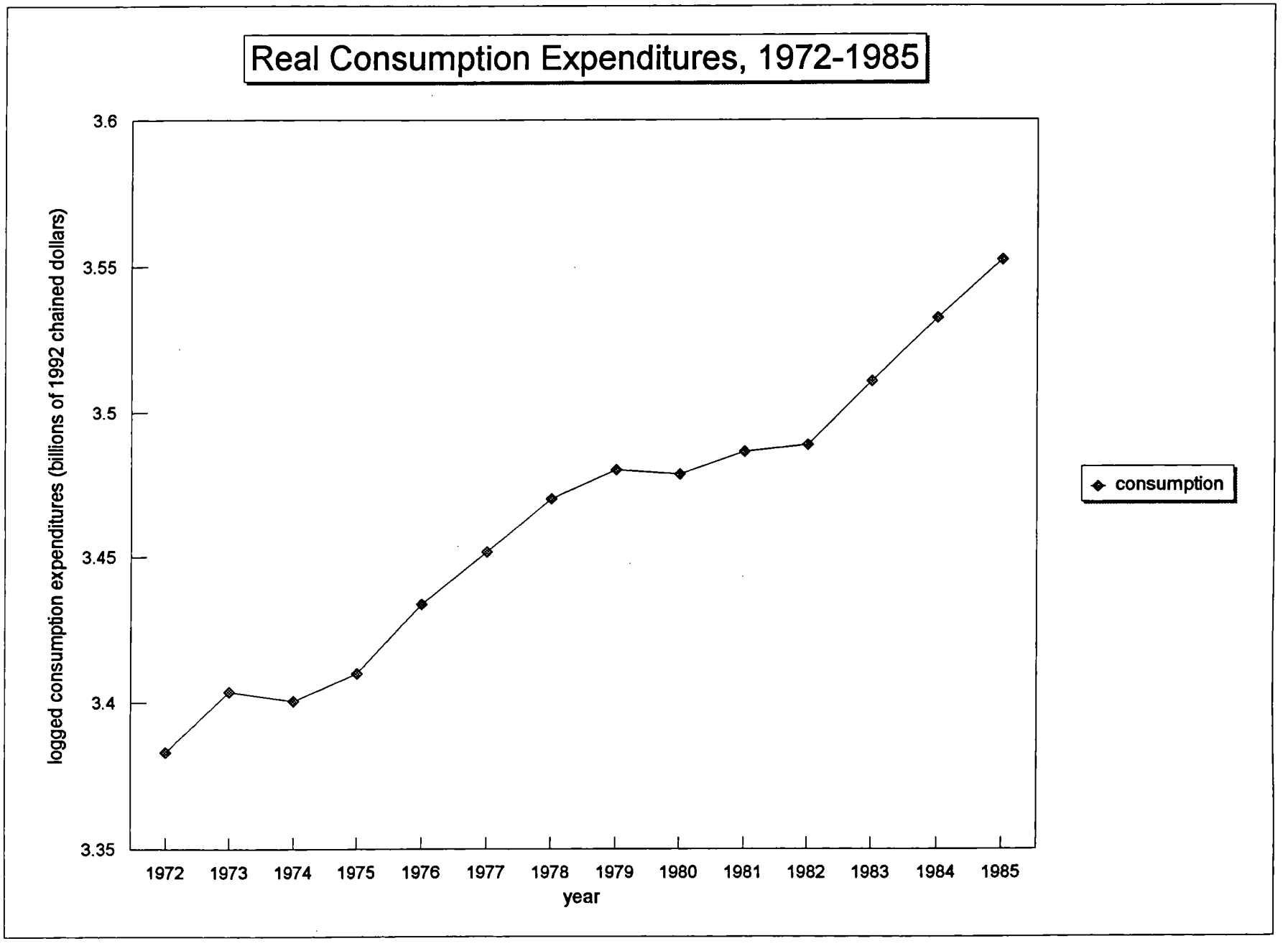
- The DRI model in the IAT analysis found that consumption under climate policy (1990 emissions level in 2010) fell under the baseline consumption in 2000 and stayed below baseline through 2020. DRI indicates that a small increase in unemployment, peaking at 4/10 of 1% in 2005, will occur. Projections of the inflation rate are too sensitive to Federal Reserve responses, the nature of the permit allocation (auction or grandfathering), and the characteristics of revenue recycling.

Comparability of Performance after the Oil Shocks and with a Carbon Stabilization Policy

- The shocks were surprises while a stabilization policy would lead to anticipated price changes.

- The shocks represented temporary price spikes while a stabilization policy would likely lead to permanently higher prices. Indeed, carbon prices may grow indefinitely under a given stabilization policy if growth in demand driven by income, population, and technology (e.g., vehicle miles travelled) outstrips innovation in fossil fuel alternatives, and in efficient energy use.


Unemployment and Inflation Rates, 1972-1985
percent
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
year
inflation rate
unemployment rate


Real Consumption Expenditures, 1972-1985
logged consumption expenditures (billions of 1992 chained dollars)
3.6
3.55
3.5
3.45
3.4
3.35
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
year
consumption

A Detailed Comparison of Average Energy Prices Increases
A $100/ton Carbon Price Increase Vs. OPEC Price Shocks of the 1970's

A comparison of average energy prices from a given carbon price increase with the OPEC price shocks of the 1970s is complicated because government statistics tell two different stories about increases in inflation-adjusted primary fuel prices during the 1970s. The Bureau of Labor Statistics (BLS) suggests increases of about a factor of two and a half, while Energy Information Agency (EIA) data suggest price increases of roughly a factor of three and a half, depending on the choice of deflator. This memo addresses these discrepancies and also assesses the equivalence of the 1970's oil shocks to the fuel price increases from a $100/ton price of carbon. It concludes that the implications for primary fuel prices of a $100/ton carbon price are likely to be in the range of ½ of the average fuel price increases observed between 1972 and 1982, although the exact comparison is quite sensitive to the weighting method and the choice of weights.

Federal Statistics on the Magnitude of the Oil Price Shocks

BLS data indicate that nominal producer prices for a fossil fuel composite rose from 16.8 in 1972 to 100 in 1982, a multiple of about 6. (Although real energy prices in 1981 were about 6 percent higher than in 1982, 1982 is taken as a comparison year.) Prices for finished producer goods rose by a factor of 2.4 over this interval, while the consumer price index rose by a multiple of 2.3. Thus the price of primary fuel rose by a factor of 2.5=6/2.4 relative to finished producer goods and 2.6=6/2.3 relative to consumer prices. If compared with the increase in the GDP implicit price deflator, an even broader measure of prices, then the relative price change is 2.8 fold.

The Energy Information Agency uses a different approach to calculate average energy prices; this different approach leads to different conclusions. Unlike the BLS, which calculates average energy price increases by weighting price increases for homogeneous fuels by their share of value, the EIA calculates average energy price increases by weighting the price increases by their share of total energy use measured in British thermal units. The fossil fuel nominal price index rose by a factor of 7.89 during this period, from .35 to 2.76. Deflating by the GDP implicit price deflator (that the EIA prefers) yields a real price change of 3.8 fold. (Using instead the CPI to improve comparability with the BLS statistics gives a real price change of 3.4 fold.)

Thus, relative to consumer prices, the BLS approach implies that nominal energy prices from 1972 to 1982 rose by 160 percent, while the EIA approach implies an increase of 240 percent. Relative to the GDP deflator, the BLS approach implies an increase of 180 percent, and the EIA approach implies an increase of 280 percent. Thus the difference between the two methods is between 80 and 100 percentage points.

Average Fuel Price Increases from Carbon Price Increases

To develop estimates of the average fuel price increases from a positive carbon price we rely here on two sources of information about effects of a $100/ton carbon price. The ACCF book "An Economic Perspective on Climate Change Policies"contains a chapter by Lawrence

Horwitz that states that $100/ton implies tax rates of $1.66/mcf for natural gas, $11.42/barrel for crude oil, and $56.4/short ton for coal (p.126). In addition, the IAT May 30 draft report states that "a permit price of $100/ton is the equivalent of a price increase of 26 cents per gallon of refined petroleum product, $1.49 per thousand cubic feet of natural gas, and $52.52 per ton of coal. Ignoring the fact that the price increase of the refined petroleum product is not strictly comparable to the price increase of crude oil, the ACCF estimate is equivalent to 27 cents per gallon, given 42 gallons per barrel. Thus these estimates are fairly close given the imprecision of model forecasts. We will use the IAT forecasts, which are summarized below.

Fuels	Current Prices	Baseline Prices (2010) Range of 4 models	Price Increase With $100/ton Carbon Price	Percentage Increase Over Baseline
Coal ($/ton)	$27	$13.80 to $16.90	$52	333 %
Oil ($/barrel)	$17	$20.41 to $21.24	$10.9	53 %
Natural Gas ($/1000cf)	$ 2.04	$ 2.01 to $2.46	$ 1.49	66%

There are a variety of methods to average these fuel price increases. However, valid comparisons between increases due to carbon prices and increases due to the oil price shocks of the 1970s should rely on identical averaging methods. We limit this analysis to methods adopted by BLS and EIA and described above.

To implement the EIA method, we weight the above percentage price increases by each fuel's share of total Btus. Using the average of the weights implied by the 1972 mix and the 1982 mix would imply an increase of only 123 percent. (These weights were .23, .34 and .43 respectively for coal, natural gas and petroleum). Using instead weights implied by the Btu consumption estimates in EIA's reference case forecast for 2010 (22.68, 42.24, and 28.77 quads respectively for coal, natural gas and petroleum), the average energy price increase from a $100/ton carbon price is estimated as 165 percent.[1] This is approximately half the comparable Btu-weighted average energy price increase observed from 1972 to 1982. Thus using the Btu weighted approach preferred by EIA, the average primary fuel price increase from a $100/ton carbon price is between 33 and 49 percent of the average fuel price increases observed from 1972 to 1982 depending on the choice of weights and the index used to deflate the 1970 fuel price increases.

To implement the BLS method we use the value weights used by BLS in its producer

[1]Note that this approach, like EIA's approach to the oil price shocks of the 70's, averages only fossil fuels. Average increases of all primary fuel prices including renewables would be smaller.

price index of fuel prices. Using the 1982 value weights (.14, .37 and .50 respectively) the average energy price increase from a $100/ton carbon price is 97 percent. Using the 1972 value weights, the average energy price increase from a $100/ton carbon price is 167 percent. Recall that the increase BLS calculated for the period 1972 to 1982 was 160 percent relative to consumer prices (measured by the CPI) and 180 percent relative to the GDP deflator. Thus on a value-weighted basis the magnitude of the average fuel price increases associated with a $100/ton carbon price is the same as either half of the 1972 to 1982 oil price increases, or the totality of these price increases, depending on the choice of weights. An alternative way of implementing the EIA approach would be to use weights consistent with the 2010 baseline. The EIA in its publication Annual Energy Outlook gives estimates of average end-user prices and average energy consumption for coal, natural gas and petroleum products. Using these to calculate value, and taking as weights the share of total value attributible to each fuel gives weights of .06, .22 and .72 respectively. Since petroleum has by far the largest weight, and its price increase is 53 percent, the weighted average price increase is then only 73 percent.

Carbon price vs oil shocks

1982-1972 comparisons BLS vs EIA energy price increases

BLS	nominal	relative
fuel as crude material	5.952381	
producer price total finist	2.392344	2.488095
CPI	2.308612	2.578337
GDP deflator	2.159794	2.755995
GDP 1992 deflator	2.092537	2.844576

EIA			
EIA	nominal	7.885714	
GDP deflator		2.159794	3.651142
GDP 1992 deflator		2.092537	3.768494
CPI		2.308612	3.415781
EIA	real	3.778846	

2010 Btu weights

	units	baseline prices	Prices w/ $100/TC from 7/95 m	increase over baseline	consumption weights quad Btu AEO 1994 Table A1	q units	conversions to quad Btu AER'94 Table D2	quantities in Btu	quantity shares	
coal	ton	15.7625	68.2825	3.3319588	22.68	quad Btu	45	22.68	0.320442	1.067699
natural gas	1000cf	2.2625	3.7525	0.6585635	28.77	quad Btu	1	28.77	0.406486	0.267697
crude petrol	barrels	20.5875	31.5075	0.5304189	42.24	quad Btu	470	42.24	0.596801	0.316555
								93.69		1.65195

1994 Btu we	units	baseline prices	Prices w/ $100/TC from 7/95 m	increase over baseline	quantities AEO 1994	q units	conversions to quad Btu	quantities in Btu	quantity shares	
coal	ton	15.7625	68.2825	3.3319588	930	million short	45	20.66667	0.291996	0.972918
natural gas	1000cf	2.2625	3.7525	0.6585635	20.6	trillion cubic	1	20.6	0.291054	0.191677
crude petrol	barrels	20.5875	31.5075	0.5304189	13870	thousand bb	470	29.51064	0.416951	0.221158

Carbon price vs oil shocks

								70.7773			1.385753
1970s		baseline	Prices with $100/TC	increase over baseline	AEO 1994		to quad Btu	in Btu	shares		
	units	prices	from 7/95 m		Avg of 72&82						
coal	ton	15.7625	68.2825	3.3319588	615.6	million short	45	13.68	0.233057	0.776536	
natural gas	1000cf	2.2625	3.7525	0.6585635	20.05	trillion cubic	1	20.05	0.341578	0.224951	
crude petrol	barrels	20.5875	31.5075	0.5304189	11735	thousand bb	470	24.96809	0.425365	0.225621	
								58.69809			1.227109

value weights 1982							
		baseline	Prices w/ $100/TC	increase over baseline	Value weights BLS (Adele)	value shares	value weighted price increases
	units	prices	from 7/95 m		1982		
coal	ton	15.7625	68.2825	3.3319588	4.807	0.139787	0.46576497
natural gas	1000cf	2.2625	3.7525	0.6585635	12.649	0.367832	0.24224061
crude petrol	barrels	20.5875	31.5075	0.5304189	16.932	0.492381	0.26116824
					34.388		0.96917382

value weights 1972							
		baseline	Prices w/ $100/TC	increase over baseline	Value weights BLS (Adele)	value shares	value weighted price increases
	units	prices	from 7/95 m		1972		
coal	ton	15.7625	68.2825	3.3319588	0.728	0.394366	1.31401191
natural gas	1000cf	2.2625	3.7525	0.6585635	0.514	0.27844	0.18337035
crude petrol	barrels	20.5875	31.5075	0.5304189	0.604	0.327194	0.17354986

Carbon price vs oil shocks

					1.846		1.67093211
value weights							
2010		baseline	Prices w/ $100/TC	increase over baseline	Value weights AEO outlook	value shares	value weighted price increases
	units	prices	from 7/95 m		2010		
coal	ton	15.7625	68.2825	3.3319588	27.4428	0.061415	0.20463228
natural gas	1000cf	2.2625	3.7525	0.6585635	97.5303	0.218266	0.14374189
crude petrol	barrels	20.5875	31.5075	0.5304189	321.8688	0.720319	0.38207095
					446.8419		0.73044512

IAT baselines

	coal	natural gas	oil
DRI	13.76	2.42	21.24
AEO97NEM	16.92	2.01	20.41
SGM	16.47	2.16	20.41
Markal Macr	15.9	2.46	20.29
	15.7625	2.2625	20.5875
deltas	52.52	1.49	10.92
%change	3.331959	0.658564	0.530419