U.S. Market Consequences of Global Climate Change

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Discuss two Pew Center reports

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Overview of market consequences of climate change

- Integrated assessment of climate change impacts
  - Resulting from reference case emissions scenario
- Three climate scenarios of temperature change
  - Low (1.7ºC), Central (3.1ºC), High (5.3ºC)
  - Sea-level rise of 17 to 99 cm (7 – 40 inches)
- Two additional scenarios focused on precipitation change
  - Low and Wetter, High and Drier
  - Precipitation changes of up to 15%
- Two sets of market outcomes on specific sectors
  - Optimistic
  - Pessimistic
- Macro-economic and inter-industry modeling using these damage estimates

Summary of modeled climate change effects

Table 1

Summary of Modeled **Climate Change Effects**

	Global Mean Temperature Increase (°C)				U.S. Mean Temperature Increase[a] (°C)				Sea Level Rise (cm)				U.S. Mean Precipitation Increase b (#1,2,3), c (#4), d (#5) (% change)			
Year	2020	2050	2080	2100	2020	2050	2080	2100	2020	2050	2080	2100	2020	2050	2080	2100
Scenario 1 Low	0.3	0.7	1.1	1.3	0.4	1.0	1.4	1.7	2.6	7.4	13.1	17.2	0.5%	1.2%	1.8%	2.1%
Scenario 2 Central	0.4	1.3	2.1	2.4	0.6	1.7	2.7	3.1	7.2	21.8	42.1	54.8	0.7%	2.2%	3.4%	3.9%
Scenario 3 High	0.8	1.8	3.1	4.0	1.0	2.4	4.0	5.3	16.2	42.3	74.5	98.9	1.2%	2.9%	5.0%	6.6%
Scenario 4 High & Dry	0.8	1.8	3.1	4.0	1.0	2.4	4.0	5.3	16.2	42.3	74.5	98.9	-2.8%	-6.6%	-11.2%	-14.8%
Scenario 5 Low & Wet	0.3	0.7	1.1	1.3	0.4	1.0	1.4	1.7	2.6	7.4	13.1	17.2	2.5%	6.4%	9.4%	11.0%

a. Estimated ratio from Wigley (1999), Figure 9, estimated as +1.3 degrees per degree C change in global mean temperature.

b. Estimated ratio from Wigley (1999), Figure 10, estimated as +1.6% per degree C change in global mean temperature.

c. Estimated from Wigley (2000) and Hulme et al. (1995) SCENGEN of the BMRC GCM for precipitation sensitivity of –3.7% per degree C in global mean temperature.

d. Estimated from Wigley (2000) and Hulme et al. (1995) SCENGEN of the HADCM2 GCM for precipitation sensitivity of +8.6% per degree C in global mean temperature.

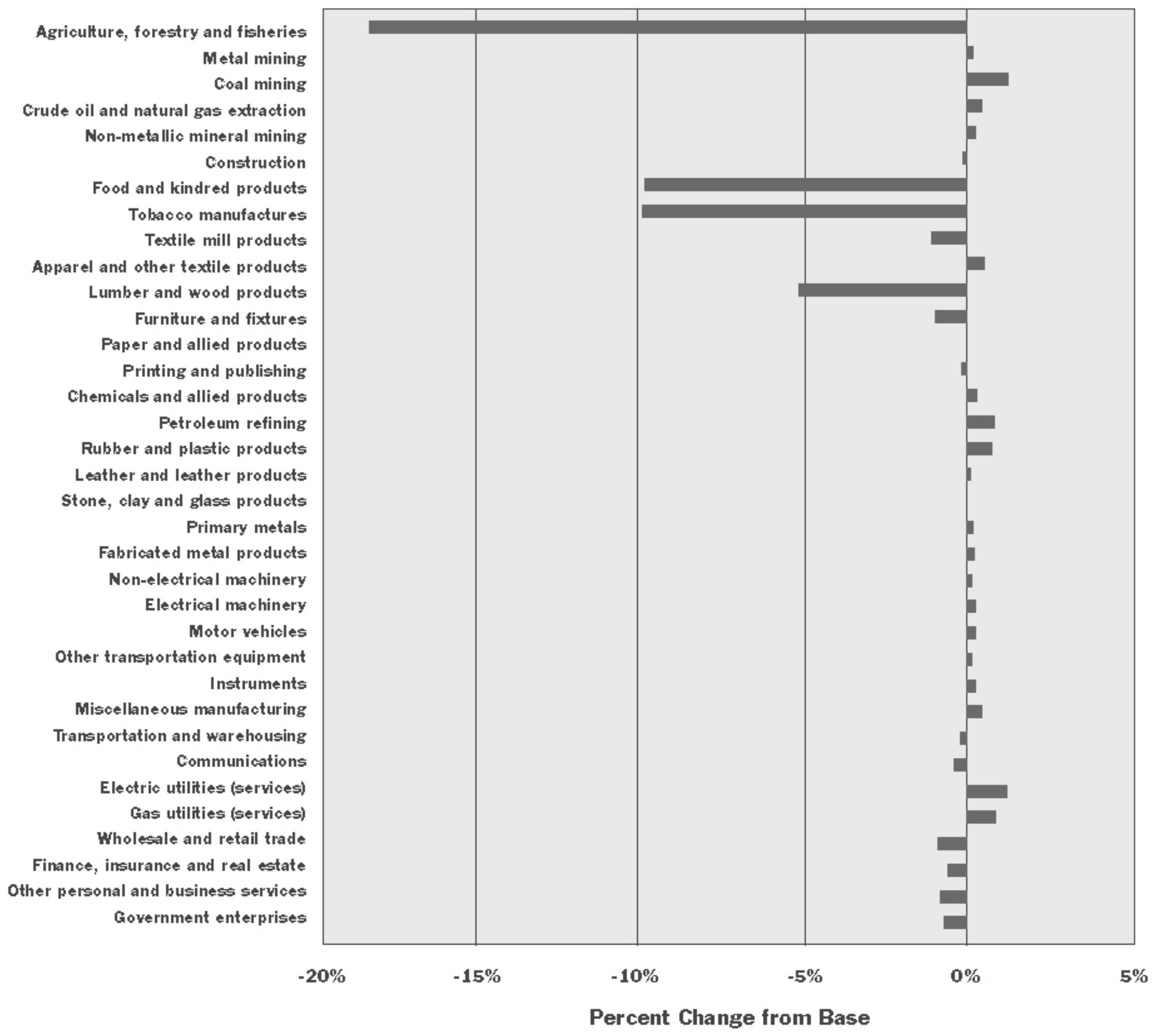
Key market activities

- Crop agriculture
  - Additional runs include livestock and fisheries
- Forestry
- Energy services (heating and cooling)
- Water Supply
- Coastal protection
  - Additional runs include storms, floods and hurricanes
- Population and labor supply
  - Mortality and morbidity
- But note
  - Key sectors (e.g., tourism) omitted due to lack of data
  - Many indirect effects omitted due to lack of data
  - **Non-market impacts not considered**
    - i.e., ecosystems, bio-diversity

Impacts on domestic output in 2050: central, pessimistic scenario

Figure 6

Impacts on **Domestic Output** in 2050: Central, Pessimistic Scenario



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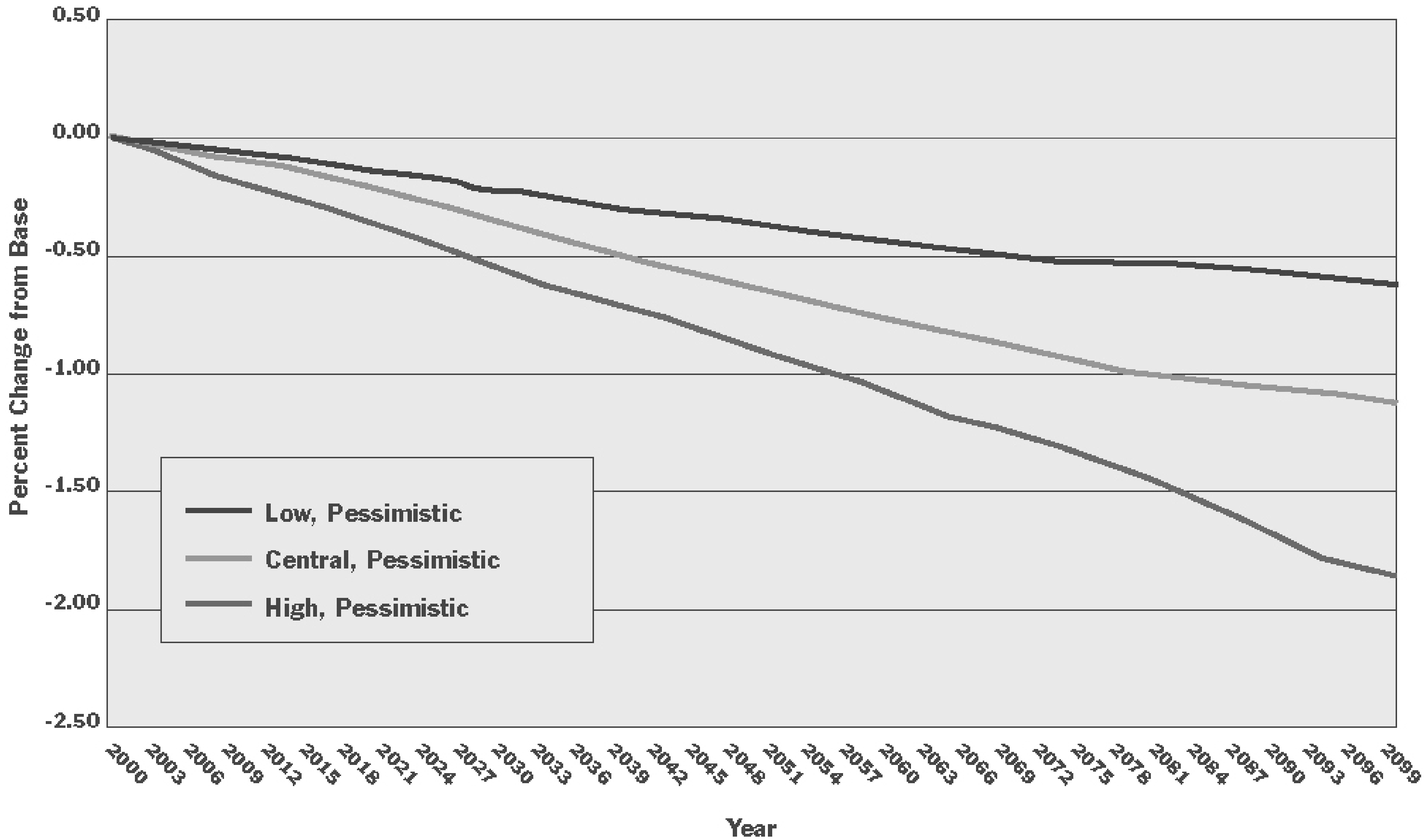
Key findings

- Climate change has the potential to impose considerable costs or produce temporary benefits for the U.S. economy over the 21st century
  - GDP losses of -0.6% to -3.0% under pessimistic outcome
  - GDP gains of 0.7% to 1.0% under optimistic outcomes
- Any economic benefits simulated for the 21st century are only transient and temporary, and hence economic damages are inevitable
  - This is due to identified thresholds in the agriculture and energy service sectors
  - Under pessimistic scenarios, increasingly negative impacts on the economy as temperatures rise
    - There may be additional thresholds in other sectors or under pessimistic assumptions

Pessimistic impacts on real GDP in low, central and high scenarios

Figure 8

Pessimistic Impacts on **Real GDP** in Low, Central and High Scenarios



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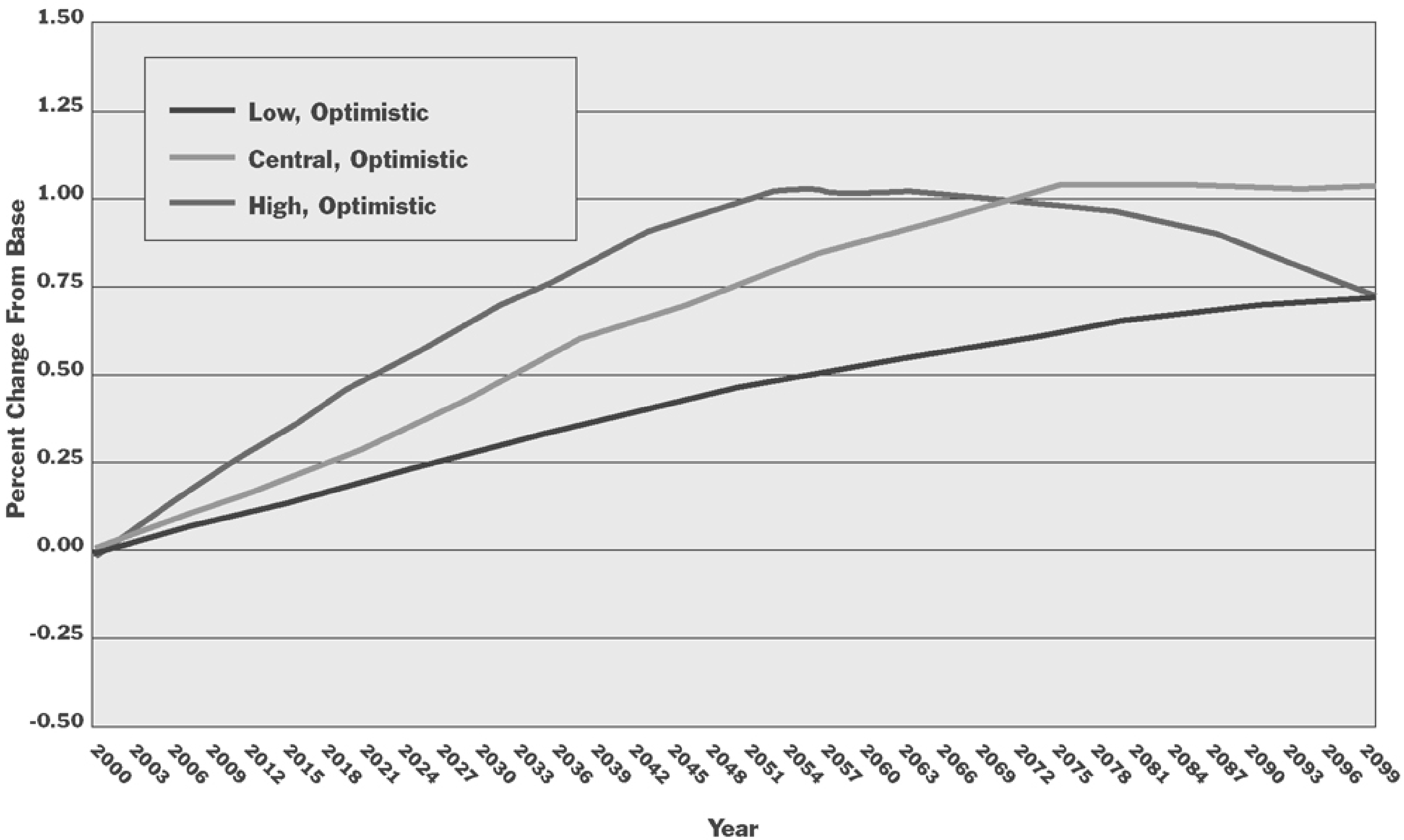
Optimistic impacts on real GDP in low, central and high scenarios

Figure 3

Optimistic Impacts on **Real GDP** in Low, Central and High Scenarios



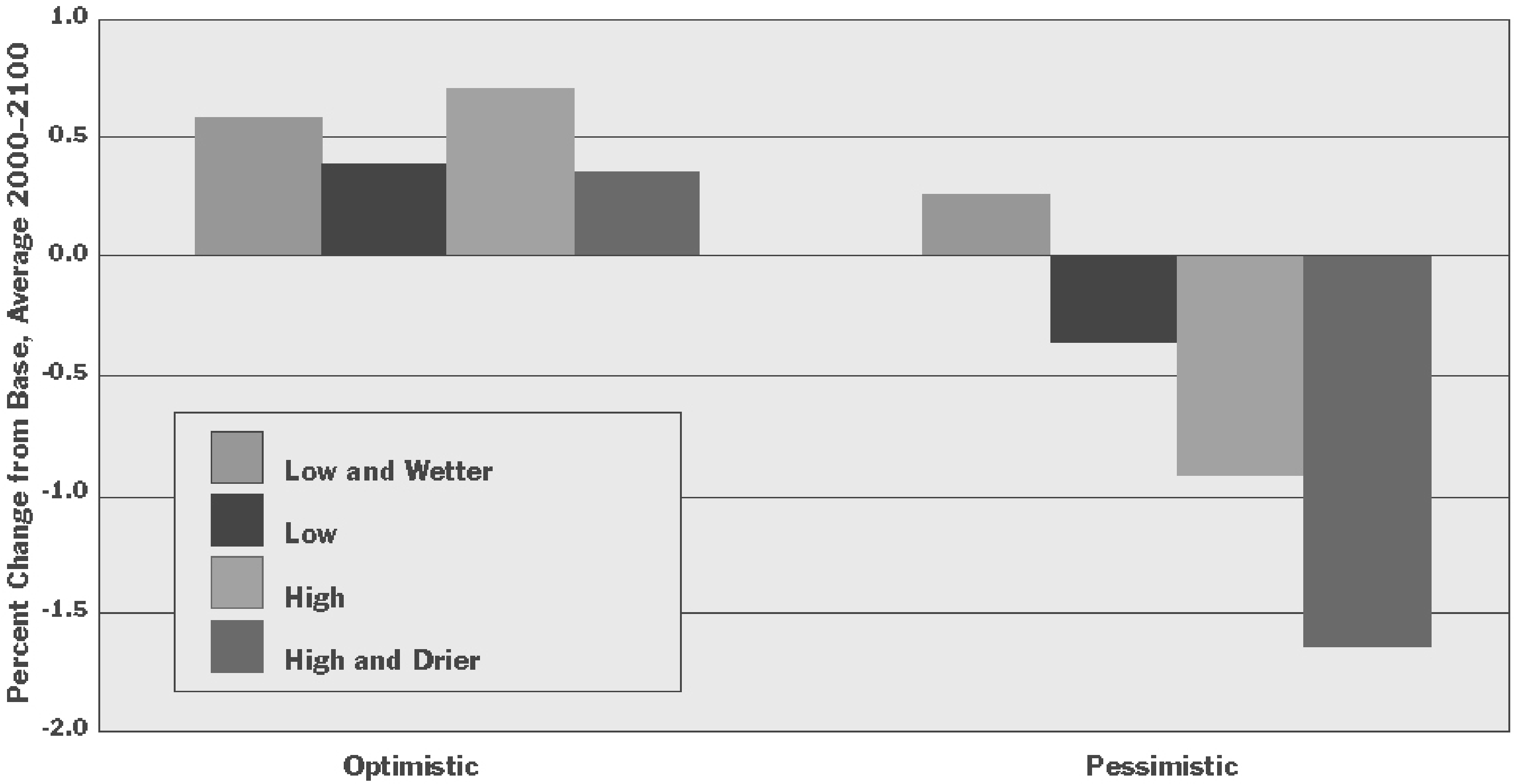
Additional findings

- All else being equal; for the economy, wetter is better
  - Greater precipitation is better for agriculture, and hence the wider economy
  - This finding does not explicitly take variability of precipitation (e.g., floods) into account
  - Any move to drier conditions is more damaging as temperatures increase further
- The effects of climate change on U.S. agriculture dominate the other market impacts considered in this analysis
  - The agriculture, forestry and fisheries industries represent only about 3.5% of total U.S. GDP
  - But crop agriculture and forestry account for between 70% and 85% of the projected economic impacts from climate change
- Deaths and illnesses attributable to climate change are small but important components of the modeled impacts of climate change for the U.S. economy as a whole
  - In this analysis, mortality and morbidity effects alone account for 6% to 9% of the aggregate impact of climate change on U.S. GDP

Contribution of precipitation to impacts on real GDP, low and high rates of warming

Figure 12

Contribution of Precipitation to Impacts on Real GDP, Low and High Rates of Warming



Policy implications

Will climate change impacts on the U.S. economy be sufficiently negative to support near-term actions to reduce GHG emissions?

- We would argue, YES
  - As climate change becomes more severe, economic losses under pessimistic assumptions become larger than economic benefits under optimistic assumptions
  - Any positive impacts of climate change under optimistic assumptions are likely to be transient and unsustainable over the long run as temperatures continue to rise
  - This analysis does not consider non-market impacts

What other nuances in this analysis give further support to near-term mitigative actions?

- If worst-case scenarios require more dramatic intervention, moderate near-term actions may help avoid more costly measures
- Consideration of impacts on developing countries (i.e., agriculture, adaptation)
- Consideration of omitted sectors (e.g., tourism), omitted indirect effects (e.g., healthcare), omitted variability impacts (i.e., precipitation)
- Possibility of threshold effects in additional sectors and also under pessimistic scenarios

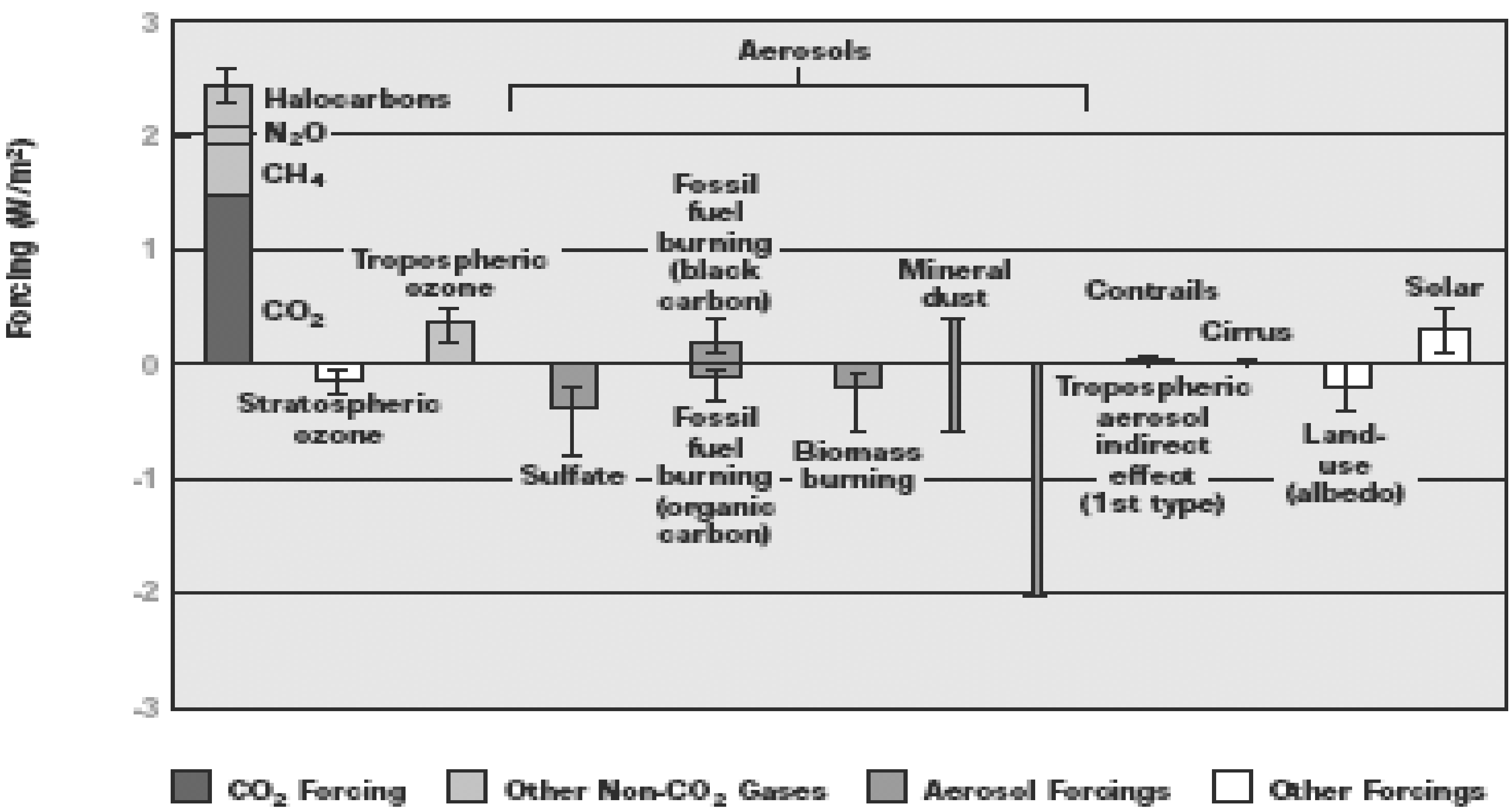
Overview of multi-gas contributors to global climate change

- What substances?
  - Kyoto Protocol gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6), radiative substances indirectly affected by emissions, aerosols / particulates, others
- How to compare importance?
  - Historical contribution to radiative forcing
  - CO_2-equivalence using global warming potentials (GWPs)
  - Economic benefit in terms of climate policy cost-effectiveness
- Two example U.S. climate policies
  - U.S. Kyoto Target (w/o international permit trading)
  - Cap set at year 2000 actual U.S. emissions (w/o international permit trading)
  - In each of above cases, CO_2-only and all GHG target

Contributions to historical radiative forcing

Figure 1

Contributions to Increased Radiative Forcing 1750 to late 1990's



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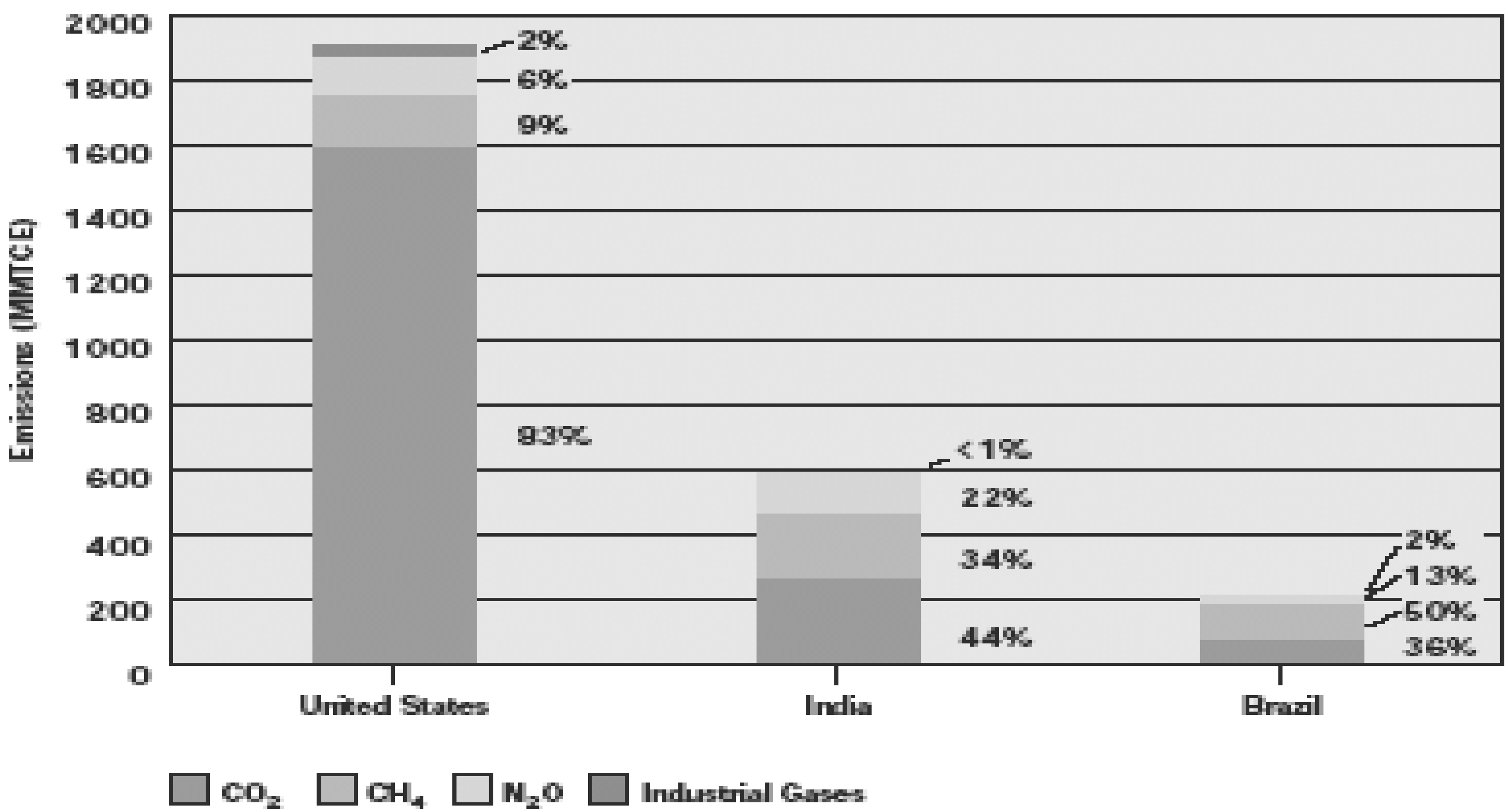
Emissions of major greenhouse gases

Figure 2

Carbon-Equivalent Greenhouse Emissions by Gas, Year 2000



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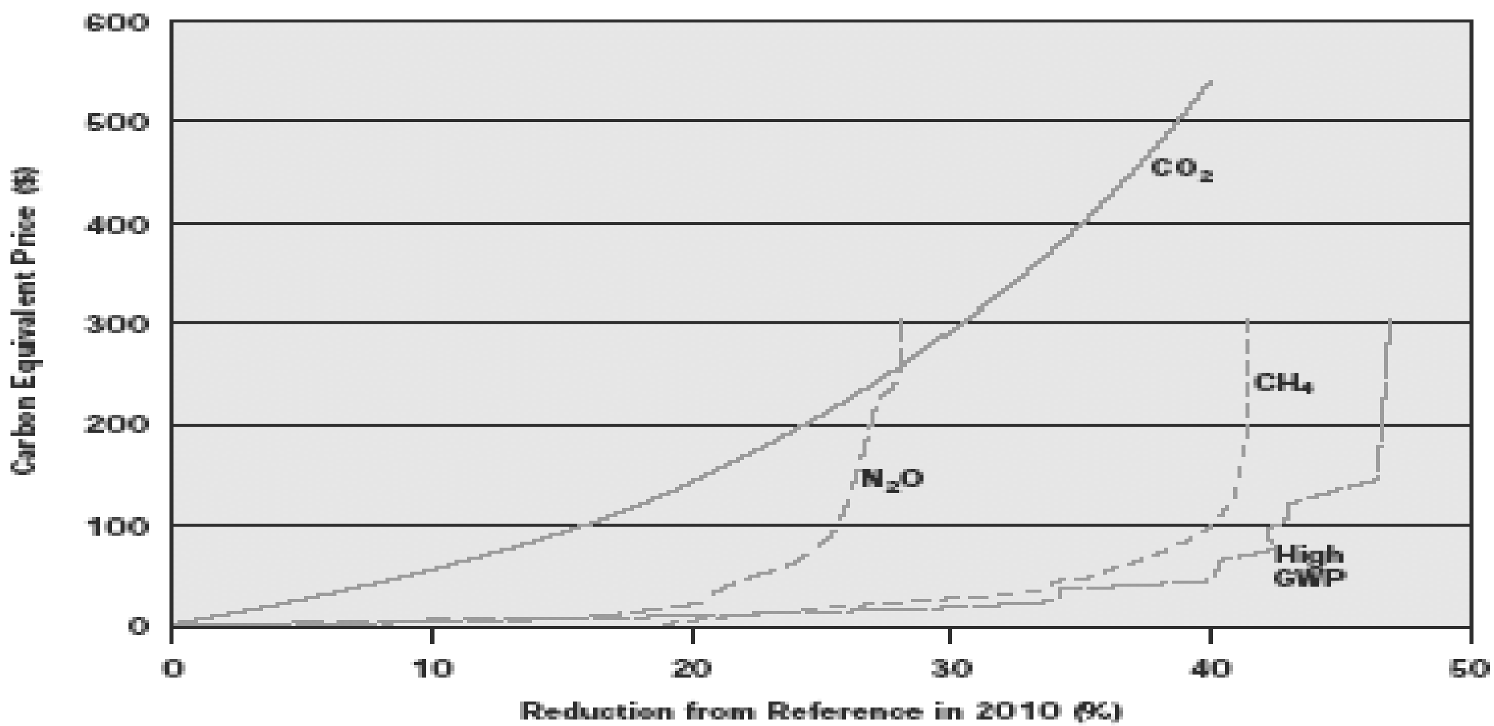
Costs of reducing principal GHGs

Figure 4

Marginal Abatement Curves for CO_2, CH_4, N_2O, and the High-GWP Industrial Gases (HFCs, PFCs, SF_6)



Sources: Methane: U.S. EPA, 1999; High-GWP Industrial gases: U.S. EPA, 2001b; Nitrous oxide: Jochen Harnisch, 2001, private communication and authors' own calculations; CO_2: Authors' own calculations based on EPPA model simulations.

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Example U.S. climate policies

Table 4

U.S. Abatement Costs of Meeting Emissions Targets

	2010 Ref. Emissions	Ref. Growth, % 1990-2010	Kyoto		Ref. Growth, % 2000-2010	Year 2000 Stabilization	
			CO_2 Only	All Gas		CO_2 Only	All Gas
CO_2 (MTC)	1904	41	1269	1376	19	1542	1735
CH_4 (MTCE)	232	31	201	95	15	220	120
N_2O (MTCE)	111	35	101	63	17	107	72
PFC (MTCE)	5	-16	5	0	-21	5	0
HFC (MTCE)	32	220	32	3	83	32	4
SF_6 (MTCE)	15	31	12	0	21	14	0
Total (MTCE)	2230		1620	1536		1920	1930
Price ($/TCE)			370	250		142	50
% Welfare loss			-0.9	-0.6		-0.1	<-0.1

Note: Carbon dioxide emissions are expressed as millions of tons of carbon (MTC). Non-CO_2 emissions are expressed in millions of tons carbon equivalent (MTCE) using 100-year global warming potentials. These scenarios are for the U.S. meeting the specified target without international emissions trading and without consideration of any carbon sink potential. Thus, the reported carbon equivalent prices are much higher than is often reported for the U.S. cost of meeting the Kyoto target. Babiker et al. (2002) estimate an international trading price of less than $50/TCE for a case where the U.S. remained a party to the Kyoto Protocol, and that includes carbon sinks as agreed to in the Protocol, compared to the figure here of $370/TCE without trading and sinks.

Policy Implications

Need to consider both CO_2 and non-CO_2 GHGs in climate mitigation efforts

- Non-CO_2 GHGs are 17% of U.S. GHG emissions
  - Up to 54% of abatement in a near-term policy
  - Reduces GHG permit price and macro-economic impacts by 1/3
- Why?
  - High GWP potency of non-CO_2 GHGs
  - e.g.; incentive of $50/TCE
    - +12.5¢/gal. gasoline (7% price increase from $1.80/gal.)
    - +$150/lb. of SF_6 (1500% increase from $10/lb.)
  - Few prior incentives to control the other GHGs (unlike energy prices to conserve fossil fuel use)
- Consider additional uncertainties
  - Monitoring and verification
  - Full range of climatic impacts from non-CO_2 GHGs

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