**Online Appendix**

### Simple Model for Welfare impacts of CTBAs vs Carbon taxes

$ontext

This model has one commodity plus a numeraire, to assess the welfare implications of using either a production or a consumption tax in one country on global welfare. A key question is whether the welfare impacts are best described by the elasticity of demand/supply, or the combined elasticities of supply and demand.

$offtext

SETS

\*Home and foreign ctries. Emission and clean. Numeraire and non

Ctry /H,F/

Commod /E,C/

;

PARAMETERS

PN Price of numeraire /1 /

Beta1 Base supply share of commodity /0.5 /

Alpha Base demand share of non-numeraire commodity /0.5 /

sigmat Elasticity of transformation in production/ 0.9 / sigma Elasticity of substitution in demand /0.9 /

Q Country resource endowments /100/

TC(Ctry) Consumption tax rate /H 0, F 0/

TP(Ctry) Production tax rate /H 0, F 0/

U0(Ctry) Base utility level /H 100,F 100/

;

VARIABLES

PI World price of good 1

SD(Ctry) Supply of the good from each ctry

SDT Global Supply and emissions

DD(Ctry) Demand for good by each ctry

U(Ctry) Utility level

EXP(Ctry) Expenditure function

CPI(Ctry) Consumer price index

Rev(Ctry) revenue from production in each country

GREV(Ctry) Govt revenue by country

GLOBEV EV globally

;

\*Initializing Variables

PI.L = 1;

U.L(Ctry)=100; CPI.L(Ctry)=1;

EQUATIONS

 SUPPLY(Ctry)

 SDTOT

 DEMAND(Ctry)

 SD\_Balance

 EXPDEF(Ctry)

 CPIDEF(ctry)

 REVDEF(Ctry)

 GREVDEF(ctry)

 UDef(ctry)

 GLOBEVDef

;

SUPPLY(Ctry).. SD(Ctry) =e= beta1\*(PI\*(1+TP(ctry))/PN)\*\*(sigmat)\*Q ;

SDTOT.. SDT =e= Sum(Ctry,SD(Ctry)) ;

DEMAND(Ctry).. DD(Ctry) =e= alpha\*(PI\*(1+TC(ctry))/PN)\*\*(-Sigma)\*U(ctry) ;

SD\_Balance.. Sum(ctry,SD(ctry)) =e= Sum(ctry,DD(ctry)) ;

EXPDEF(Ctry)..

EXP(ctry) =e= (alpha\*(PI\*(1+TC(ctry)))\*\*(1-sigma) + (1-alpha)\*PN\*\*(1-sigma))\*\*(1/(1-sigma))\*U(ctry);

CPIDEF(ctry)..

CPI(Ctry) =e= (alpha\*(PI\*(1+TC(ctry)))\*\*(1-sigma) + (1-alpha)\*PN\*\*(1-sigma))\*\*(1/(1-sigma)) ;

REVDEF(Ctry)..

 Rev(ctry) =e= (Beta1\*(PI\*(1+TP(ctry)))\*\*(1+sigmat) + (1-Beta1)\*PN\*\*(1+sigmat))\*\*(1/ (1+sigmat))\*Q;

GREVDEF(ctry)..

GREV(Ctry) =e= TC(ctry)\*PI\*DD(Ctry) - TP(ctry)\*PI\*SD(Ctry);

UDef(ctry).. U(ctry) =e= (REV(ctry) + GREV(ctry))/CPI(ctry) ;

GLOBEVDef.. GLOBEV =e= Sum(ctry,u(ctry)) ;

\*Model

Model Effic\_Cost efficiency costs of consumer and Producer tax/ all /;

Options ITERLIM = 1000, LIMROW = 50, LIMCOL = 50, SOLPRINT=ON, MCP=PATH,

NLP=CONOPT4, CNS= Conopt4

;

 SOLVE Effic\_Cost Using CNS;

\*Now solving with a tax on demand

 TC(“H”) = 0.2;

 SOLVE Effic\_Cost Using CNS;

\*Now with a Prodn tax-- last results are pdn tax

 TC(“H”) = 0.0;

 TP(“H”) = -0.2;

 SOLVE Effic\_Cost Using CNS;