Appendix C: Data and Mapping

C1: Mapping of WIOD sectors

Model Sectors	WIOD Sectors
y: emission-intensive and tradable goods	Oil; Mining and Quarrying; Chemicals and Chemical Products; Basic Metals and Fabricated Metal; Other Non-Metallic Mineral; Transport Equipment; Textiles and Textile Products; Food, Beverages and Tobacco; Pulp, Paper, Paper , Printing and Publishing
z: emission-intensive and non-tradable goods	Transport Sector (air, water, rail, road); Electricity
q: agricultural and forestry goods	Crop and Animal production; Forestry and Logging
x: emission-free and tradable goods	All remaining goods and services

Table C1: Mapping of WIOD sectors to model sectors

Table C1 shows the mapping of the 56 WIOD sectors to three composite sectors in our model.

C2: Data and Calibration

The calibration procedure for the general equilibrium analysis is standard, where base-year data defines some of the exogenous parameter values. For other parameters, we either use estimates from other studies or calibrate them based on simulations of a well-established large-scale CGE-model (Böhringer et al. 2017).

We base the calibration of the model on World Input Output Database (WIOD) data (base-year 2009)[i], and further reconstruct the empirical data to fit the model with the theoretical model. The WIOD dataset of the world is based on 43 regions with 56 sectors, linked with corresponding data of fossil related CO_2 emission from each sector. We map all the WIOD sectors into five merged sectors x, y, z, q and f. Further, we stick to the assumption from the theoretical analysis that there are no carbon related emissions in sector x, and thus set emissions in this sector equal to zero[ii].

For the agriculture and forestry sector, we need to calibrate the production function so that it captures the costs of reduced deforestation (in terms of carbon sequestration). For this purpose, we need to determine (for each region) the value share of land, the substitution elasticity between land use and the value-added composite (capital and labor), and the relationship between land use and carbon. From WIOD we have data for hectare (ha) land used in agriculture and forestry sectors (based on FAOSTAT 2018). We combine this with information about land prices in different countries, such as EUROSTAT (2016), USDA (2018), SEAB (2016), Flexor and Leite (2017) and Dislich et al. (2018),[iii] and an assumed annual rent as a percentage of the land price. Together, this gives us an estimate for the value share of land in this sector in the different regions.

Next, from Malhi et al. (1999), IPCC (2000), Gan and McCarl (2007) and Sun and Sohngen (2009), we have information about ton of CO2 per ha per year related to (reduced) deforestation in different types of forest (e.g., tropical vs. temperate vs. boreal forest). Moreover, Kindermann et al. (2008) provide estimates of marginal abatement costs related to reduced deforestation in different regions of the world, which we use to calibrate the substutition elasticity between land and other inputs to production. There are several uncertainties involved in this calibration, both with respect to land prices and CO2 sequestered per ha, implying that the numerical results should be interpreted with some caution.

Net exports in sector x, y and q in the base-year are based on the difference between a region’s production and consumption, and the balance of payment constraint is incorporated in the CGE model. The calibrated z sector consists of some sectors with (fairly limited) trade according to the

WIOD dataset. Because there is no trade for the z sector in the theoretical analysis, we simply assume that produced quantity in a region is the same as consumed quantity in the same region.

The representative agent is assumed to have a CES utility function, which is calibrated with share parameters of consumption set to base-year shares. At the top level in the CES utility function, we use a substitution elasticity of 0.5 between the four goods x, q, y and z. At the second level we integrate a substitution between domestic and imported goods for x, q and y. Here we consider two alternative approaches for sectors x and y. One approach (denoted *H*) follows the assumption in the theoretical analysis, i.e., that domestic and foreign goods are homogenous goods (perfect substitutes).

The other approach (denoted *A*) assumes that domestic and foreign goods are heterogeneous goods (imperfect substitutes), based on Armington’s approach (Armington, 1969). In this case, we also differentiate between the origins of the foreign produced goods (at the third level of the CES function). The substitution elasticities (for goods x and y) at the second and third levels are set to 16 and 32, respectively. The size of these elasticities determines how close substitutes goods produced in different origins are.

In both cases (*H* and *A*) we assume that domestic and foreign q goods are heterogeneous, and the substitution elasticities at the second and third levels are set to 4 and 8, respectively. Hence, we implicitly assume that the agricultural and forest good q is less trade-exposed than the emission-intensive (manufacturing) good y and the carbon-free good x.

We consider the approach with heterogeneous goods (*A*) more realistic than the approach with homogenous goods (*H*), and will therefore refer to the former as the benchmark case. However, there are of course uncertainties related to how trade-exposed the goods are. Thus, considering both homogenous and heterogeneous goods is useful. In addition, we consider an alternative with lower Armington elasticities for all sectors in the sensitivity analysis. Here, the second and third levels in the CES utility function the substitution elasticities are set to 4 and 8, respectively, for goods x and y, and to 2 and 4, respectively, for good q. For instance, the output response by other regions and carbon leakage that occurs in the q sector depends on forest type, product variety, international transport costs, and carbon uptake (García et al. 2018).

[i] The model is implemented as a Mixed Complementarity Problem in GAMS, using the PATH-solver.

[ii] In the WIOD dataset, sector x accounted for 14% of the global (fossil related) CO_2 emissions in 2009.

[iii] These data where relatively difficult to collect, and ideally an open-access database will be beneficial for similar future studies. Coomes et al. (2018) write: “An open-access, global land price database would enable policymakers, scientists, and civic society to better grapple with the economic, social, and environmental challenges posed by global change.”