united nations
educational, scientific
and cultural
organization

international atomic
energy agency

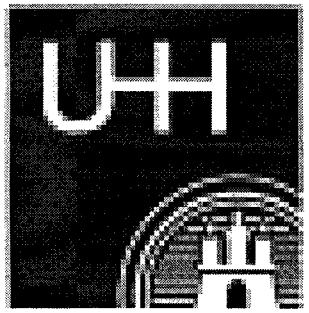
the
abdus salam
international centre for theoretical physics

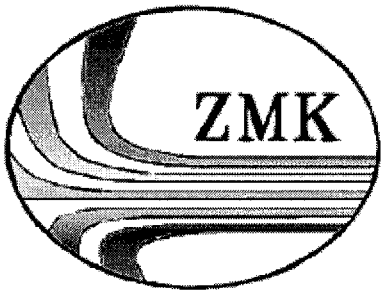
SMR.1307 - 3

Advanced Course:
CLIMATE CHANGE IN THE MEDITERRANEAN REGION
PART II: SOCIO-ECONOMIC ASPECTS AND IMPACTS
(12 - 16 November 2001)

"Climate Change Impacts"

Richard S.J. TOL
ZMK
Bundestrasse 55, 20146 Hamburg
GERMANY

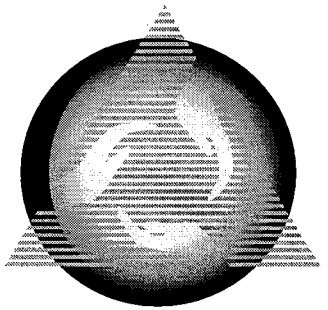




Climate Change Impacts

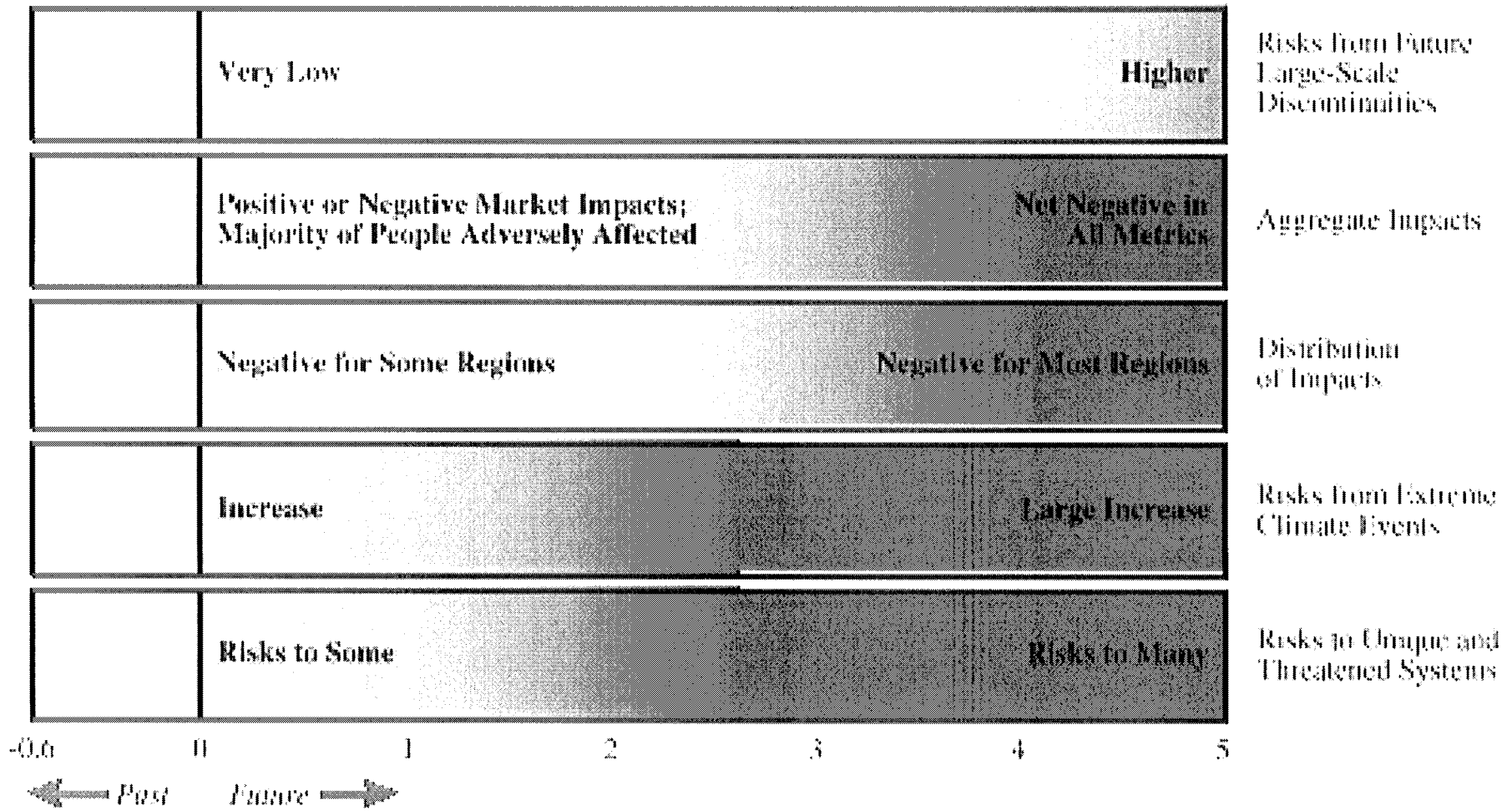
Richard S.J. Tol

Hamburg, Vrije and Carnegie Mellon Universities



Climate Change Impacts

- Impacts of climate change
- Economic valuation
- Regional and global economic impacts
- Marginals and uncertainties
- Dynamics
- Climate, change, and growth


Very Low
Higher
Risks from Future Large-Scale Discontinuities
Positive or Negative Market Impacts; Majority of People Adversely Affected
Not Negative in All Metrics
Aggregate Impacts
Negative for Some Regions
Negative for Most Regions
Distribution of Impacts
Increase
Large Increase
Risks from Extreme Climate Events
Risks to Some
Risks to Many
Risks to Unique and Threatened Systems
-0.6
0
1
2
3
4
5
Past
Future

Impacts of Climate

- Changing temperatures, precipitation and atmopsheric composition affect plants and animals, both in managed and in unmanaged systems
- The specialised are likely to loose, as are the marginalised
- Climate change affects water (for drinking, irrigation, cooling), droughts and floods
- Climate change affects energy production and consumption; tourism; construction; transport; labour productivity and so on

Impacts of Climate –2

- Sea level rise leads to land loss and higher costs for coastal protection, wetland loss, salt intrusion
- Climate change also affects human health, through heat stress (cardiovascular, respiratory), cold stress (cardiovascular), vector-borne diseases (malaria, dengue fever, schistosomiasis), other infectuous diseases (cholera), water and food quantity and quality, air pollution, and extreme weather events

Impacts of Climate -3

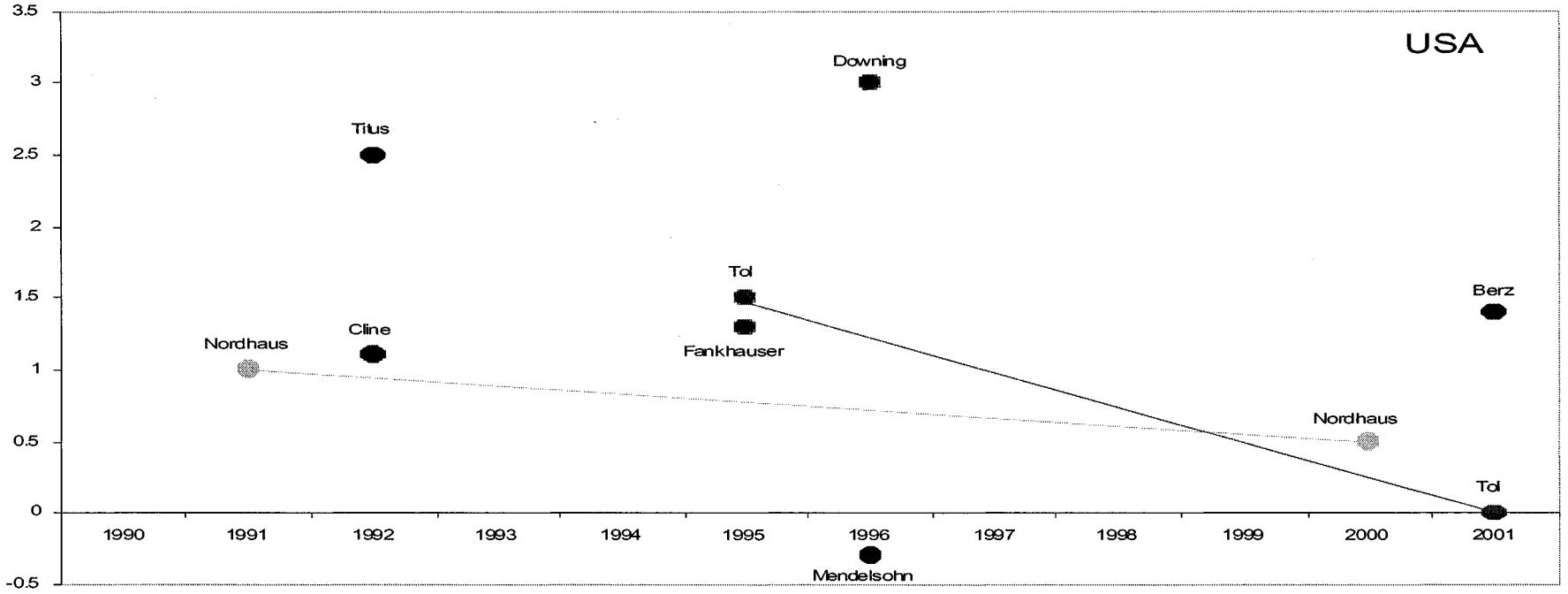
- Climate change has many different impacts, with different effects for different countries, sectors, times
- If one wants to get insights, high level indicators need to be used
- If one wants to compare the impacts of climate change to the impacts of emission reduction, include the impacts in the national accounts, or determine how much compensation should be paid, money is the appropriate indicator

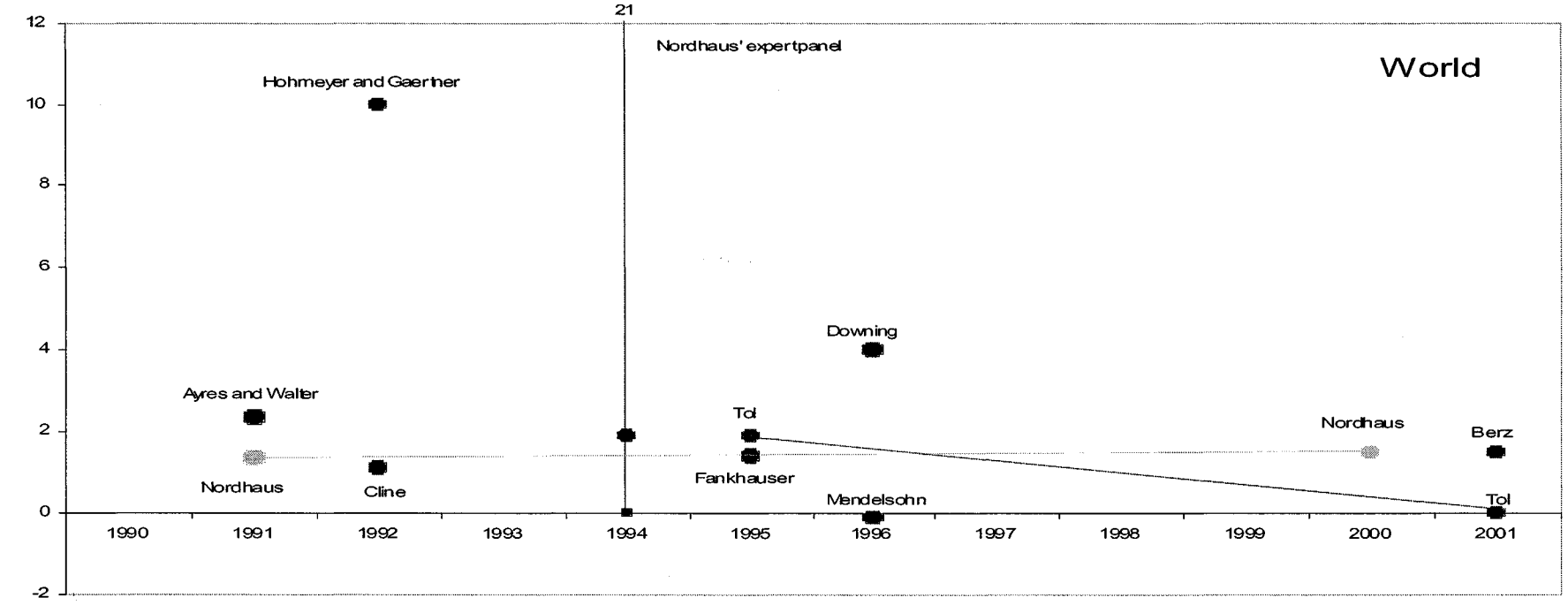
Monetary Valuation

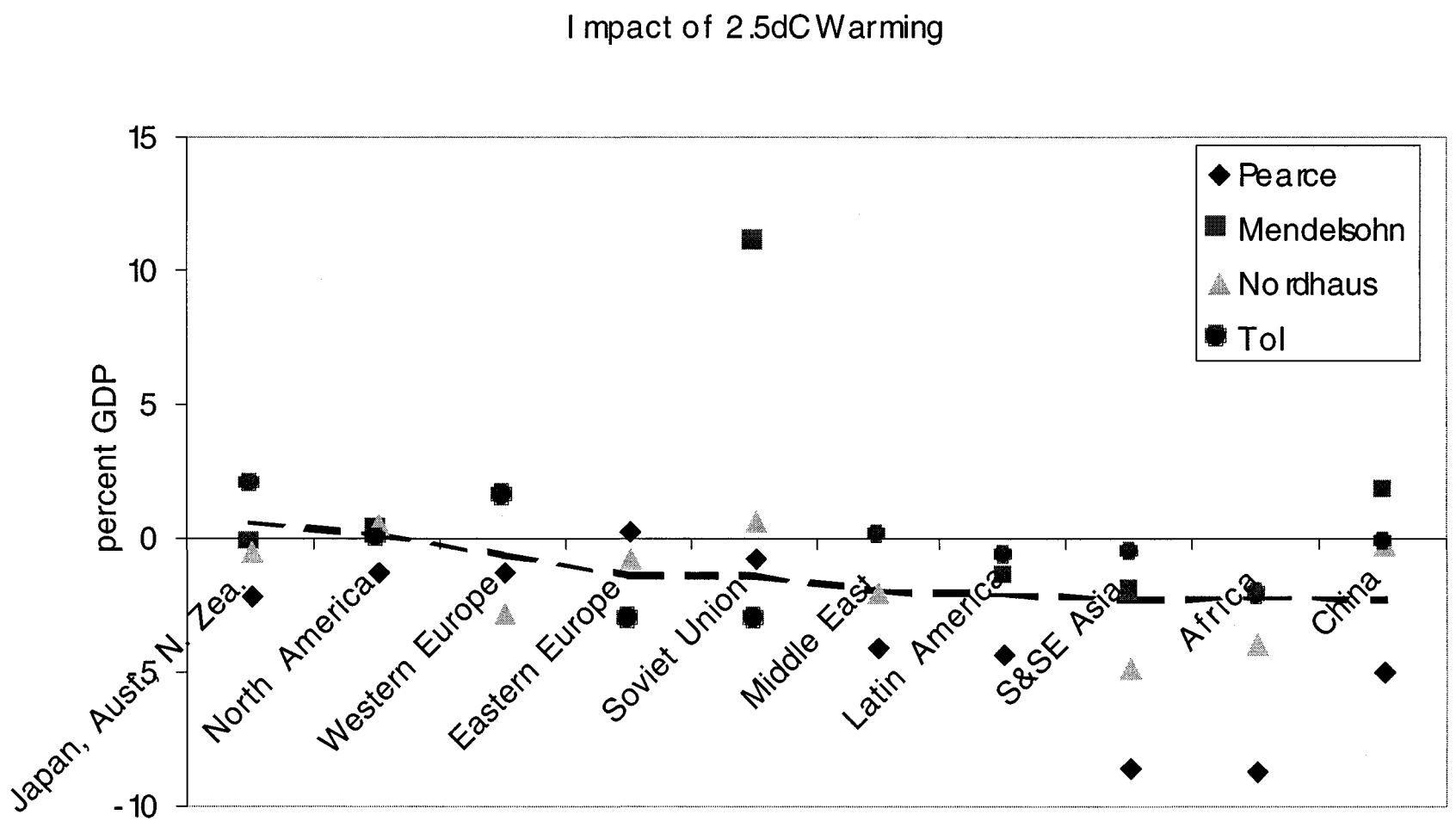
- The aim is to express a welfare loss in an equivalent income loss
- Three methods
  - Travel cost
  - Hedonic pricing
  - Contingent valuation
- All three methods have considerable problems, but contingent valuation has the additional drawback that one is dealing with *stated* rather than *revealed* preferences, often in an *unfamiliar* context

Monetary Valuation -2

- Willingness to pay and willingness to accept compensation are different, because the budget constraint is different, voluntary and involuntary risks are different, and people attach value to the status quo
- Valuation is expensive, therefore, estimated values are extrapolated (benefit transfer) from one place to the next and from one case to the next - as values are highly context-specific, this introduces all sorts of uncertainties, which are not well-understood

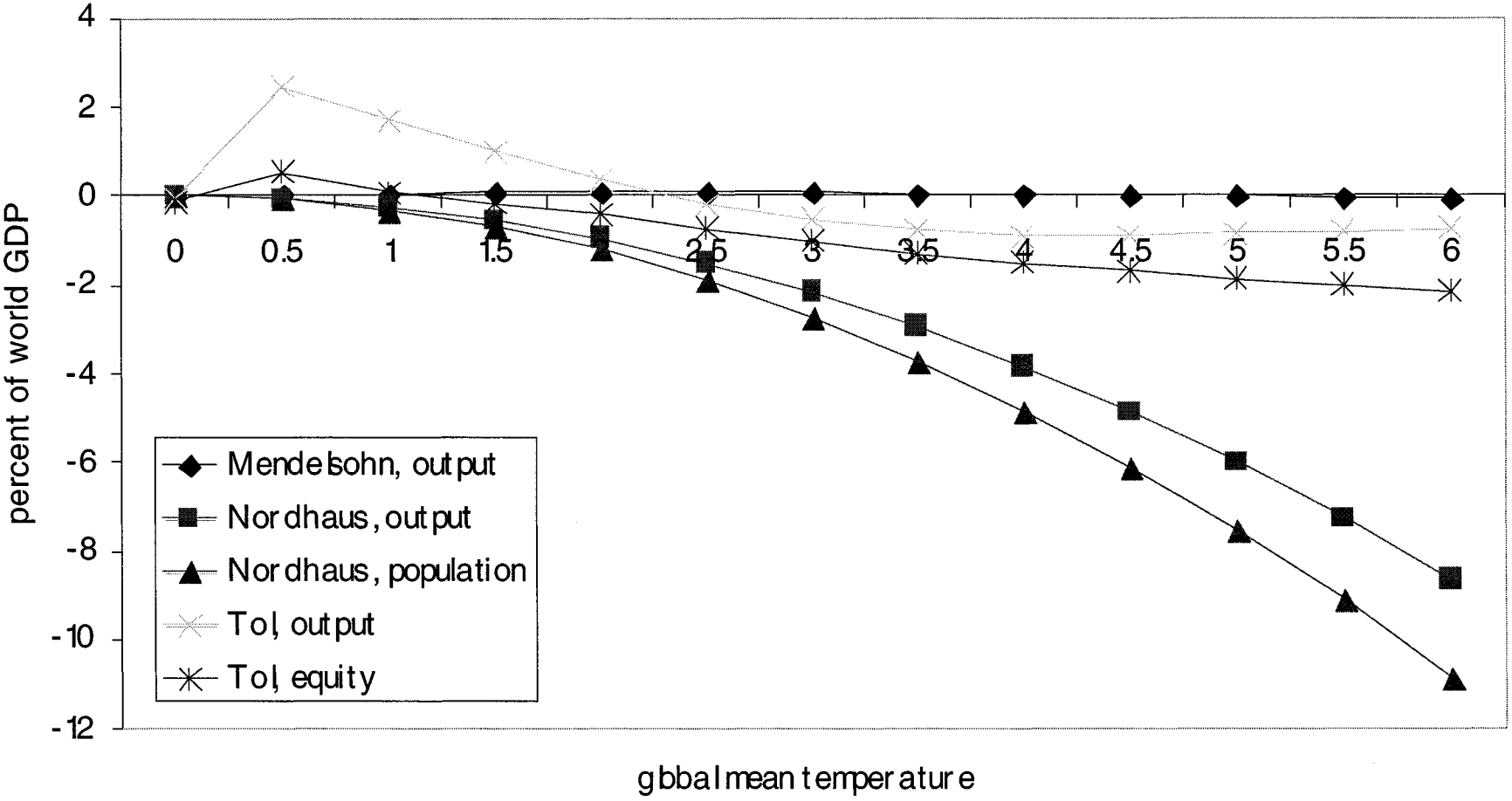

USA
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Downing
Titus
Tol
Berz
Cline
Nordhaus
Fankhauser
Nordhaus
Tol
Mendelsohn


World
21
Nordhaus' expertpanel
12
10
8
6
4
2
0
-2
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Hohmeyer and Gaertner
Downing
Ayres and Walter
Tol
Nordhaus
Berz
Nordhaus
Cline
Fankhauser
Mendelsohn
Tol


Impact of 2.5dC Warming
15
10
5
0
-5
-10
percent GDP
Pearce
Mendelsohn
Nordhaus
Tol
Japan, Aust, N. Zea.
North America
Western Europe
Eastern Europe
Soviet Union
Middle East
Latin America
S&SE Asia
Africa
China

Global Aggregate Damage of Climate Change

%GDP	Pearce	Nordhaus	Tol
Output	1.5–2.0	1.5	0.0
Population		1.9	
Equity			0.8


4
2
0
-2
-4
-6
-8
-10
-12
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
percent of world GDP
global mean temperature
Mendelsohn, output
Nordhaus, output
Nordhaus, population
Tol, output
Tol, equity

Equity Weighing

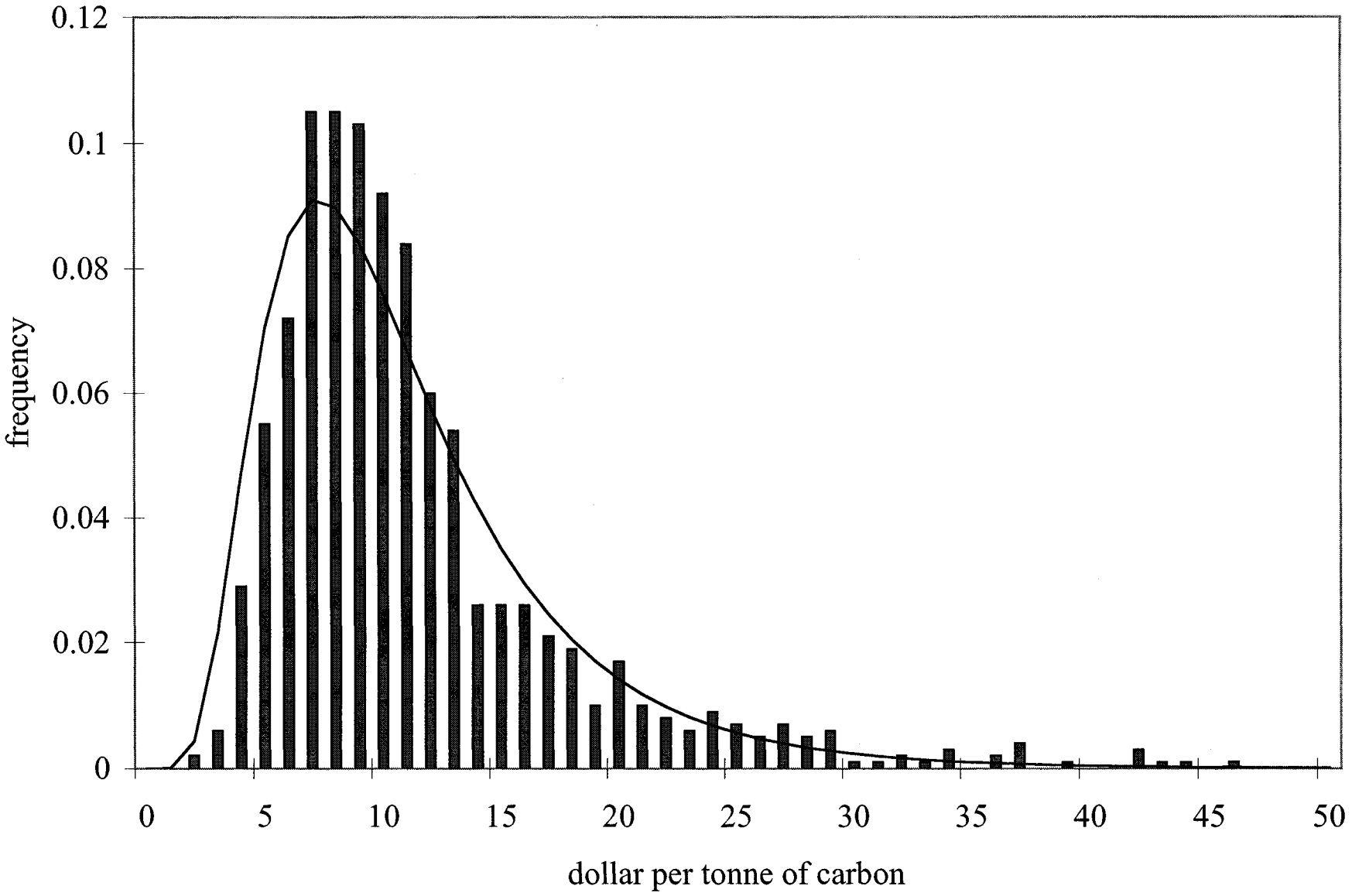
- Equity weights

- Utility and welfare functions

- If _=0 and *e*=1, or if _=1

Marginal cost estimates

		0%	1%	3%
Nordhaus 1994	BG			5
	EV			12
Fankhauser 1994	EV		20 (6–45)	
Tol 1999	BG	73	23	9
	EW	171	60	23
	EVW	244	82	35
		(143)	(51)	(22)
Downing 2000	BG	75	46	16
Tol 2000	BG	20	4	−7

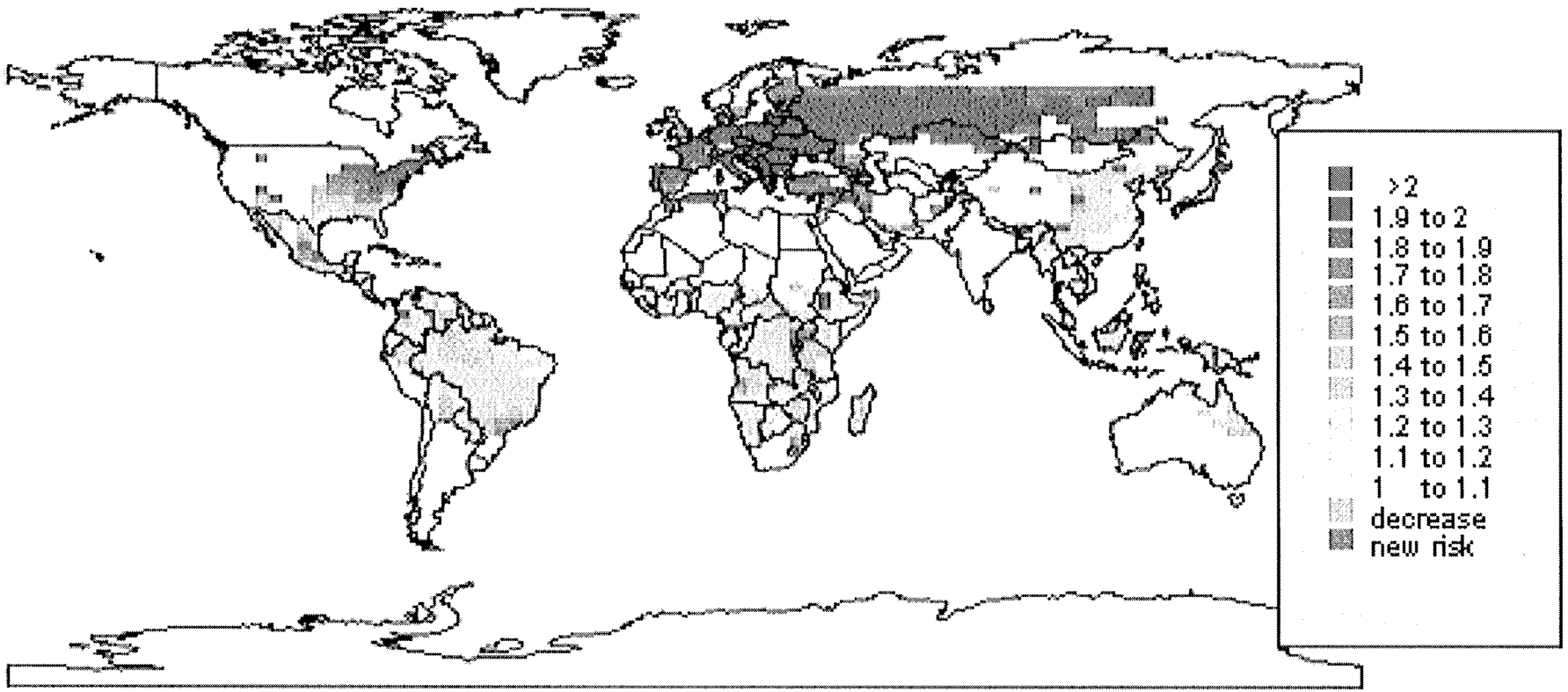

0.12
0.1
0.08
0.06
0.04
0.02
0
frequency
0
5
10
15
20
25
30
35
40
45
50
dollar per tonne of carbon

Caveats

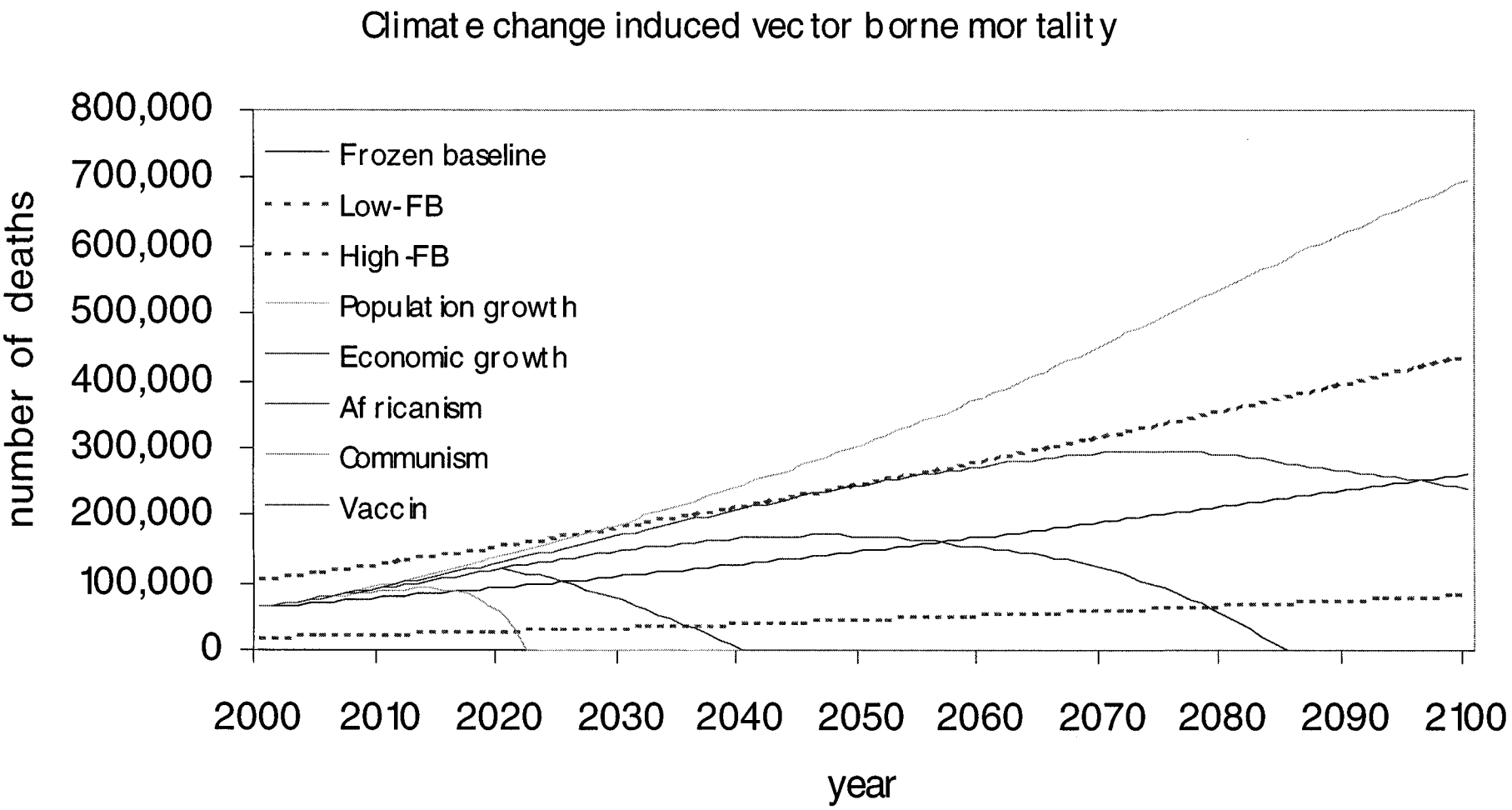
- Based on a few case studies, with a lot of extrapolation
- Valuation problematic
- Interactions and higher-order effects ignored
- Adaptation not treated well
- Many impacts ignored, some may be large
- Large scale disruptions ignored
- Uncertainties unknown
- Dynamics understudied

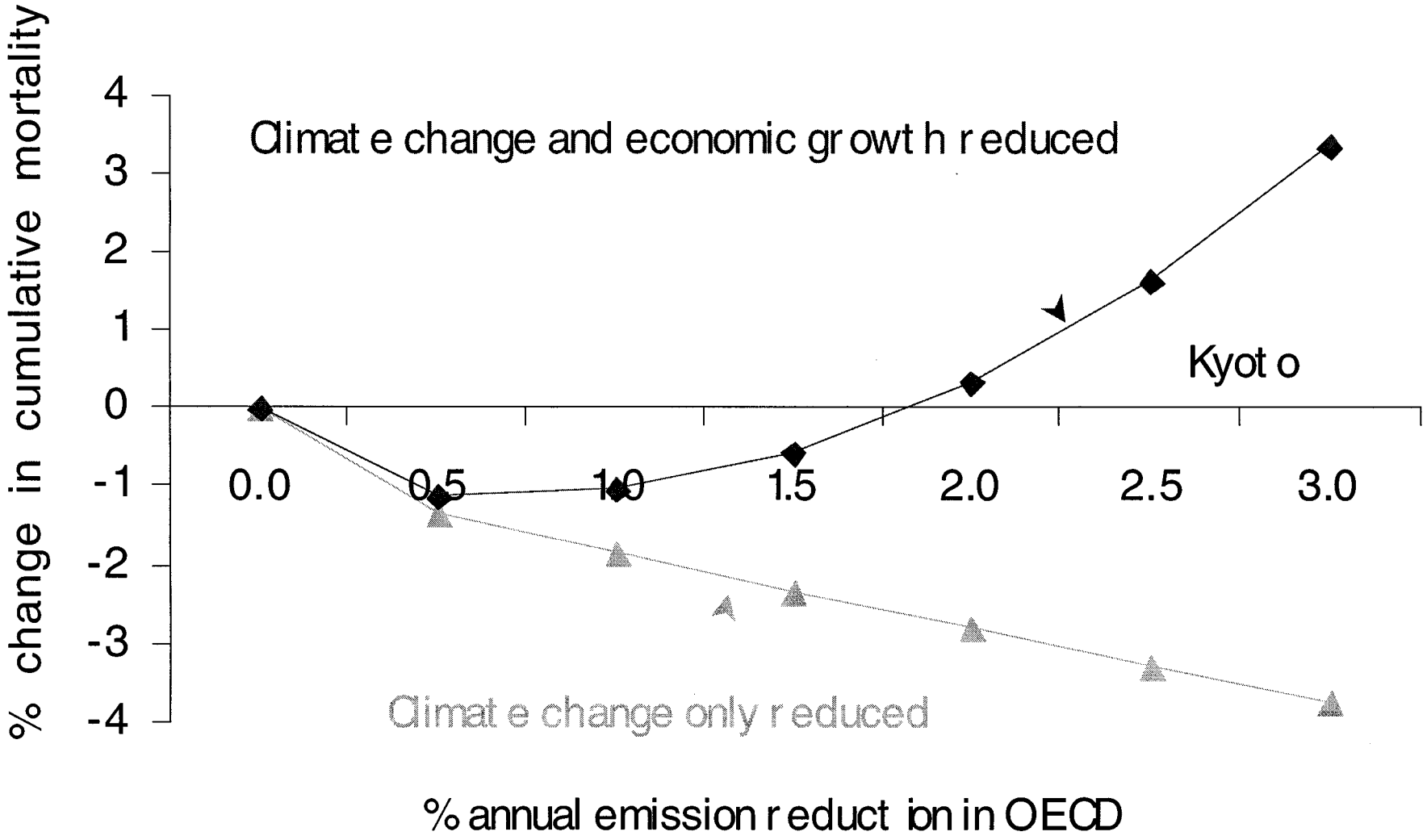
Dynamics

- Vulnerability to climate change is a function of exposure and adaptive capacity, both of which depend on development status
- Future vulnerability will be very different from current vulnerability
- Not only is future development uncertain, but also the link between development, exposure and adaptive capacity is unclear
- I will illustrate this with the case of malaria


>2
1.9 to 2
1.8 to 1.9
1.7 to 1.8
1.6 to 1.7
1.5 to 1.6
1.4 to 1.5
1.3 to 1.4
1.2 to 1.3
1.1 to 1.2
1 to 1.1
decrease
new risk

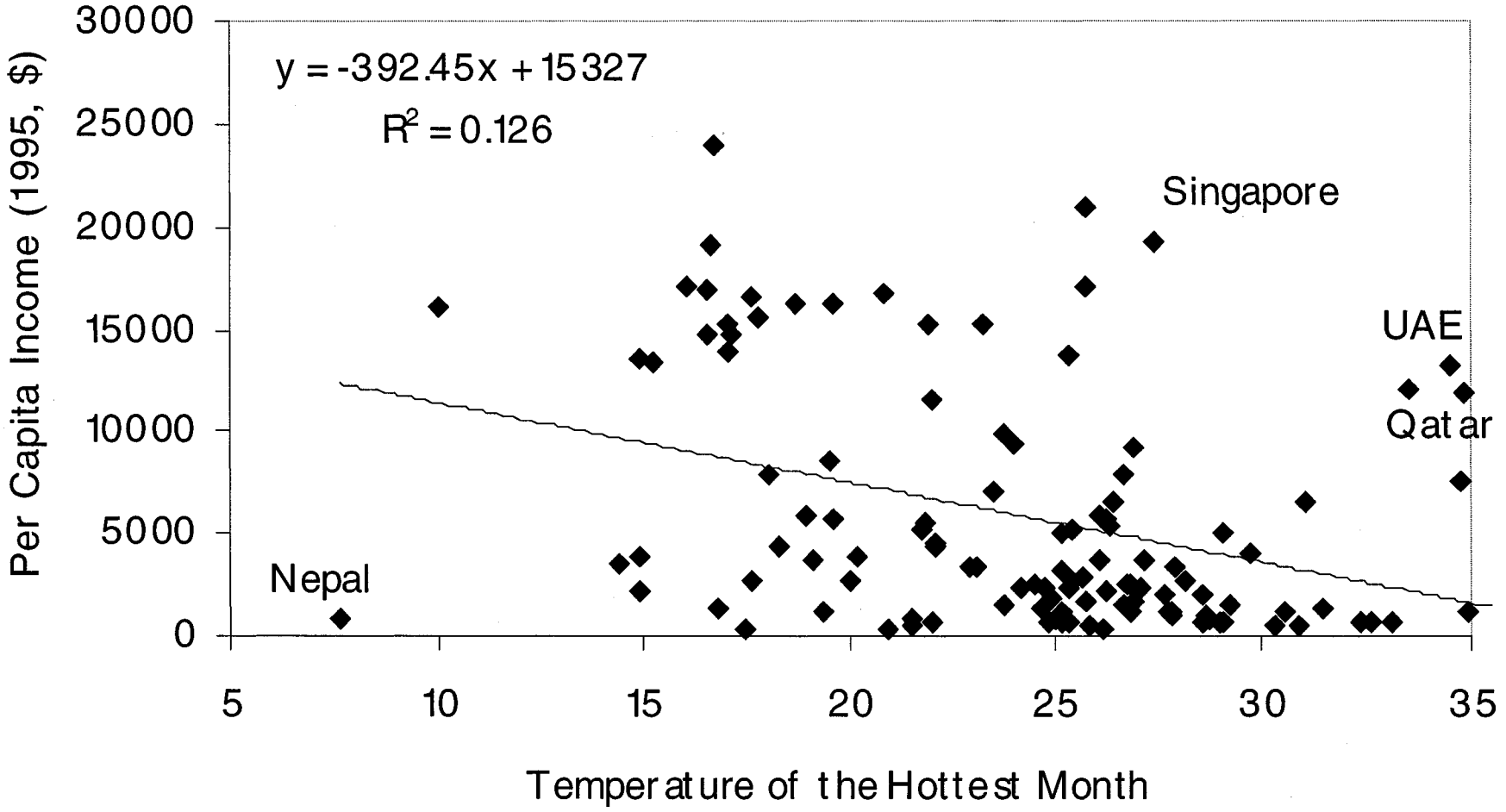

vectors present, transmitting the parasite
vectors present, currently not transmitting the parasite
vectors present, but current climate too cold for parasite
climate warm enough for parasite, but no vectors present

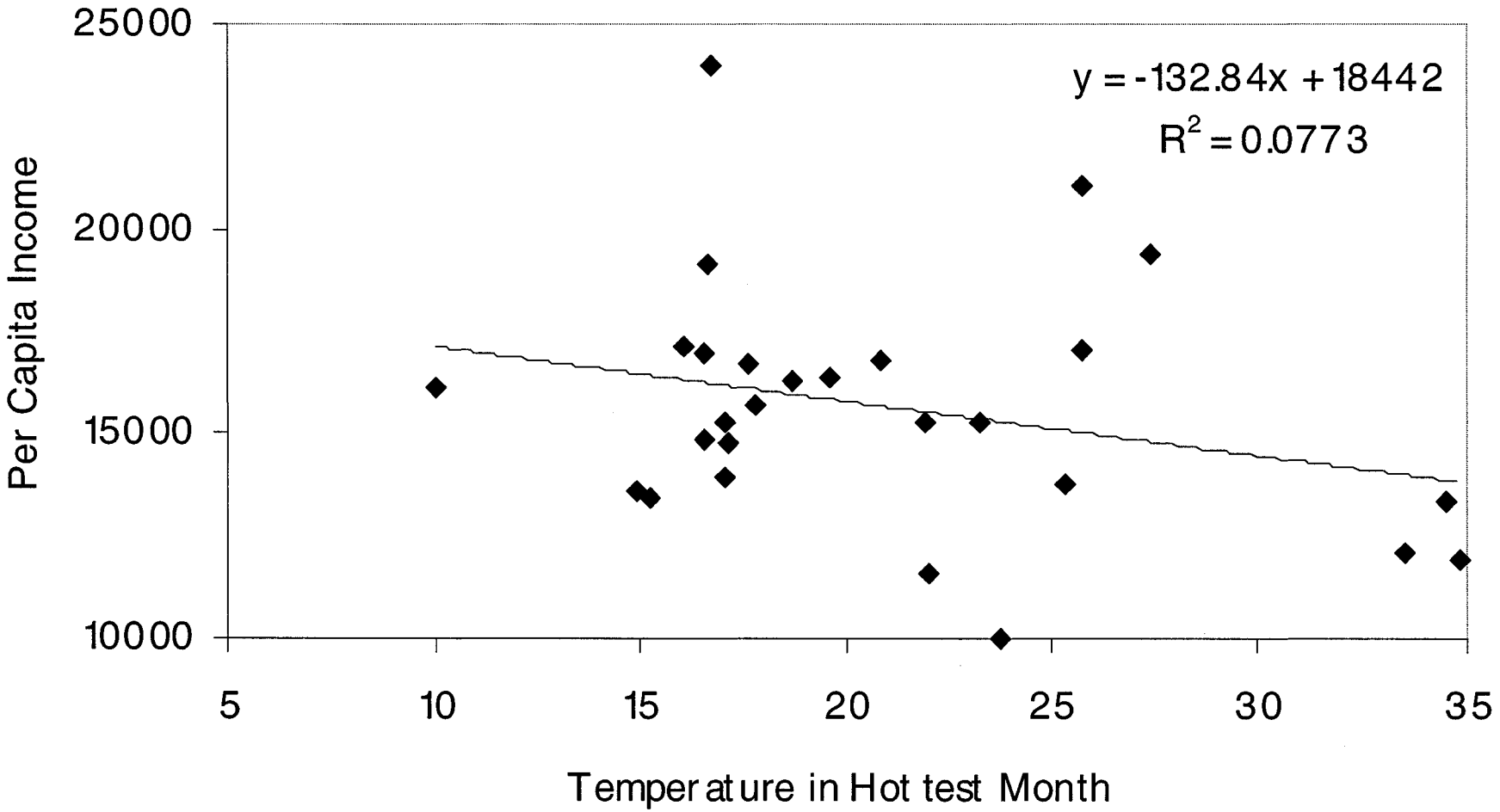

Climate change induced vector borne mortality
number of deaths
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Frozen baseline
Low-FB
High-FB
Population growth
Economic growth
Africanism
Communism
Vaccin
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
year

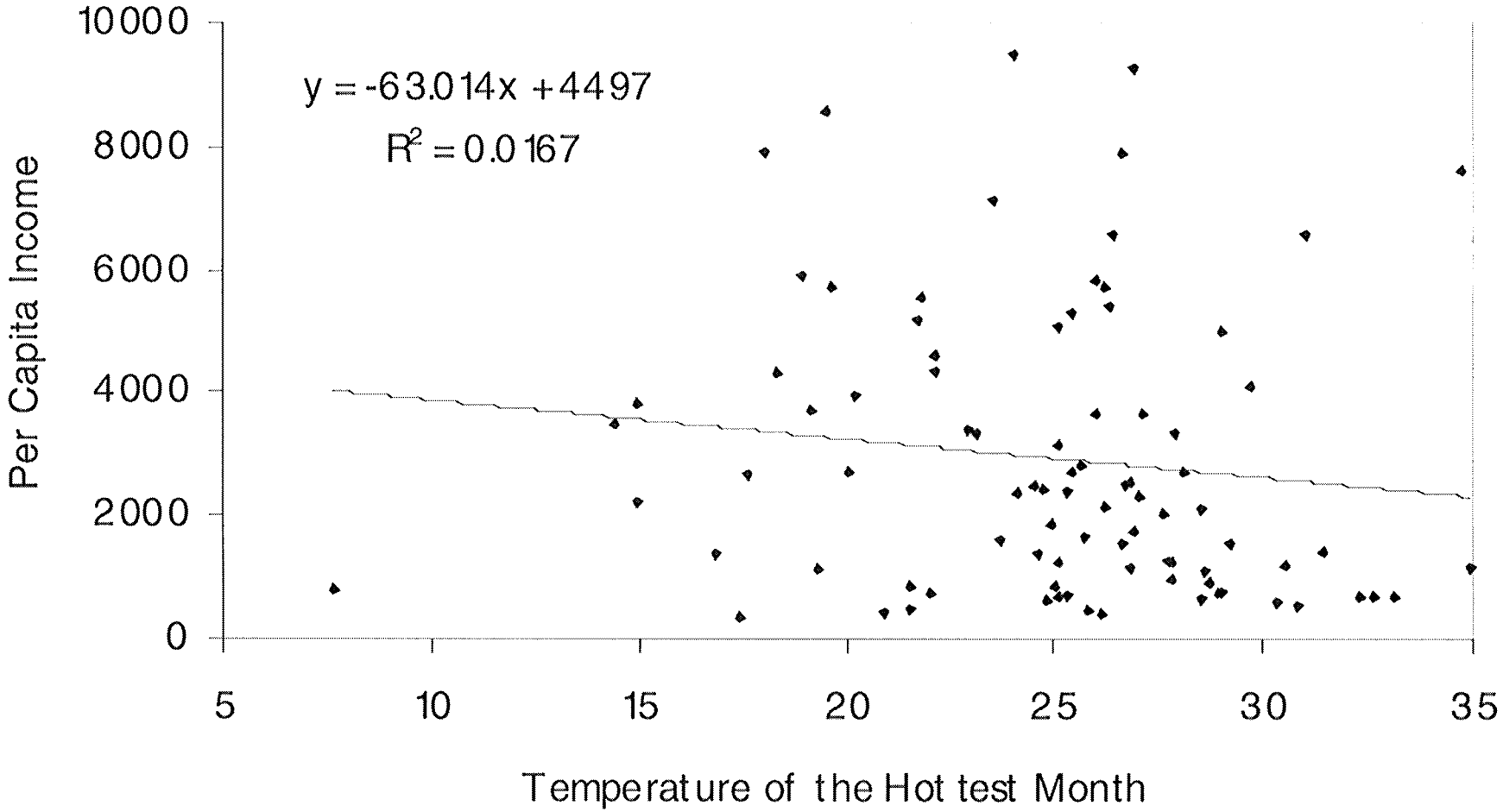

% change in cumulative mortality
4
3
2
1
0
-1
-2
-3
-4
Climate change and economic growth reduced
Kyoto
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Climate change only reduced
% annual emission reduction in OECD

Climate and Income

- Hot countries are poorer, and grow slower than do cool countries
- The implications of this for climate change are unclear
- Climate is important to agricultural economies
- Climate is also important for institutions (variability and saving; adverse conditions and cooperation)
- More advanced economies, however, are largely independent of climate


y = -392.45x + 15327
R2 = 0.126
Singapore
UAE
Qatar
Nepal
Per Capita Income (1995, $)
30000
25000
20000
15000
10000
5000
0
5
10
15
20
25
30
35
Temperature of the Hottest Month


y = -132.84x + 18442
R^2 = 0.0773
Per Capita Income
25000
20000
15000
10000
5
10
15
20
25
30
35
Temperature in Hot test Month


y = -63.014x + 4497
R² = 0.0167
Per Capita Income
10000
8000
6000
4000
2000
0
5
10
15
20
25
30
35
Temperature of the Hot test Month

Climate and Income

	Ln y	Ln y	Ln y
Ln T	−1.1 (4.6)		
TropicAr		−1.0 (5.1)	
Malaria			−1.6 (6.6)
Ln k	0.4 (9.4)		
Ln h	0.4 (4.8)		
Pop 100 km		1.1 (5.3)	
LnDistance		−0.3 (3.4)	
R^2	0.87	0.50	0.69
N	97	129	83

Climate and Growth

	Ln y_{8085}	y_{6590}	y_{6590}
Ln T	−0.3 (2.1)		
TropicAr		−0.9 (2.3)	−0.4 (0.8)
Malaria			−2.6 (3.9)
Ln y_{80}	−0.0 (9.6)		
y_{65}		−2.4 (8.0)	−2.7 (7.6)
dMalaria			−4.5 (2.1)
Institution		0.3 (2.6)	0.5 (3.7)
R^2	0.08	0.50	0.69
N	97	129	83

Conclusions

- In the next century, climate change will spell substantial trouble in developing countries, but developed countries and the world economy are little vulnerable, may even benefit
- Climate change impacts are very uncertain, the research of the past ten years has mainly uncovered how little we know
- Climate has long been a blind spot of economists, but there are some fine intellectual challenges waiting to be solved