COIN-INT model extensions within the ACCREU project

Technical Documentation

Alexandra Lehner[1], Eva Preinfalk[1], Nina Knittel[1], and Gabriel Bachner[1]

[1]Wegener Center for Climate and Global Change, University of Graz, Austria

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Summary

This technical documentation describes the extensions to the COIN-INT computable general equilibrium (CGE) model within the ACCREU project. COIN-INT is a multi-regional and multi-sectoral model of the global economy, which is tailored to the analysis of macroeconomic effects of climate policy with a European focus. Within ACCREU, the model is expanded by a set of impact and adaptation modules covering a range of different climate impacts under three Representative Concentration Pathways (RCPs) and three different adaptation levels until 2080. This documentation presents the conceptual framework of the novel model developments, like new deficit financing mechanisms, persistence of climate damages, and impact-specific adjustments of consumption and welfare measurement. Moreover, this document shows how impacts and adaptation are implemented, including the presentation of corresponding model code.

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1 Introduction

This document describes the extensions to the COIN-INT model that were realised in the ACCREU project. For the technical description of the basic COIN-INT model, refer to the COIN-INT model core documentation (Bachner, 2026). The model is implemented in GAMS, using the MPSGE framework.

2 Impacts and Adaptation in the COIN-INT model: Conceptual description

The extensions to the COIN-INT model introduce sectoral climate impacts and adaptation data from work package 2 (WP2) to the macro-economic model to study economy-wide spill-over effects and fiscal consequences. In the ACCREU project, a broad set of climate impacts are studied, which are implemented in COIN-INT for 3 different RCPs: RCP 2.6 RCP 4.5 and RCP 7.0, until 2080, and three different levels of adaptation are considered for each impact. Table 1 summarizes the data source, the general configuration of used data (e.g., which General Circulation Model, GCM, has been applied, and further uncertainty constellations), as well as the explanation of the adaptation levels, for each impact.

Generally, impacts affect sectoral output, factor productivity, stocks of production factors or the demand for certain goods and services. Higher levels of adaptation usually lead to lower climate impacts, but are connected to higher adaptation costs for private or public households.In the following, we describe the required changes to the COIN-INT model code deviating from the standard model formulation to implement the ACCREU-specific impacts and adaptation data.

Table 1: Impact categories, data sources, general configuration, and adaptation levels.

Impact category	**WP2 data source (model)**	**General configuration**	**Explanation of adaptation levels**		
			low	**medium / reference**	**high**
Sea level rise	DIVA	GCM uncertainty: 50th quantile, including migration	Constant dike heights	Constant flood protection standards	Quadrupling flood protection standards
Flooding	GLOFRIS	GCM IPSL–CM5A-LR, no zoning	Constant dike heights	Constant flood protection standards	Optimal flood protection standards
Agricultural impacts	GLOBIOM	GCM IPSL, including RCP mitigation effects	Limited expansion of irrigation to already equipped areas	Sustainable irrigation expansion in equipped areas	Optimal expansion of irrigated areas and conversion of rainfed areas
Wildfire	ForeFire by DTU	only modelled for Spain in 2050, for high/low burning years	No adaptation considered (not available from sectoral modelling).		
Biodiversity	Biodiversity loss	CLIM_RCP configuration, no SSP	No adaptation considered (not available from sectoral modelling).		
Labour productivity and energy-related adaptation	*Impact:* Labour productivity (CMCC) *Adaptation:* Sectoral energy demand estimates for agricultural, industrial and commercial sectors (CMCC)	GCM uncertainty: 50th quantile, including heating and cooling	No additional technological adoption, frozen technology at historical climate. Variation in the intensive use of existing stock due to climate change (costs included).	Variation in energy-intensive capital stock due to future climate (costs included). Intensive use of existing stock under future climate (costs included).	Variation in energy-intensive capital stock due to future climate (costs included), plus changes due to variation in per-capita income affecting energy-intensive capital stock under future climate (costs included).
Labour supply	Labour supply (CMCC)	GCM uncertainty: 50th quantile	No adaptation considered (not available from sectoral modelling).		
Health (mortality and morbidity) and energy-related adaptation	*Impact:* Health (BC3) *Adaptation:* Residential energy demand and AC investment costs (CMCC)	GCM uncertainty: 50th quantile; mortality measured as value of a statistical life (VSL) added ex-post to welfare	No additional technological adoption, frozen technology at historical climate. Variation in the intensive use of existing stock due to climate change (costs included).	Variation in energy-intensive capital stock due to future climate (costs included). Intensive use of existing stock under future climate (costs included).	Variation in energy-intensive capital stock due to future climate (costs included), plus changes due to variation in per-capita income affecting energy-intensive capital stock under future climate (costs included).

2.1 Impact-specific implications for consumption and welfare

Impacts interfere with welfare through direct and indirect channels. In the following, two important assumptions are discussed within the model extensions. One refers to reconstruction and health expenditures that do not enter the welfare equation, and the second refers to mortality that enters the welfare calculation ex-post.

Some impacts, for example those that create damages to human health (see section 4.6), and some forms of adaptation increase the demand for goods and services with the aim to restore the status quo. Therefore, consumption of this kind is not interpreted as welfare-enhancing and does not enter the welfare calculation, but still enters GDP calculation.

The health/energy data includes monetary mortality cost estimations, quantified by the statistical value of life. This monetary value does not enter any objective function within the model, but is deducted from welfare ex-post.

2.2 Persistence of Impacts in the Capital Accumulation Equation

One novelty that accrued in the ACCREU project is the discussion of persistence of damages over time. In particular, impacts that deteriorate the capital stock reduce future production possibilities due to lower availability of production factors. This is represented by a modified capital accumulation function.

$$KS_{t+1} = KS_t(1-\delta) - dmg_t + I_t \tag{1}$$

where

KS_t is the capital stock in period t,

dmg_t are damages to the capital stock in period t

δ is the capital depreciation rate,

I_t are conventional investments in period t,

In GAMS, the according code snippet looks like the following, and happens before a particular recursive dynamic model run:

Code Snippet 1: Capital accumulation equation

```
*** capital accumulation of physical capital stock
loop(ttk,
    KS(r) = KS(r)*(1-delta(r)) - capital_acc_shock(r) + Invest.L(r);
    );
```

2.3 Adaptation as a Form of Capital

Adaptation investments are understood as a form of investment in capital that does not enter any production function directly. Adaptation investments are entering the GDP calculation via the I (investments) parameter, but do not enter the capital accumulation function, meaning that they do not generate rents like conventional capital and also cannot be converted to productive capital that could be used as a production factor.

$$I_t^{GDP} = I_t^{conv} + I_t^{ada} \tag{2}$$

$$I_t^{acc} = I_t^{conv} \tag{3}$$

where

I_t^{GDP} are investments entering the GDP calculation,

I_t^{acc} are investments entering the capital accumulation function (1),

I_t^{conv} are conventional investments done by private households,

I_t^{ada} are adaptation investments done by private and the public household.

3 Financing of Public Adaptation

Financing planned public adaptation requires assumptions about the sources of funding. Under a budget-neutral assumption, adaptation expenditures must be offset by equivalent reductions in other public expenditures. In ACCREU, we additionally consider domestic and international green bonds as alternative financing instruments for adaptation expenditures. These alternatives are now described in the following sections.

3.1 Budget-Neutral Financing

The standard assumption in the modeling framework is budget-neutral financing of public adaptation investment and other adaptation expenditures. This means that ceteris paribus, total expenditures are held constant compared to the baseline, but their composition is shifted.

The public income balance looks like the following:

$$GOV_{budget_neutral} : T_t = p_t^{W_{GOV}} W_{GOV,t} + s_t + \overline{I_{ada,t}} p_t^I \tag{4}$$

where

T_t is total tax revenue

$p_t^{W_{GOV}} W_{GOV_t}$ are public consumption expenditures

s_t are public transfers to private households

$\overline{I_{ada,t}}$ are adaptation investment expenditures

If adaptation investments are introduced in a certain height, then expenditures for public consumption are reduced to keep the balance. Tax rates remain unaffected. The structure

of public expenditures is fixed and scales with income. This means that adaptation investments scale the expenditure for consumption goods and services down.

Some adaptation requires expenditures for a certain consumption good or service (for example increased public construction demand for the maintenance of flood dykes). Total expenditures again remain unaffected, but the demand for construction goods is increased by the quantity required, proportionately downscaling other consumption expenditure. This means that total public consumption expenditure remains the same (ceteris paribus), but its composition changes. In the MPSGE model code, the modified income balance is realised through the public demand block. The parameters introduced here will be described in detail in section 4.

Code Snippet 2: The public household represented by the public demand block in the MPSGE model code

```
$DEMAND:GOVHH(eur)
         D:PWGOV(eur)            Q:(Cons_gov(eur)/div)
         E:PTAXINC(eur)          Q:(tax_income_abs(eur)/div)    R:txlvl(eur)
         E:PTRANSF(eur)          Q:(-transfers_abs(eur)/div)    R:adjtr(eur)

***investment costs for adaptation
***maintenance costs must be added to gov cons ex post...its not reflected in welfare
         E:PG("CGDS",eur)        Q:(-ada_investment_pub(eur)/div)
         E:PG("CON",eur)         Q:(-ada_maintenance_pub(eur)/div)

***morbidity shock as demand for health services
         E:PG("HHT",eur)         Q:(-morb_shock(eur)/div)
```

3.2 Deficit Financing

In the following, we describe the technical implementation of the deficit financing options, that expand the COIN-INT model by public bond products. The domestic government issues one of two types of bonds, with funds being provided by private households.These households buy bonds from the government, which then invests the funds into adaptation. In return, the government pays interest to private households. We assume that outstand-

ing debt is rolled over at maturity, with new bonds issued immediately to replace maturing bonds.

The two types of green bonds target different households. In the domestic green bond case, bonds are issued exclusively to the private household in the UK. In the international green bond case, bonds are issued to private households in the European Union. Bonds are distributed to different regions according to the strength of their investment activity in the baseline. If one country exhibits investments in the height of I_r, private household $PrivHH_r$ will receive bonds in the amount of

$$B_{r,t,received} = B_{t,issued} * \frac{I_{r,bl}}{\sum_{r}^{deu} I_{r,bl}} \tag{5}$$

where

$B_{t,issued}$ is the height of bonds issued,

$I_{r,bl}$ is the investment activity of region r in the baseline.

Households take the funds for buying government bonds from their savings. In the COIN-INT model, savings determinate investments. Therefore, households decrease their investments to fund these bonds. Bond purchasing is not interfering with private consumption. In return, households receive interest payments, which increase their income and flow both into increased consumption and investments. The governmental household receives funds for their issued bonds, which are fully invested in adaptation. However, they have to pay interest to the private household, which is taken out of the regular budget, reducing governmental expenditures on consumption (if assuming constant transfers). This results in a new income balance for the public household. On the revenue side, the government receives bond revenue in the height $\overline{B}_t$, and on the expenditure side, it pays interest in the height $\sum_{\iota=0}^{t} \overline{B_\iota}(\bar{\imath})^{t-\iota}$.

$$GOV_{bond} : T_t + \overline{B_t} = p_t^{W_{GOV}} W_{GOV,t} + \overline{s_t} + \sum_{\iota=0}^{t} \overline{B_\iota}(\bar{i})^{t-\iota} + \overline{I_{ada,t}} p_t^I \tag{6}$$

where

T_t is total tax revenue

$\overline{B_t}$ is the quantity of bonds issued

$p_t^{W_{GOV}} W_{GOV_t}$ are public consumption expenditures

$\bar{i}$ is the interest rate

$\overline{I_{ada,t}}$ are adaptation investment expenditures

In order to implement bonds, 2 new commodities are introduced to the MPSGE model; *BOND*, *BONDIPMT*. These represent the financial flows of bonds and interest payments.

Code Snippet 3: Bond commodities

```
1  *** in commodities block
2  $commodities:
3  *** [...]
4      PBOND(deu)      !Dummy price leel for bond good
5      PBONDIPMT(deu)  !Dummy price level for bond interest payments
```

These flows of the bond and interest "commodities" and respective monetary flows are then implemented as endowments in the private household and public household demand blocks. For the private household, this means a negative endowment of funds for government bonds in the height of *ADAbonds* and a positive endowment of interest payments by the state in the height of *ADAbondipmt* and vice versa for the public household (lines 18 and 19). The height of the bonds is the invested in adaptation as negative CGDS endowment, so in this case *ADAbonds=ADAincrcost*.

Code Snippet 4: Bonds in the private demand block

```
1  $DEMAND:REGHH(deu)  s:0
2      D: PWPHH(deu)   Q:((sum(es,(Intermediate(es,"PrivHH",deu)*(pg0(es,"PrivHH",deu))))
           *adjWPRIVmlt(deu))/div)
3      D: PG("CGDS",deu)   Q:(((SAVE1(deu)+DEPR(deu))*adjSAVEmlt(deu))/div)
```

```
*** [...]
    E: PBOND(deu)Q:((-ADAbonds(deu))/div)
    E: PBONDIPMT(deu)Q:((ADAbondipmt(deu))/div)
*** [...]
```

Code Snippet 5: Bonds in the public demand block

```
$DEMAND:GOVHH(deu)  s:0
*** [...]
    E: PG("CGDS", deu)      Q:((-ADAincrcost(deu))/div)
    E: PBOND(deu)  Q:((ADAbonds(deu))/div)
    E: PBONDIPMT(deu)Q:((-ADAbondipmt(deu))/div)
*** [...]
```

Now, if these flows are implemented as as endowments, it implicitly changes the residual available income of the private and public household. This means that for the private household, the funds for bonds would be taken out from general expenditures, decreasing both consumption and investments accordingly. In order to only decrease investments and keep consumption constant, the savings rate has to be adjusted.

$$adjSAVE_{r,t} = svrt_{r,t} * \frac{C_{r,b} + I_{r,b}}{I_{r,b}} \tag{7}$$

$$adjCONS_{r,t} = \frac{C_{r,b} + I_{r,b} - I_{r,b} * adjSAVE_{r,t}}{C_{r,b}} \tag{8}$$

where

$svrt_{r,old} = \frac{I_{r,t}}{C_{r,t}+I_{r,t}}$ is the target savings rate,

$C_{r,b}$ is benchmark private consumption,

$I_{r,b}$ is benchmark investment.

Now, we want to adjust *svrt* such that the savings in our impact/adaptation scenarios are decreased by the amount of the bonds B and absolute consumption is left constant in comparison to the baseline. Buying bonds decreases the household's endowment, which is

split between investment and consumption according to the relation between investment and consumption, which can be expressed by the savings rate. The savings rate thus must be lower, such that savings are cut by the amount of the share of consumption in the endowment decrease:

$$svrt_{r,new} = \frac{I_{r,bl} - b_{r,t} * C_{r,bl}}{C_{r,bl} + I_{r,bl}} \tag{9}$$

where

$b_{r,t} = \frac{B_{r,t,received}}{C_{r,bl}+I_{r,bl}}$ is the share of bond finances in the household budget,

$C_{r,b}$ is baseline private consumption,

$I_{r,b}$ is baseline investment,

$B_{r,t,received}$ is the height of the bonds purchased by the household.

This equation can then be simplified to

$$svrt_{new} = \frac{(I_{r,bl} - B_{r,bl,received}) * C_{r,bl} + (I_{r,bl})^2}{(C_{r,bl} + I_{r,bl})^2} \tag{10}$$

This new savings rate can then be plugged into (7) and subsequently decreases investments by the amount of the bonds, and increases consumption in (8) back to the baseline height.

Code Snippet 6: adjusted savings rate calculation

```
1  svrt("%COUNTRY%") = ((INV_BL.L("%COUNTRY%") -ADAbonds("%COUNTRY%")/div) *
       CONSBL.L("%COUNTRY%") + sqr(INV_BL.L("%COUNTRY%"))) / sqr(CONSBL.L("%COUNTRY%") +
       INV_BL.L("%COUNTRY%"));
2
3  *** [...]
4  *** unchanged from the original model:
5  adjSAVE(deu) = ((svrt(deu)*(GDPBENCH(deu)-CURRAC0(deu)-WGOV0(deu)))/INV0(deu);
6  adjWPRIV(deu) = (WPRIV0(deu) + INV0(deu) - INV0(deu)*adjSAVE(deu))/(WPRIV0(deu));
```

4 Impact and Adaptation Modules

Impacts and Adaptation inputs are initialised and scaled to the model baseline in respective input files. Since the model is recursive-dynamic, impact and adaptation parameters are updated each period, pulling data from the impact/adaptation inputs. These parameters then enter the MPSGE model code in a specific time step. The impact modules and parameters are explained in detail in the following subsections.

Code Snippet 7: Example code for the general implementation of an impact

```
*** [Impact file]
*** r = set of regions
*** tt = set of time steps
output_impact_data(r,tt) = data_from_excel(r,tt);


*** [MPSGE model code initialisation]

$ontext
$model:COININT2

*** [...]

$PROD:Y("example_sector",r)
         O:PD("example_sector",r) Q:((Output("example_sector",r)-output_shock(r)/div)
             A:PRODTAX(r)     T:Output_tax("example_sector",r)

***      [...]

$offtext
$sysinclude mpsgeset COININT2


*** [recursive dynamic loop]
loop(tt$(ord(tt)<ttvar),

***[...]

    if((PLCY = 1 AND BASELI = 0 AND IMPACT = 1),
*** impact module:
        output_shock(r) = output_impact_data(r,tt)
```

```
31
32 *** [...]
33 );
```

Some parameters (*output_shock, lsup_shock, ada_investment_priv, ada_investment_pub, ada_maintenance_pub, capital_acc_shock*) can be affected by various impacts/adaptation measures, which model implementation will therefore be explained in the following, while impact-specific parameters will be introduced in their respective subsections.

Code Snippet 8: Structure of the Impact/Adaptation module

```
1  *** after model specification, in recursive dynamic loop:
2  if((PLCY = 1 AND BASELI = 0 AND IMPACT = 1),
3
4  ***reset all additive impacts to 0 / 1
5      output_shock(es,r)=1;
6      lsup_shock(r)=1;
7      ada_investment_priv(r)=0;
8      ada_investment_pub(r)=0;
9      ada_maintenance_pub(r)=0;
10     capital_acc_shock(r)=0;
11
12
13 ***    ----------------------------------------
14 ***   BIODIVERSITY (FROM CMCC)
15 ***    ----------------------------------------
16 ***[-> Code Snippet 17]
17
18 ***    ----------------------------------------
19 ***    GLOBIOM
20 ***    ----------------------------------------
21 ***[-> Code Snippet 18]
22
23 ***    ----------------------------------------
24 ***    FORE FIRE
25 ***    ----------------------------------------
26 ***[-> Code Snippet 20]
27
28 ***    ----------------------------------------
29 ***    lABOUR_ENERGY
30 ***    ----------------------------------------
31 ***[-> Code Snippet 21]
32
```

```
***    ----------------------------------------
***    HEALTH_ENERGY
***    ----------------------------------------
***[-> Code Snippet 34]

***    ----------------------------------------
***    DIVA
***    ----------------------------------------
***[-> Code Snippet 38]

***    ----------------------------------------
***    GLOFRIS
***    ----------------------------------------
***[-> Code Snippet 41]

);
***end of impacts

*** ------------------------
*** ------------------------
*** S O L V E
*** ------------------------
*** ------------------------
$include COININT2.gen
COININT2.iterlim=99999;
COININT2.workspace = 500;
SOLVE COININT2 using mcp;
```

4.1 General Impact/Adaptation parameters

In the following, the entry points in the model code of parameters related to several impacts are presented. Note that these parameters are interpreted as being additive, meaning that a specific stock/flow of a good/service/resource can be shocked by several impacts, and we use the baseline stock/flow as a starting point each time. This means that if for example the input data suggests that a specific capital stock is reduced by 2% by one impact type and 1% by another, the total shock is $KS * (1 - (0.02 + 0.01))$ (and not the multiplicative aggregate $KS * (1 - 0.02) * (1 - 0.01)$).

output_ shock(es,r) relates to impacts that reduce outputs of a sectoral production block.

Code Snippet 9: Entry point for the parameter output_shock in land using sectors

```
*** LAND USING SECTORS: lau /AGC, AGL/
*** -------------------------------------
$PROD:Y(lau,r)   *** [...]
    O:PD(lau,r)   Q:(((Output(lau,r))*output_shock(lau,r))/div)   A:PRODTAX(r)
        T:Output_tax(lau,r)
*** [...]
```

Code Snippet 10: Entry point for the parameter output_shock in fossil fuel using sectors

```
*** NON-FOSSIL RESOURCE USING SECTORS: reu /FFO/
*** -------------------------------------
$PROD:Y(reu,r)   *** [...]
    O:PD(reu,r)   Q:((Output(reu,r)*output_shock(reu,r))/div)   A:PRODTAX(r)
        T:Output_tax(reu,r)
*** [...]
```

lsup_ shock(r) relates to impacts to the labour supply. It therefore enters the model code via private households' endowment in the respective MPSGE private household demand block.

Code Snippet 11: Entry point for the parameter lsup_shock in the regional private household demand block in European regions

```

*** FINAL DEMAND AND ENDOWMENTS - European regions
*** -------------------------------------
$DEMAND:REGHH(eur)  s:0
*** [...]
*** primary factor and resource endowments
    E:PPF("LAB",eur)   Q:(((sum(ess,Intermediate("LAB",ess,eur))) / div) * labgr(eur) *
        lsup_shock(eur))  R:TFPG(eur)
    E:PPF("SKL",eur)   Q:(((sum(ess,Intermediate("SKL",ess,eur))) / div) * labgr(eur) *
        lsup_shock(eur))  R:TFPG(eur)
```

Code Snippet 12: Entry point for the parameter lsup_shock in the regional private household demand block in the rest of the world

```
*** FINAL DEMAND AND ENDOWMENTS - Rest of World regions
*** -------------------------------------
$DEMAND:REGHH(row)  s:0
***[...]
```

```
5     E:PPF("LAB",row)
          Q:(((sum(ess,Intermediate("LAB",ess,row)))/div)*labgr(row)*lsup_shock(row))
          R:TFPG(row)
6     E:PPF("SKL",row)          Q:
          (((sum(ess,Intermediate("SKL",ess,row)))/div)*labgr(row)*lsup_shock(row))
          R:TFPG(row)
```

ada_investment_priv is adaptation investment undertaken by private households. They enter the MPSGE private household demand block via forced consumption of investment good *CGDS*, realised via negative endowment.

Code Snippet 13: Entry point for the parameter ada_investment_priv in the regional private household demand block in European regions

```
1  $DEMAND:REGHH(eur)  s:0
2  *** [...]
3  ***ada investment costs
4  *energy - adaptatation investment (fe for AC)
5            E:PG("CGDS",eur)          Q:( -ada_investment_priv(eur)/div)
```

Code Snippet 14: Entry point for the parameter ada_investment_priv in the regional private household demand block in the rest of the world

```
1  $DEMAND:REGHH(row)  s:0
2  *** [...]
3  ***ada investment costs
4           E:PG("CGDS",row)
                Q:(-(ada_investment_priv(row)+ada_investment_pub(row))/div)
```

ada_investment_pub is adaptation investment undertaken by public households. They enter the MPSGE public household demand block via forced consumption of investment good *CGDS*.

ada_maintenance_pub are maintenance costs of existing adaptation infrastructure. They enter the MPSGE public household demand block via forced consumption of construction good *CON* in European regions. They enter the MPSGE general household demand block in the rest of the world, since there is no differentiation between households.

Code Snippet 15: Entry point for the parameter ada_investment_pub and ada_maintenance_pub in the regional public household demand block in European regions

```
1  $DEMAND:GOVHH(eur)
2  *** [...]
```

```
***investment costs for adaptation
***maintenance costs must be added to gov cons ex post...its not reflected in welfare
    E:PG("CGDS",eur)        Q:(-ada_investment_pub(eur)/div)
    E:PG("CON",eur)         Q:(-ada_maintenance_pub(eur)/div)
```

Code Snippet 16: Entry point for the parameter ada_investment_pub and ada_maintenance_pub in the regional public household demand block in the rest of the world

```
$DEMAND:REGHH(row)
*** [...]
***ada investment costs
         E:PG("CGDS",row)
             Q:(-(ada_investment_priv(row)+ada_investment_pub(row))/div)
  E:PG("CON",row)         Q:(-ada_maintenance_pub(row)/div)
```

capital_acc_shock relates to shocks to the capital stock, which is explained in detail in section 2.2.

In the following, the impact/adaptation-specific parameters and their entry points in the model code are presented.

4.2 Biodiversity Impact Module

Table 2: Implementation of biodiversity impacts on agricultural productivity

	Biodiversity impact variable	**Parameter**	**COIN-INT implementation**
Impact	Consequences of pollination loss on crop yields	Projected yield shocks (%). Up to 2070 relative to 2020.	Relative change in total factor productivity of crop sector.

Code Snippet 17: Biodiversity Impacts entry point in the Impact/Adaptation module

```
***    ----------------------------------------
***  BIODIVERSITY (FROM CMCC)
***    ----------------------------------------
   if((activate_biodiversity=1),
        output_shock("AGC",r)=output_shock("AGC",r)*(1+biodiv_run(r,tt)/100);
        );
```

For the model entry point for *output_shock*, see section 4.1.

4.3 Agricultural Impacts Module

Table 3: Implementation of impacts and adaptation based on GLOBIOM

	Parameter	GLOBIOM variable	COIN-INT implementation
Impact	Change productivity of agricultural production (crop)	Agricultural Production|Non-Energy|Crops	Change in TFP of crop sector
	Change productivity of agricultural production (livestock)	Agricultural Production|Non-Energy|Livestock	Change in TFP of livestock sector
Adaptation	Public sector funds investment for irrigation expansion	Investment Costs|Total Irrigation Cost (Efficiency improvement Cost + Expansion Cost + Upgrade Cost)	Government investment demand to crowd out public consumption. Irrigation capital is not considered in capital accumulation.
	Production cost structure of crop sector	Water withdrawal|Irrigation	Change in intermediate demand for utility (includes water) by the crop sector.

Code Snippet 18: Agricultural Impacts entry point in the Impact/Adaptation module

```
***   ----------------------------------------
***   GLOBIOM
***   ----------------------------------------
   if((activate_globiom=1),
        output_shock("AGC",r) = output_shock("AGC",r) * ((crop_impact_scen(r,tt) /
            crop_impact_ref(r,tt)) * share("AGC",r) + (1-share("AGC",r)));
        output_shock("AGL",r) = output_shock("AGL",r) * livestock_impact_scen(r,tt) /
            livestock_impact_ref(r,tt);

        ada_investment_pub(r) = ada_investment_pub(r) + irrigation_cost(r,tt);
        water_withdrawals("OSG","AGC", r) =
            water_withdrawal_scen(r,tt)/water_withdrawal_ref(r,tt);
        );
```

For the model entry point for *output_shock* and *ada_investment_pub*, see section 4.1.

water_withdrawals("OSG","AGC",r) increases the intermediate water demand by sector "AGC" from utility sector "OSG". It enters the MPSGE production block of the crop sector "AGC".

Code Snippet 19: Entry point for the parameter water_withdrawals in the agricultural production block

```
*** LAND USING SECTORS: lau /AGC, AGL/
*** -------------------------------------
$PROD:Y(lau,r)           *** [...]
*** [...]
    I:PG(int,r)   Q:(Intermediate(int,lau,r)*water_withdrawals(int,lau,r)/div)
                   P:(1 + Comtax(int,lau,r))   A:PRODTAX(r)   T:Comtax(int,lau,r)   int:
```

4.4 Forest Fire Module

Table 4: Implementation of burnt area from forest fire and impacts on agriculture & forestry

	ForeFire variable	Parameter	COIN-INT implementation
Impact	i) Burnt area on ALL agricultural land and commercially used forests	% land burnt in high/low fire hazard year	Loss of total factor productivity from destroyed harvest in the year of the burn
	ii) Burnt area - multiannual crops: olive groves, fruit trees & berry plantations	% land burnt in high/low fire hazard year	Multi-annual effect on the return on capital tied to this land

Code Snippet 20: Forest Fire Impacts entry point in the Impact/Adaptation module

```
1  ***    ----------------------------------------
2  ***    FORE FIRE
3  ***    ----------------------------------------
4     if((activate_forefire=1),
5          output_shock("AGC","ESP") =
               output_shock("AGC","ESP")*(1-TFP_shock_agri("ESP",tt));
6          output_shock(reu,"ESP") = output_shock(reu,
               "ESP")*(1-TFP_shock_fore("ESP",tt)*0.11);
7      );
```

For the model entry point for *output_shock*, see section 4.1.

4.5 Labour/Energy Module

Table 5: Implementation of labour supply and productivity impacts and energy-related adaptation

	Labour/energy variable	Parameter	COIN-INT implementation
Impact: lal	Labour productivity	Labour input in sectoral production	Adjustment of labour input differentiated for agricultural, industrial and commercial sectors mimicking high and low exposure sectors.
	Labour supply	Labour endowment	Adjustment of regional labour endowment, reducing labour income and thereby consumption possibilities.
Adaptation	Sectoral energy demand estimated for agricultural, industrial and commercial sectors (for heating and cooling)	Sectoral production	Increased energy demand in sectoral production split for fossil fuels and electricity and differentiated for agricultural, industrial and commercial sectors.

Code Snippet 21: Labour/Energy entry point in the Impact/Adaptation module

```
***   ----------------------------------------
***   lABOUR_ENERGY
***   ----------------------------------------


    if((activate_L_energy=1),
***       labour productivity and supply shock with sectoral energy demand shock for heating and cooling, no investment for AC
***       high-exposure: agricultural, hunting, forestry and fishing; construction; mining and quarrying ----> production blocks for lau, reu, fos
***       low-exposure: manufacturing and utilities -----> production blocks for ELY, P_C, eso
***       energy demand shocks: _AGR for lau and reu, _IND for ELY, fos, P_C, and _COM for eso
        lprod_shck_HE(r) = labprod_shck_HE_data(r,tt);
        lprod_shck_LE(r) = labprod_shck_LE_data(r,tt);

        lsup_shock(r)  = lsup_shock(r)+(labsup_shck_data(r,tt)-1);

***       adapation
***       electricity (ely) or fossil fuel (fof)
        enerD_AGR_shck_fof(r) = enerD_shck_data_AGR(r,"fof",tt);
        enerD_IND_shck_fof(r) = enerD_shck_data_IND(r,"fof",tt);
        enerD_COM_shck_fof(r) = enerD_shck_data_COM(r,"fof",tt);

        enerD_AGR_shck_ely(r) = enerD_shck_data_AGR(r,"ely",tt);
        enerD_IND_shck_ely(r) = enerD_shck_data_IND(r,"ely",tt);
        enerD_COM_shck_ely(r) = enerD_shck_data_COM(r,"ely",tt);
    );
```

lprod_ shck_ HE(r) are labour productivity shocks to the labour force in high-exposure sctors. They enter the MPSGE production blocks of defined high-exposure sectors via factor demand for both high-skilled and low-skilled labour.

Code Snippet 22: Entry point for the parameter lprod_shck_HE in the production block of land using sectors

```
*** LAND USING SECTORS: lau /AGC, AGL/
*** -------------------------------------
$PROD:Y(lau,r)       ***[...]
*** [...]
    I:PPF("LAB",r)                          Q:((Intermediate("LAB",lau,r)/div) *
        lprod_shck_HE(r))                 P:(1 + Fact_tax("LAB",lau,r))   A:FACTTAX(r)
            T:Fact_tax("LAB",lau,r)  esu:
```

```
6       I:PPF("SKL",r)                          Q:((Intermediate("SKL",lau,r)/div) *
            lprod_shck_HE(r))                 P:(1 + Fact_tax("SKL",lau,r))   A:FACTTAX(r)
                T:Fact_tax("SKL",lau,r)  esu:
```

Code Snippet 23: Entry point for the parameter lprod_shck_HE in the production block of non-fossil resource using sectors

```
1  *** NON-FOSSIL RESOURCE USING SECTORS: reu /FFO/
2  ***  sector uses its own specific resource PR with elasticity of zero at top level of
       nesting
3  ***  process emissions at top level
4  *** -------------------------------------
5  $PROD:Y(reu,r)        ***[...]
6  ***[...]
7       I:PPF("LAB",r)                          Q:((Intermediate("LAB",reu,r)/div) *
            lprod_shck_HE(r))                 P:(1 + Fact_tax("LAB",reu,r))   A:FACTTAX(r)
                T:Fact_tax("LAB",reu,r)  esu:
8       I:PPF("SKL",r)                          Q:((Intermediate("SKL",reu,r)/div) *
            lprod_shck_HE(r))                 P:(1 + Fact_tax("SKL",reu,r))   A:FACTTAX(r)
                T:Fact_tax("SKL",reu,r)  esu:
```

Code Snippet 24: Entry point for the parameter lprod_shck_HE in the production block of fossil resource using sectors

```
1  *** FOSSIL RESOURCE USING SECTORS: fos /COA, OIL, GAS/
2  ***  each sector uses its own specific resource PR with elasticity of zero at top level
       of nesting
3  ***  assuming no AEEI since these sectors are energy sectors themselves
4  ***  process emissions at top level
5  *** -------------------------------------
6  $PROD:Y(fos,r)          s:0      v(s):0
7  ***[...]
8       I:PPF("LAB",r)                          Q:((Intermediate("LAB",fos,r)/div) *
            lprod_shck_HE(r))       P:(1 + Fact_tax("LAB",fos,r))   A:FACTTAX(r)
            T:Fact_tax("LAB",fos,r)  v:
9       I:PPF("SKL",r)                          Q:((Intermediate("SKL",fos,r)/div) *
            lprod_shck_HE(r))       P:(1 + Fact_tax("SKL",fos,r))   A:FACTTAX(r)
            T:Fact_tax("SKL",fos,r)  v:
```

lprod_ shck_ LE(r) are labour productivity shocks to the labour force in low-exposure sctors. They enter the MPSGE production blocks of defined low-exposure sectors via factor demand for both high-skilled and low-skilled labour.

Code Snippet 25: Entry point for the parameter lprod_shck_LE in the production block of the electricity sector

```
1  *** ELECTRICITY SECTOR: /ELY/
2  ***  assuming no AEEI since this sectors is energy sector itself
```

```
***  process emissions at top level
*** -------------------------------------
$PROD:Y("ELY",r)        ***[...]
***[...]
    I:PPF("LAB",r)                          Q:((Intermediate("LAB","ELY",r)/div) *
        lprod_shck_LE(r))     P:(1 + Fact_tax("LAB","ELY",r)) A:FACTTAX(r)
        T:Fact_tax("LAB","ELY",r)        esu:
    I:PPF("SKL",r)                          Q:((Intermediate("SKL","ELY",r)/div) *
        lprod_shck_LE(r))     P:(1 + Fact_tax("SKL","ELY",r)) A:FACTTAX(r)
        T:Fact_tax("SKL","ELY",r)        esu:
```

Code Snippet 26: Entry point for the parameter lprod_shck_LE in the production block of the refined petrol and coal products sector

```
*** REFINED PETROL AND COAL PRODUCTS: /P_C/
***  assuming no AEEI since this sectors is energy sector itself
***  process emissions at top level
*** -------------------------------------
$PROD:Y("P_C",r)        ***[...]
***[...]
    I:PPF("LAB",r)                          Q:((Intermediate("LAB","P_C",r)/div) *
        lprod_shck_LE(r))     P:(1 + Fact_tax("LAB","P_C",r)) A:FACTTAX(r)
        T:Fact_tax("LAB","P_C",r)        esu:
    I:PPF("SKL",r)                          Q:((Intermediate("SKL","P_C",r)/div) *
        lprod_shck_LE(r))     P:(1 + Fact_tax("SKL","P_C",r)) A:FACTTAX(r)
        T:Fact_tax("SKL","P_C",r)        esu:
```

Code Snippet 27: Entry point for the parameter lprod_shck_LE in the production block of other economic sectors

```
*** OTHER ECONOMIC SECTORS: eso /FID, MAN, OSG, CON, SVC, TRN, EDU, HHT/
***  process emissions at top level
*** -------------------------------------
$PROD:Y(eso,r)           ***[...]
***[...]
    I:PPF("LAB",r)                          Q:((Intermediate("LAB",eso,r)/div) *
        lprod_shck_LE(r))                P:(1 + Fact_tax("LAB",eso,r))   A:FACTTAX(r)
            T:Fact_tax("LAB",eso,r)  esu:
    I:PPF("SKL",r)                          Q:((Intermediate("SKL",eso,r)/div) *
        lprod_shck_LE(r))                 P:(1 + Fact_tax("SKL",eso,r))   A:FACTTAX(r)
            T:Fact_tax("SKL",eso,r)  esu:
```

For the model entry point for *lsup_shock*, see section 4.1

enerD_AGR_shck_fof refers to increased intermediate fossil fuel demand, and ***enerD_AGR_shck_ely*** refers to increased intermediate electricity demand by agricul-

tural sectors. They enter the model via intermediate good demand in the agricultural production sectors.

Code Snippet 28: Entry point for the parameters enerD_AGR_shck_fof and enerD_AGR_shck_ely in the production block of agricultural sectors

```
*** LAND USING SECTORS: lau /AGC, AGL/
*** -------------------------------------
$PROD:Y(lau,r)          ***[...]
***[...]
    I:PG(ele,r)
        Q:((Intermediate(ele,lau,r)/div)*AEEI(ele,r)*enerD_AGR_shck_ely(r))  P:(1 +
        Comtax(ele,lau,r))       A:PRODTAX(r)     T:Comtax(ele,lau,r)      elc:
***[...]
    I:PG(fos,r)                              Q:((Intermediate(fos,lau,r)/div)*AEEI(fos,r)
        * enerD_AGR_shck_fof(r))  P:(1 + Comtax(fos,lau,r))       A:PRODTAX(r)
        T:Comtax(fos,lau,r)      fos.tl:
    I:PCO2EU#(fos)$(memeur(r))               Q:((CO2(fos,lau,r)/div)*AEEI(fos,r) *
        enerD_AGR_shck_fof(r))           P:0.000001
                                                                          fos.tl:
    I:PCO2ROW(r)#(fos)$(NOT memeur(r))       Q:((CO2(fos,lau,r)/div)*AEEI(fos,r) *
        enerD_AGR_shck_fof(r))           P:0.000001
                                                                          fos.tl:
```

Code Snippet 29: Entry point for the parameters enerD_AGR_shck_fof and enerD_AGR_shck_ely in the production block of non-fossil resource using sectors

```
*** NON-FOSSIL RESOURCE USING SECTORS: reu /FFO/
***  sector uses its own specific resource PR with elasticity of zero at top level of
    nesting
***  process emissions at top level
*** -------------------------------------
$PROD:Y(reu,r)          ***[...]
    I:PG(ele,r)                              Q:((Intermediate(ele,reu,r)/div)*AEEI(ele,r)
        * enerD_AGR_shck_ely(r))      P:(1 + Comtax(ele,reu,r))       A:PRODTAX(r)
        T:Comtax(ele,reu,r)      elc:
***[...]
    I:PG(fos,r)                              Q:((Intermediate(fos,reu,r)/div)*AEEI(fos,r)
        * enerD_AGR_shck_fof(r))      P:(1 + Comtax(fos,reu,r))       A:PRODTAX(r)
        T:Comtax(fos,reu,r)      fos.tl:
    I:PCO2EU#(fos)$(memeur(r))               Q:((CO2(fos,reu,r)/div)*AEEI(fos,r) *
        enerD_AGR_shck_fof(r))               P:0.000001
                                                                          fos.tl:
    I:PCO2ROW(r)#(fos)$(NOT memeur(r))       Q:((CO2(fos,reu,r)/div)*AEEI(fos,r) *
        enerD_AGR_shck_fof(r))               P:0.000001
                                                                          fos.tl:
```

enerD_IND_shck_fof refers to increased intermediate fossil fuel demand, and ***enerD_IND_shck_ely*** refers to increased intermediate electricity demand by industrial sectors. They enter the model via intermediate good demand in the industrial production sectors.

Code Snippet 30: Entry point for the parameters enerD_IND_shck_fof and enerD_IND_shck_ely in the production block of fossil resource using sectors

```
*** FOSSIL RESOURCE USING SECTORS: fos /COA, OIL, GAS/
***  each sector uses its own specific resource PR with elasticity of zero at top level
    of nesting
***  assuming no AEEI since these sectors are energy sectors themselves
***  process emissions at top level
*** -------------------------------------
$PROD:Y(fos,r)          s:0      v(s):0
***[...]
    I:PG(ele,r)                              Q:((Intermediate(ele,fos,r)/div) *
        enerD_IND_shck_ely(r))         P:(1 + Comtax(ele,fos,r))       A:PRODTAX(r)
        T:Comtax(ele,fos,r)      v:
***[...]
    I:PG(foss,r)                             Q:((Intermediate(foss,fos,r)/div) *
        enerD_IND_shck_fof(r))        P:(1 + Comtax(foss,fos,r))      A:PRODTAX(r)
        T:Comtax(foss,fos,r)     v:
    I:PCO2EU#(foss)$(memeur(r))   Q:((CO2(foss,fos,r)/div) * enerD_IND_shck_fof(r))
        P:0.000001   v:
    I:PCO2ROW(r)#(foss)$(NOT memeur(r))   Q:((CO2(foss,fos,r)/div) *
        enerD_IND_shck_fof(r))   P:0.000001   v:
```

Code Snippet 31: Entry point for the parameters enerD_IND_shck_fof and enerD_IND_shck_ely in the production block of electricity sector

```
*** ELECTRICITY SECTOR: /ELY/
***  assuming no AEEI since this sectors is energy sector itself
***  process emissions at top level
*** -------------------------------------
$PROD:Y("ELY",r)       ***[...]
***[...]
    I:PG(ele,r)                              Q:((Intermediate(ele,"ELY",r)/div) *
        enerD_IND_shck_ely(r))       P:(1 + Comtax(ele,"ELY",r))     A:PRODTAX(r)
        T:Comtax(ele,"ELY",r)            elc:
***[...]
    I:PG(fos,r)                              Q:((Intermediate(fos,"ELY",r)/div) *
        enerD_IND_shck_fof(r))       P:(1 + Comtax(fos,"ELY",r))     A:PRODTAX(r)
        T:Comtax(fos,"ELY",r)            fos.tl:
```

```
10      I:PCO2EU#(fos)$(memeur(r))              Q:((CO2(fos,"ELY",r)/div) *
            enerD_IND_shck_fof(r))                P:0.000001
                                                                              fos.tl:
11      I:PCO2ROW(r)#(fos)$(NOT memeur(r))      Q:((CO2(fos,"ELY",r)/div) *
            enerD_IND_shck_fof(r))                P:0.000001
                                                                              fos.tl:
```

Code Snippet 32: Entry point for the parameters enerD_IND_shck_fof and enerD_IND_shck_ely in the production block of refined petrol and coal products sector

```
1   *** REFINED PETROL AND COAL PRODUCTS: /P_C/
2   ***  assuming no AEEI since this sectors is energy sector itself
3   ***  process emissions at top level
4   *** ------------------------------------
5   $PROD:Y("P_C",r)        ***[...]
6   ***[...]
7       I:PG(ele,r)                           Q:((Intermediate(ele,"P_C",r)/div) *
            enerD_IND_shck_ely(r))       P:(1 + Comtax(ele,"P_C",r))     A:PRODTAX(r)
            T:Comtax(ele,"P_C",r)            elke:
8       I:PG("COA",r)                         Q:((Intermediate("COA","P_C",r)/div) *
            enerD_IND_shck_fof(r))     P:(1 + Comtax("COA","P_C",r))   A:PRODTAX(r)
            T:Comtax("COA","P_C",r)          COA:
9       I:PCO2EU$(memeur(r))                  Q:((CO2("COA","P_C",r)/div) *
            enerD_IND_shck_fof(r))              P:0.000001
                                                                              COA:
10      I:PCO2ROW(r)$(NOT memeur(r))          Q:((CO2("COA","P_C",r)/div) *
            enerD_IND_shck_fof(r))             P:0.000001
                                                                              COA:
11      I:PG("OIL",r)                         Q:((Intermediate("OIL","P_C",r)/div) *
            enerD_IND_shck_fof(r))    P:(1 + Comtax("OIL","P_C",r))   A:PRODTAX(r)
            T:Comtax("OIL","P_C",r)          OIL:
12      I:PCO2EU$(memeur(r))                  Q:((CO2("OIL","P_C",r)/div) *
            enerD_IND_shck_fof(r))              P:0.000001
                                                                              OIL:
13      I:PCO2ROW(r)$(NOT memeur(r))          Q:((CO2("OIL","P_C",r)/div) *
            enerD_IND_shck_fof(r))              P:0.000001
                                                                              OIL:
14  ***[...]
15      I:PG("GAS",r)                         Q:((Intermediate("GAS","P_C",r)/div) *
            enerD_IND_shck_fof(r))     P:(1 + Comtax("GAS","P_C",r))   A:PRODTAX(r)
            T:Comtax("GAS","P_C",r)          GAS:
16      I:PCO2EU$(memeur(r))                  Q:((CO2("GAS","P_C",r)/div) *
            enerD_IND_shck_fof(r))              P:0.000001
                                                                              GAS:
```

```
17      I:PCO2ROW(r)$(NOT memeur(r))            Q:((CO2("GAS","P_C",r)/div) *
            enerD_IND_shck_fof(r))              P:0.000001
                                                                            GAS:
```

enerD_COM_shck_fof refers to increased intermediate fossil fuel demand, and ***enerD_COM_shck_ely*** refers to increased intermediate electricity demand by commercial economic sectors. They enter the model via intermediate good demand in commercial production sectors.

Code Snippet 33: Entry point for the parameters enerD_IND_shck_fof and enerD_IND_shck_ely in the production block of other economic sectors

```
1   *** OTHER ECONOMIC SECTORS: eso /FID, MAN, OSG, CON, SVC, TRN, EDU, HHT/
2   ***  process emissions at top level
3   *** -----------------------------------
4   $PROD:Y(eso,r)          ***[...]
5   ***[...]
6       I:PG(ele,r)                             Q:((Intermediate(ele,eso,r)/div)*AEEI(ele,r)
            * enerD_COM_shck_ely(r))      P:(1 + Comtax(ele,eso,r))       A:PRODTAX(r)
            T:Comtax(ele,eso,r)      elc:
7   ***[...]
8       I:PG(fos,r)                             Q:((Intermediate(fos,eso,r)/div)*AEEI(fos,r)
            * enerD_COM_shck_fof(r))      P:(1 + Comtax(fos,eso,r))       A:PRODTAX(r)
            T:Comtax(fos,eso,r)      fos.tl:
9       I:PCO2EU#(fos)$(memeur(r))              Q:((CO2(fos,eso,r)/div)*AEEI(fos,r) *
            enerD_COM_shck_fof(r))               P:0.000001
                                                                        fos.tl:
10      I:PCO2ROW(r)#(fos)$(NOT memeur(r))      Q:((CO2(fos,eso,r)/div)*AEEI(fos,r) *
            enerD_COM_shck_fof(r))               P:0.000001
                                                                        fos.tl:
```

4.6 Health/Energy Module

Code Snippet 34: Health/Energy entry point in the Impact/Adaptation module

```
1   ***    ----------------------------------------
2   ***    HEALTH_ENERGY
3   ***    ----------------------------------------
4
5
6       if((activate_H_energy=1),
7   ***        health shock with residential energy demand shock for cooling, including
    investment for AC
```

Table 6: Implementation of health impacts and energy-related adaptation

	Labour/ energy variable	Parameter	COIN-INT implementation
Impact: he	Morbidity costs	Heat related annual morbidity medical costs estimations	Expenditure-neutral shift of government expenditures towards health services, reducing all other public expenditures, except for transfers, which scales with tax income.
	Mortality costs	Heat-related annual deaths monetized via the VSL	Ex-post consideration of mortality in terms of welfare costs.
Adaptation	Energy demand for adaptation (only for cooling) estimated for the residential sector	Private consumption	Consumption-neutral shift of private consumption towards energy split for fossil fuels and electricity
	Investment costs for new installation of air condition appliances and retrofitting existing infrastructure	Private investment demand	Forced investment crowding out generic private investment.

```
8
9   ***       morbidity & mortality data
10          morb_shock(r) = morb_shck_data(r,"SSP2","%RCPVAR%",tt)*div;
11          mort_shock(r) = mort_shck_data(r,"SSP2","%RCPVAR%",tt);
12
13
14  ***       adapation
15          enerD_RES_shck_fof(r) = enerD_shck_data_RES(r,"fof",tt);
16          enerD_RES_shck_ely(r) = enerD_shck_data_RES(r,"ely",tt);
17          ada_investment_priv(r) = ada_investment_priv(r)+AC_inv_shck_data(r,tt)*div;
18
19          );
```

morb_shock refers to increased demand for health services by the public household. The parameter enters the MPSGE model code via forced consumption of health services by the public household demand block in European regions and the general household demand block in the rest of the world.

Code Snippet 35: Entry point for the parameter morb_shock in the public household demand block in European regions

```
1  $DEMAND:GOVHH(eur)
2  ***[...]
3  ***morbidity shock as demand for health services
4      E:PG("HHT",eur)          Q:(-morb_shock(eur)/div)
```

Code Snippet 36: Entry point for the parameter morb_shock in the general household demand block in the rest of the world

```
*** FINAL DEMAND AND ENDOWMENTS - Rest of World regions
*** -------------------------------------
$DEMAND:REGHH(row)  s:0
***[...]
***morbidity shock as demand for health services /div?
    E:PG("HHT",row)         Q:(-morb_shock(row)/div)
```

mort_shock refers to increased mortality. It enters the welfare calculation ex-post. For a description, refer to section 2.1.

enerD_RES_shck_fof refers to increased final fossil fuel demand and ***enerD_RES_shck_ely*** refers to increased final electricity demand by private households. They enter the model via consumption input into the MPSGE welfare production block of the private household in Europe, (corresponds to the general household in the rest of the world).

Code Snippet 37: Entry point for the parameter enerD_RES_shck_fof and enerD_RES_shck_ely in the private household demand block

```
***CONSUMPTION private
*** -------------------------------------
$PROD:WPHH(r)    ***[...]
***[...]
    I:PG(ele,r)                          Q:(((Intermediate(ele,"PrivHH",r)/div) *
        AEEI(ele,r)   * adjstPRIV(ele,r)) * enerD_RES_shck_ely(r))      P:(1 +
        Comtax(ele,"PrivHH",r))  A:CONSTAX(r)     T:Comtax(ele,"PrivHH",r)        elc:
***[...]
    I:PG(fos,r)                          Q:(((Intermediate(fos,"PrivHH",r)/div) *
        AEEI(fos,r)   * adjstPRIV(fos,r)) * enerD_RES_shck_fof(r))     P:(1 +
        Comtax(fos,"PrivHH",r))  A:CONSTAX(r)     T:Comtax(fos,"PrivHH",r)        fos.tl:
    I:PCO2EU#(fos)$(memeur(r))           Q:(((CO2(fos,"PrivHH",r)/div) * AEEI(fos,r)
        * adjstPRIV(fos,r)) * enerD_RES_shck_fof(r))      P:0.000001
                                                                                fos.tl:
    I:PCO2ROW(r)#(fos)$(NOT memeur(r))      Q:(((CO2(fos,"PrivHH",r)/div) * AEEI(fos,r)
        * adjstPRIV(fos,r)) * enerD_RES_shck_fof(r))      P:0.000001
                                                                                fos.tl:
```

4.7 Sea Level Rise Module

Table 7: Implementation of impacts and adaptation for sea level rise from DIVA

	DIVA variable	Parameter	COIN-INT implementation
Impact	Expected Annual Damages (EAD)	Capital stock	Reduced capital stock K; reduced capital stock accumulation with lower capital availability for production (i.e., a lower capital endowment in the economy).
	Land loss	Land endowment	Reduction of land endowment (lower cropland availability for agricultural crop production).
	Expected number of people flooded annually	Labour endowment	Labour supply loss in the amount of two weeks, following (Parrado et al., 2020) and (Bachner et al., 2022).
	Migration costs (Private capital loss) and endowment change for government transfers	Capital endowment (Private capital loss) and endowment change for government transfers	Negative private capital endowment compensated by public transfers; only in European regions, in Rest of the World, there is only one regional household that loses capital.
	Number of people migrating	Labour income	Labour income loss in the amount of 24% according to estimates by (Athey et al., 2023).
Adaptation	Sea dikes cost investment	Government investment demand	Forced investment crowding out public consumption. Sea dikes are not considered in the accumulation of capital stock.
	Sea dikes cost maintenance	Government demand for construction	Consumption-neutral shift of public consumption towards construction.

Code Snippet 38: Sea Level Rise Impacts entry point in the Impact/Adaptation module

```
***    ----------------------------------------
***    DIVA
***    ----------------------------------------
    if((activate_diva=1),

        capital_acc_shock(r) = capital_acc_shock(r)+diva_EAD_data(r,tt);
        ada_investment_pub(r) = ada_investment_pub(r)+diva_migration_cost_data(r,
            tt)*div;
        ada_investment_pub(r) = ada_investment_pub(r)+diva_investment_costs_data(r,
            tt)*div;

        ada_maintenance_pub(r)=
            ada_maintenance_pub(r)+diva_maintenance_costs_data(r,tt)*div;
        lsup_shock(r) = lsup_shock(r)+(diva_labloss_data(r,tt)-1);

        diva_landloss_data_CUM(r)  = diva_landloss_data_CUM(r) +
            diva_landloss_data_yearly(r,tt) * 5;
        diva_landloss(r) = 1 - (diva_landloss_data_CUM(r) / Land_WDI(r));

```

```
16      );
```

For the model entry point for *capital_acc_shock*, see section 2.2.

For the model entry point for *ada_investment_pub* and *ada_maintenance_pub*, see section 4.1.

diva_landloss refers to land lost due to sea level rise. It enters the MPSGE model via reduced endowment of factor land of the regional private household in European regions and the general household in the rest of the world.

Code Snippet 39: Entry point for the parameter diva_landloss in the private household demand block in European regions

```
1  *** FINAL DEMAND AND ENDOWMENTS - European regions
2  *** -------------------------------------
3  $DEMAND:REGHH(eur)  s:0
4  ***[...]
5      E:PPF("LND",eur)
           Q:(((sum(ess,Intermediate("LND",ess,eur)))/div)*lndgr(eur)*diva_landloss(eur))
                          R:TFPG(eur)
```

Code Snippet 40: Entry point for the parameter diva_landloss in the general household demand block in the rest of the world

```
1  *** FINAL DEMAND AND ENDOWMENTS - Rest of World regions
2  *** -------------------------------------
3  $DEMAND:REGHH(row)  s:0
4  ***[...]
5      E:PPF("LND",row)
           Q:(((sum(ess,Intermediate("LND",ess,row)))/div)*lndgr(row)*diva_landloss(row))
                           R:TFPG(row)
```

4.8 Flooding Module

Code Snippet 41: Flooding Impacts entry point in Impact/Adaptation module

```
1  ***    ----------------------------------------
2  ***    GLOFRIS
3  ***    ----------------------------------------
4      if((activate_glofris=1),
5
6          capital_acc_shock(r)=capital_acc_shock(r)+EAD_glofris(r,tt);
7          ada_investment_pub(r) = ada_investment_pub(r)+INV_glofris(r,tt)*div;
```

Table 8: Implementation of impacts and adaptation for river flooding from GLOFRIS

	Parameter	GLOFRIS variable(s)	COIN-INT implementation
Impact	Increased construction demand	EAD	Increased demand for construction goods by private households
	Labour endowment	EAAP	Labour supply loss in the amount of two weeks (following (Parrado et al., 2020) and (Bachner et al., 2022)
Adaptation	i. Government investment demand	Costs	Forced investment demand (financed by shifting public consumption in the budget neutral scenario)
	ii. Government demand for construction	Maintenance	Consumption-neutral shift of public consumption towards construction

```
8       ada_maintenance_pub(r) = ada_maintenance_pub(r)+MAIN_glofris(r,tt)*div;
9       lsup_shock(r) = lsup_shock(r)+(LABOURLOSS_glofris(r,tt)-1);
10    );
```

For the model entry point for *capital_acc_shock*, see section 2.2.

For the model entry point for *ada_investment_pub*, *ada_maintenance_pub* and *lsup_shock* see section 4.1.

5 Powershell Interface

The amount of model runs, including a number of different impacts within three climate scenarios and for three adaptation levels, necessitated the development of a script that automates model runs in a systematic way. For this project, this was realised within Windows PowerShell. For the documentation and a tutorial, please refer the repository here.

References

Athey, S., Simon, L. K., Skans, O. N., Vikstrom, J., and Yakymovych, Y. (2023). The Heterogeneous Earnings Impact of Job Loss Across Workers, Establishments, and Markets. *NBER Working Paper Series*, 34946.

Bachner, G. (2026). COIN-INT 2.0 model documentation. forthcoming.

Bachner, G., Lincke, D., and Hinkel, J. (2022). The macroeconomic effects of adapting to high-end sea-level rise via protection and migration. *Nature Communications*, 13(1):5705.

Parrado, R., Bosello, F., Delpiazzo, E., Hinkel, J., Lincke, D., and Brown, S. (2020). Fiscal effects and the potential implications on economic growth of sea-level rise impacts and coastal zone protection. *Climatic Change*, 160(2):283–302.