The damage functions in models that compute the Social Cost of Carbon

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Samuelson condition

x = emission abatement
MC = marginal cost of abatement
MB_i = marginal benefit of abatement to person i

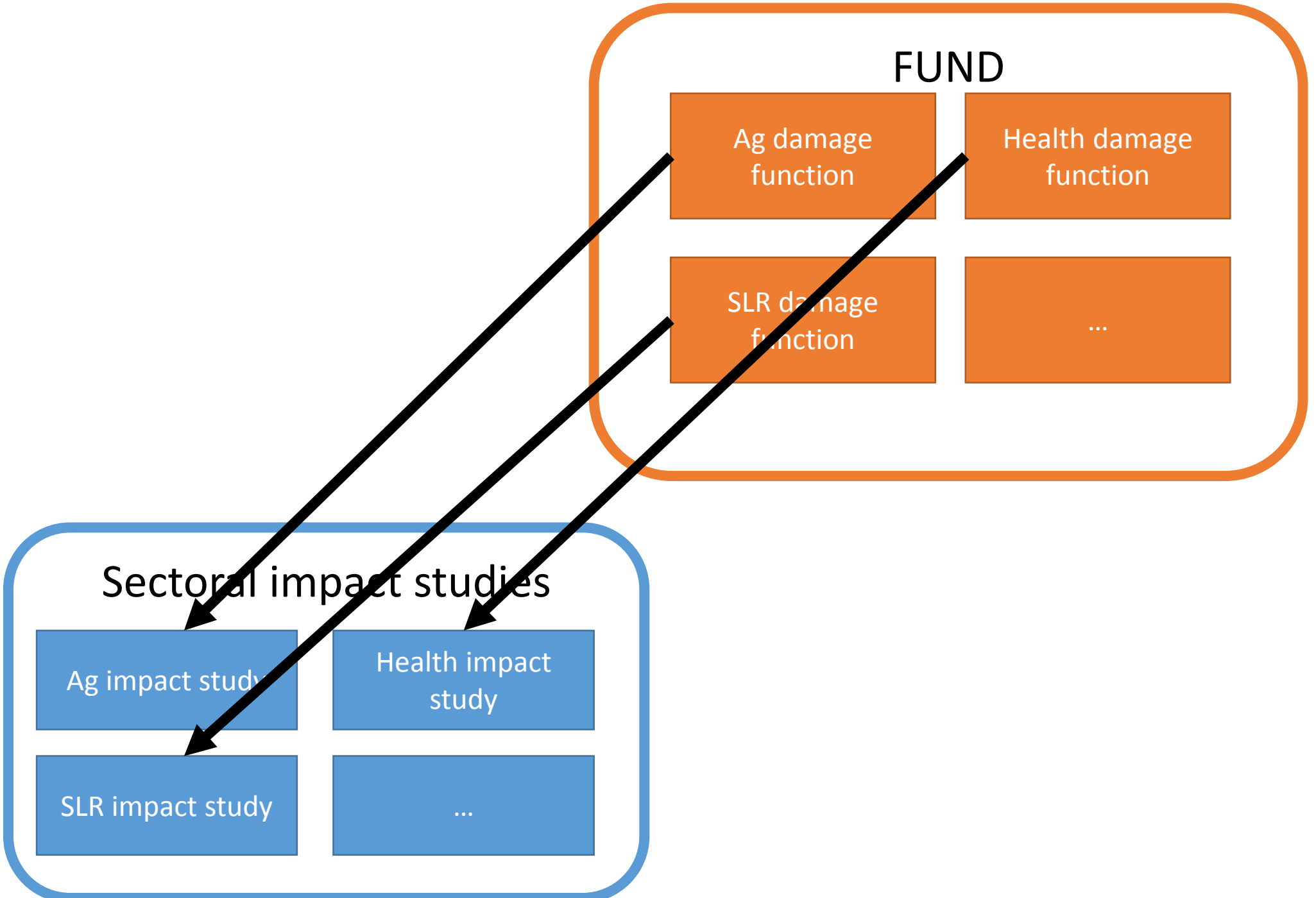
$$MC(x) = \sum_i MB_i(x)$$

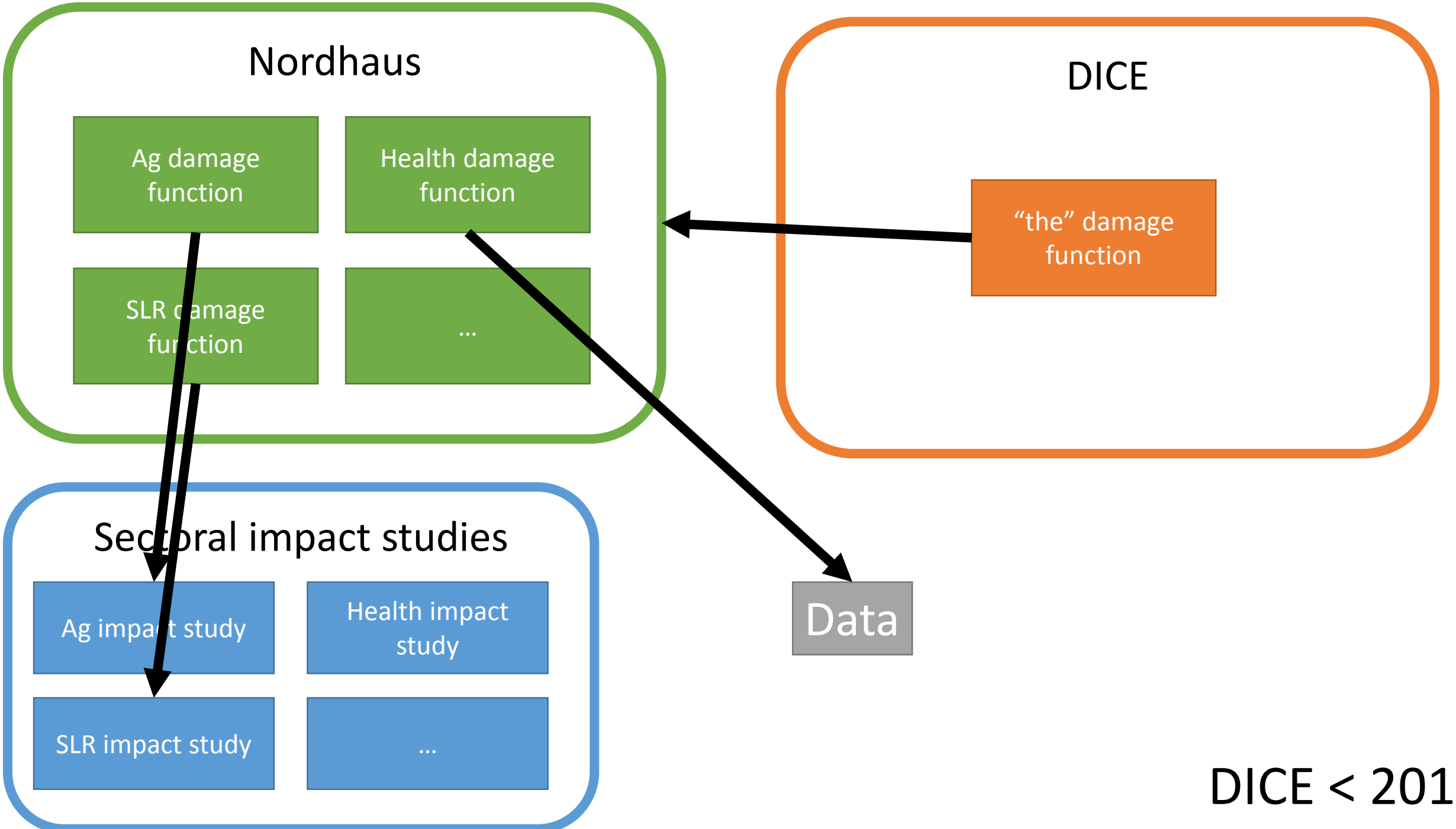
Social Cost of Carbon

$$MB_i = \sum_s MB_{is}(x)$$

$$D(T) = \beta_1 T + \beta_2 T^2$$

“[…] The bottom line here is that the damage functions used in most IAMs are completely made up, with no theoretical or empirical foundation. […]” (Pindyck, 2013)


FUND
Ag damage function
Health damage function
SLR damage function
…
Sectoral impact studies
Ag impact study
Health impact study
SLR impact study
…


Nordhaus
Ag damage function
Health damage function
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DICE
"the" damage function
Sectoral impact studies
Ag impact study
Health impact study
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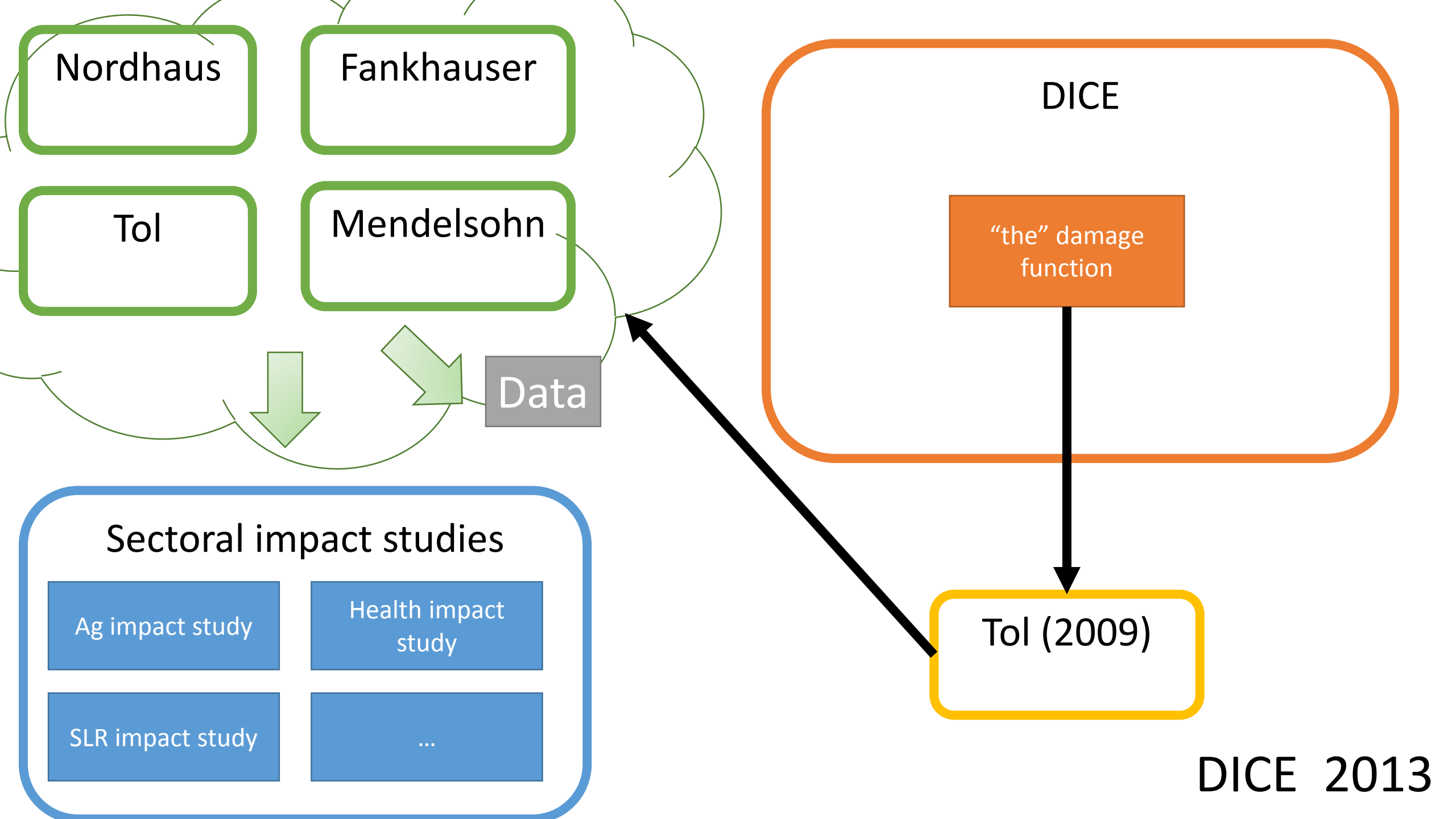
Data

DICE < 2013


Nordhaus
Fankhauser
Tol
Mendelsohn
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"the" damage function
Tol (2009)
Sectoral impact studies
Ag impact study
Health impact study
SLR impact study
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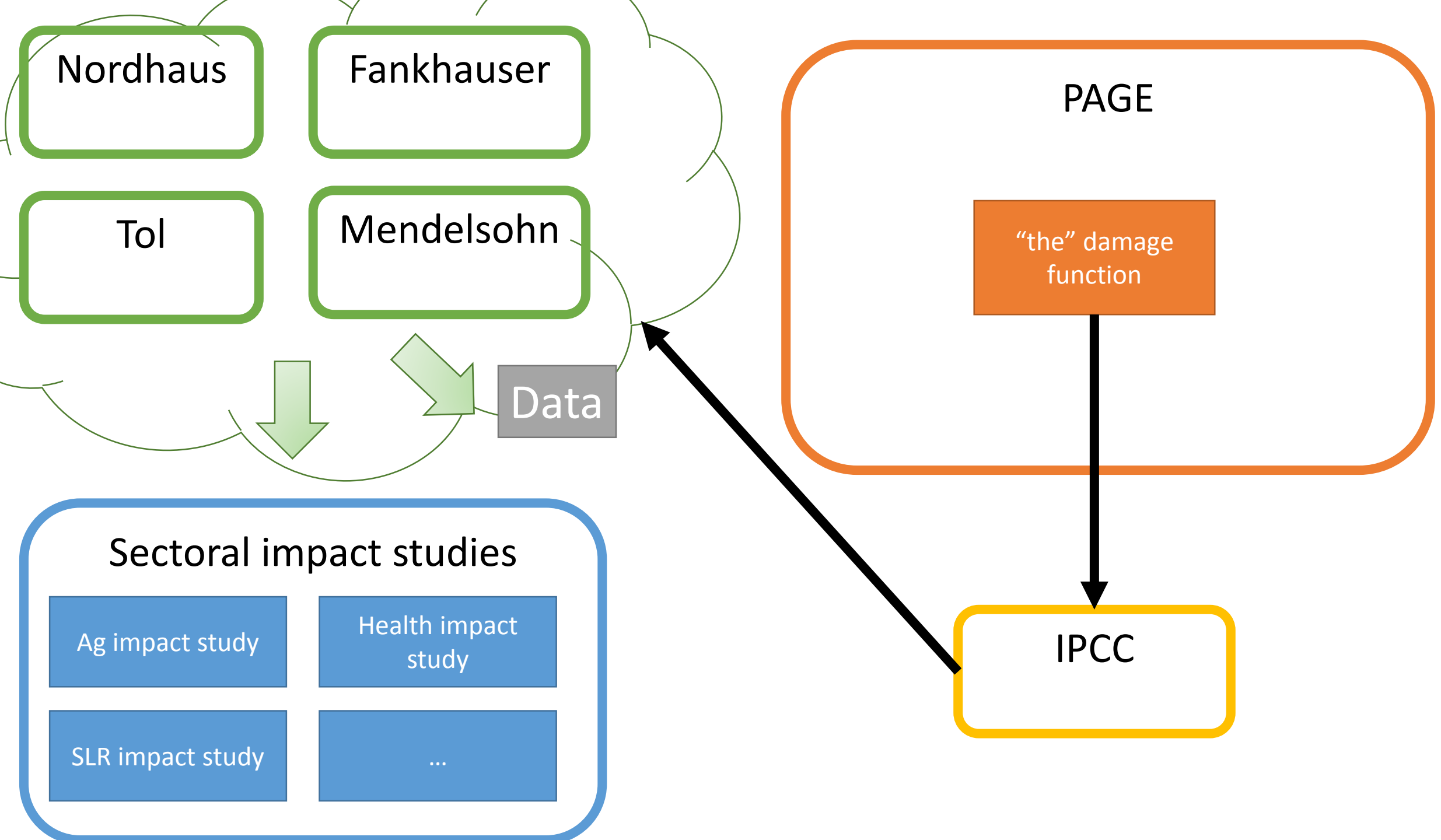
Nordhaus
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Study	Warming (°C)	Impact (% of GDP)
Nordhaus (1994a)	3.0	−1.3
Nordhaus (1994b)	3.0	−4.8 (−30.0 to 0.0)
Fankhauser (1995)	2.5	−1.4
Tol (1995)	2.5	−1.9
Nordhaus and Yang (1996)[a]	2.5	−1.7
Plambeck and Hope (1996)[a]	2.5	2.5 (−0.5 to −11.4)
Mendelsohn, Schlesinger, and Williams (2000)[a,b,c]	2.5	0.0[b] 0.1[b]
Nordhaus and Boyer (2000)	2.5	−1.5
Tol (2002)	1.0	2.3 (1.0)
Maddison (2003)[a,d,e]	2.5	−0.1
Rehdanz and Maddison (2005)[a,c]	1.0	−0.4
Hope (2006)[a,f]	2.5	0.9 (−0.2 to 2.7)
Nordhaus (2006)	2.5	−0.9 (0.1)

Tol (2009)

$$A_{t,r} = A^r_{t,r} + A^l_{t,r} + A^f_{t,r}$$

$$A^r_{t,r} = \alpha_r \left(\frac{\Delta T_t}{0.04}\right)^{\beta} + \left(1 - \frac{1}{\rho}\right) A^r_{t-1,r}$$

$$A^l_{t,r} = \delta^l_r T_t + \delta^q_r T_t^2$$

$$A^f_{t,r} = \gamma_r \ln \frac{CO2_t}{275}$$

$$\frac{GAP_{t,r}}{Y_{t,r}} = \frac{GAP_{1990,r}}{Y_{1990,r}} \left(\frac{y_{1990,r}}{y_{t,r}}\right)^{\epsilon}$$

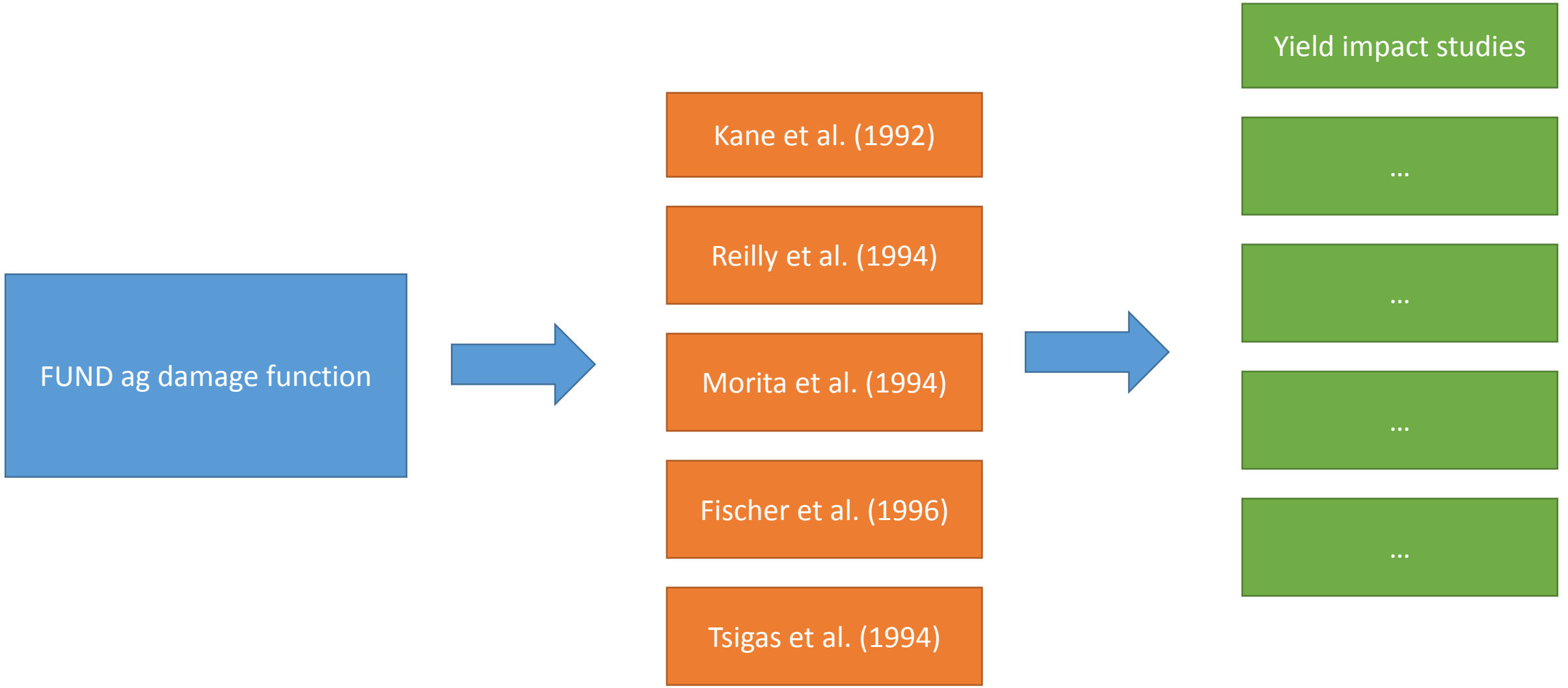
FUND ag damage function
Kane et al. (1992)
Reilly et al. (1994)
Morita et al. (1994)
Fischer et al. (1996)
Tsigas et al. (1994)
Yield impact studies
…
…
…
…

TABLE IV: Yield effects, scenario A

Countries/regions	% change in yield				
	Wheat	Corn	Soybean	Rice	Other[a]
United States	−10	−15	−15		−10
Canada	−15	+5	+5		−10
European Community	−10				
Other Europe	+15				
Japan	−5				
Australia	+10				
China	+10				
U.S.S.R.	+10				
Brazil					
Argentina					
Pakistan					
Thailand					
Rest of the World					

[a] Other coarse grains, groundnuts, c

TABLE VII: Welfare effects of climate change scenarios

	Scenario A	
	Net welfare change (mill. $1986)	% of 1986 GDP
US	194	0.005
Canada	−167	−0.047
European Community	−673	−0.019
Other Europe	−51	−0.010
Japan	−1209	−0.062
Australia	66	0.038
USSR	658	0.032
China	2882	1.280
Brazil	−47	−0.017

Kane et al. (1992)

Thank you!

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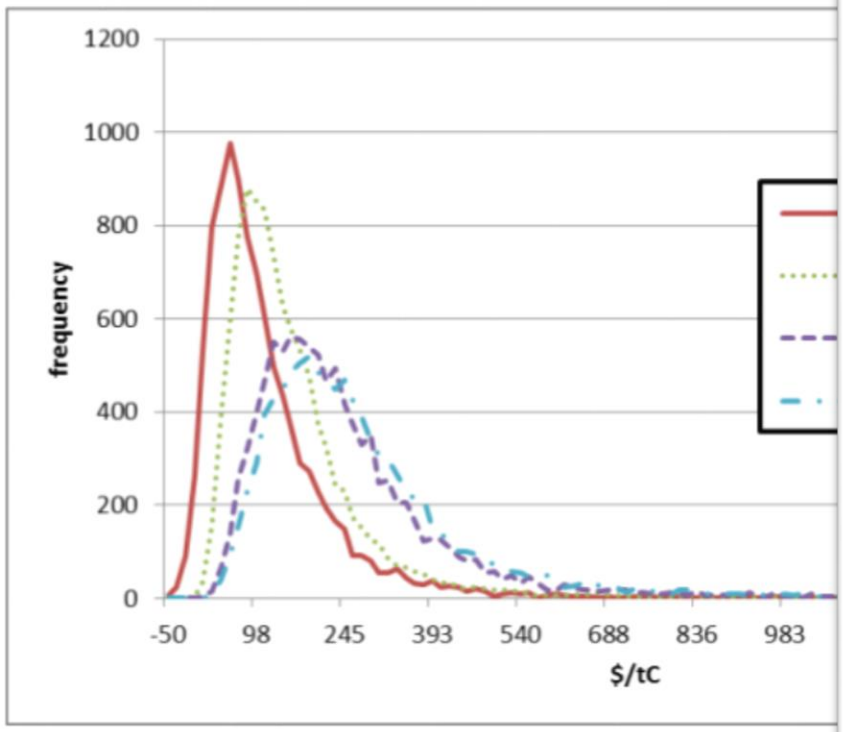
Adaptation – Malaria

$$D_{t,r}^{v} = D_{1990,r}^{v} \alpha_{r}^{v} \left(T_{t} - T_{1990}\right)^{\beta} \left(\frac{y_{t,r}}{y_{1990,r}}\right)^{\gamma}$$

$$\gamma = -2.65\ (0.69)$$

Uncertainty

Figure 2: Frequency distributions (10,000 runs) for climate sensitivity sce
time preference of 1%



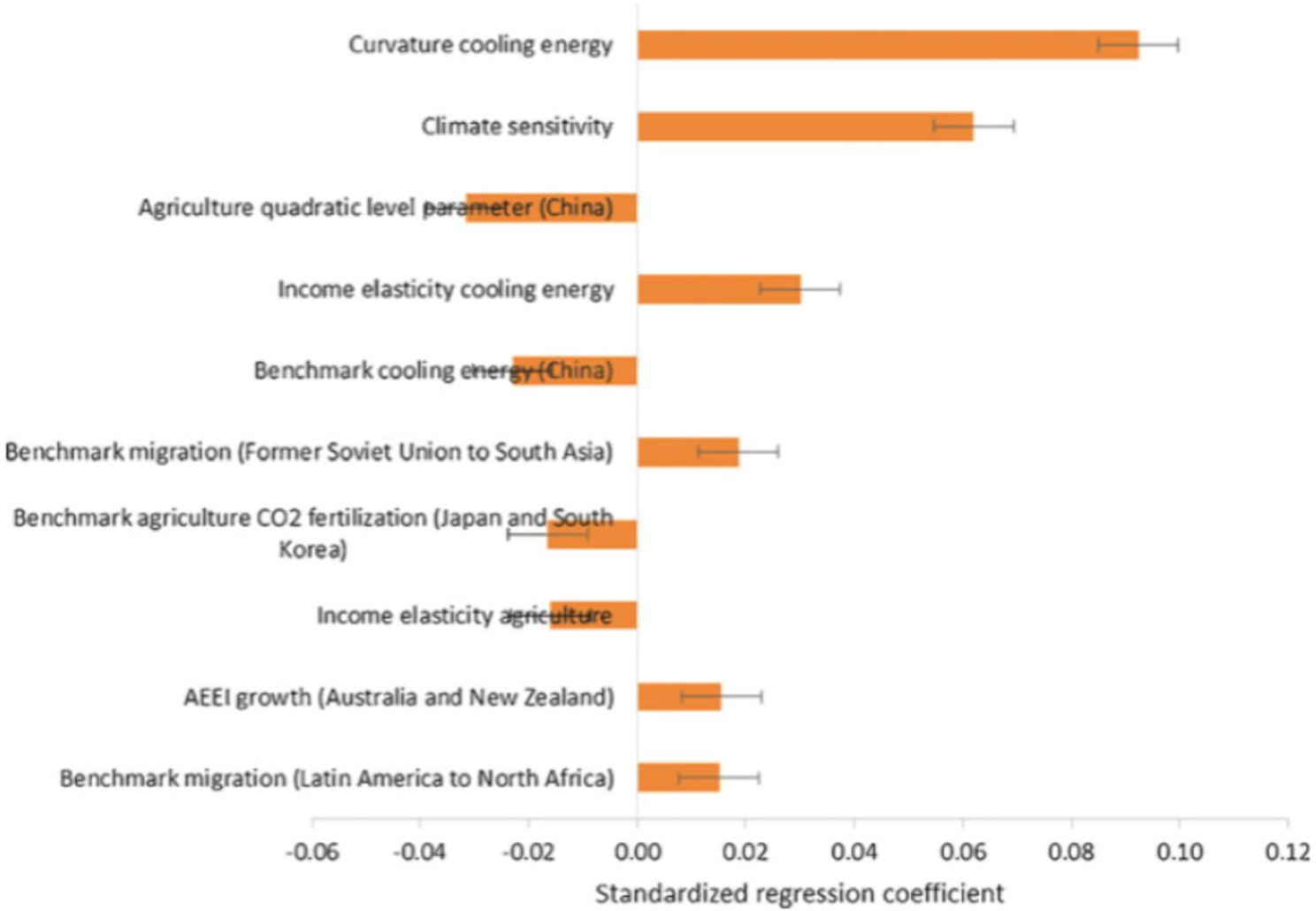


Fig. 2 The ten most important parameters that determine the social cost of carbon and their standardised regression coefficient for a 1 % pure rate of time preference and a 1.5 rate of risk aversion. 90 % confidence