ECONOMY-WIDE ESTIMATES OF THE IMPLICATIONS OF CLIMATE CHANGE: HUMAN HEALTH

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December 3, 2004

Working Paper FNU-57

Abstract

We study the economic impacts of climate-change-induced change in human health, viz. cardiovascular and respiratory disorders, diarrhoea, malaria, dengue fever and schistosomiasis. Changes in morbidity and mortality are interpreted as changes in labour productivity and demand for health care, and used to shock the GTAP-E computable general equilibrium model, calibrated for the year 2050. GDP, welfare and investment fall (rise) in regions with net negative (positive) health impacts. Prices, production, and terms of trade show a mixed pattern. Direct cost estimates, common in climate change impact studies, underestimate the true welfare losses.

Key words

Impacts of climate change, human health, computable general equilibrium

JEL Classification

C68, D58, Q25

1. Introduction

Of the many impacts of climate change, those on human health are often placed amongst the most worrying (e.g., Smith *et al.*, 2001). The impacts of climate change on human health are many and complex. Global warming would increase heat-related health problems, which mostly affect people with pre-established cardiovascular and respiratory disorders. On the other hand, global warming would reduce cold-related health problems, again most prevalent in people with cardiovascular disorders. Climate change would affect the range and abundance of species carrying diseases, and would affect the virulence of those diseases as well. Malaria, in particular, is generally thought to increase because of climate change. Other vector-borne diseases may increase or decrease, but currently make much less victims than does malaria. Climate change would allow diseases to invade immunologically naïve populations with unprepared medical systems. Climate change would affect water-borne diseases too, with cholera and diarrhoea being potentially most problematic (McMichael *et al.*, 2001).

Human health therefore figures prominently in assessments of the impacts of climate change. The welfare costs (or benefits) of health impacts contribute substantially to the total costs of climate change (Cline, 1992; Fankhauser, 1995; Tol, 2002a,b). The majority of estimates of the economic damages of global warming rely on the methodology of direct costs, that is, damage equals price times quantity. In case of human health, the price is typically equal to the value of a statistical life, which is based on estimates of the willingness to pay to reduce the risk of death or diseases, or the willingness to accept compensation for increased risk (see Viscusi and Aldy, 2003, for a recent review). This method ignores that human health impacts also affect labour productivity and the demand for health services. In this paper, we estimate the economic effects of human health impacts, and compare these to the direct welfare costs. This is part of a larger research programme, in which earlier papers looked at sea level rise (Bosello *et al.*, 2004) and tourism (Berritella *et al.*, 2004). Jorgenson *et al.* (2004) do something similar, but their model is restricted to the USA. Their health impacts include cardiovascular and respiratory disorders (as do ours) and ozone-related health problems (which we exclude) but not vector- and water-borne diseases (which we include; note that these diseases are not very important in the USA). Jorgenson *et al.* (2004) include changes in labour productivity (as do we) but exclude the induced demand for health care (which we include).

The structure of the paper is as follows. Section 2 presents the FEEM variant of the GTAP-E CGE model. Section 3 presents the baseline scenarios, without climate change. Section 4 discusses the implications of sea level rise. Section 5 discusses how these implications are brought into the CGE. Section 6 presents the results. Section 7 concludes.

2. Model and simulations

In order to assess the systemic, general equilibrium effects of health impacts, induced by the global warming, we made an unconventional use of a standard multi-country world CGE model: the GTAP model (Hertel, 1996), in the version modified by Burniaux and Truong (2002), and subsequently extended by ourselves.

First, we derived benchmark data-sets for the world economy at some selected future years (2010, 2030, 2050), using the methodology described in Dixon and Rimmer (2002). This entails inserting, in the model calibration data, forecasted values for some key economic variables, to identify a hypothetical general equilibrium state in the future.

Since we are working on the medium-long term, we focused primarily on the supply side: forecasted changes in the national endowments of labour, capital, land, natural resources, as well as variations in factor-specific and multi-factor productivity.

Most of these variables are “naturally exogenous” in CGE models. For example, the national labour force is usually taken as a given. In this case, we simply shocked the exogenous variable “labour stock”, changing its level from that of the initial calibration year (1997) to some future forecast year (e.g., 2050). In some other cases we considered variables, which are normally endogenous in the model, by modifying the partition between exogenous and endogenous variables. In the model, simulated changes in primary resources and productivity induce variations in relative prices, and a structural adjustment for the entire world economic system. The model output describes the hypothetical structure of the world economy, which is implied by the selected assumptions of growth in primary factors.

We obtained estimates of the regional labour and capital stocks by running the G-Cubed model (McKibbin and Wilcoxen, 1998). This is a rather sophisticated dynamic CGE model of the world economy, with a number of notable features, such as rational expectations intertemporal adjustment, international capital flows based on portfolio selection (with non-neutrality of money and home bias in the investments), sticky wages, endogenous economic policies, public debt management. We coupled this model with GTAP, rather than using it directly, primarily because the latter turned out to be much easier to adapt to our purposes, in terms of regional and sectoral disaggregation and changes in the model equations.

We got estimates of land endowments and agricultural land productivity from the IMAGE model version 2.2 (IMAGE Team, 2001). IMAGE is an integrated assessment model, with a particular focus on the land use, reporting information on seven crop yields in 13 world regions, from 1970 to 2100. We ran this model by adopting the most conservative scenario about the climate (IPCC B1), implying minimal temperature changes.

A rather specific methodology was adopted to get estimates for the natural resources stock variables. As explained in Hertel and Tsigas (2002), values for these variables in the original GTAP data set were not obtained from official statistics, but were indirectly estimated, to make the model consistent with some industry supply elasticity values, taken from the literature. For this reason, we prefer to fix exogenously the price of the natural resources, making it variable over time in line with the GDP deflator, while allowing the model to compute endogenously the stock levels.

3. Health Impacts of Climate Change

We evaluate the impacts of human health changes in the eight regions of GTAP-EF (see Table 1). Tol (2002a) presents estimates of the change in mortality due to vector-borne diseases (viz., malaria, schistosomiasis, dengue fever) as the result of a one degree increase in the global mean temperature. The estimates result from overlaying the model-studies of Martens *et al.* (1995, 1997), Martin and Lefebvre (1995), and Morita *et al.* (1994) with mortality figures of the WHO (Murray and Lopez, 1996). Martens *et al.* (1995, 1997) standardize their results to an increase in the global mean temperature of 1.16°C. Martin and Lefebvre (1995), and Morita *et al.* (1994), however, present their results (for malaria only) for various increases in the global mean temperature (2.8°C to 5.2°C). Both studies suggest that the relationship between global warming and malaria is linear. This relationship is assumed to apply to schistosomiasis and dengue fever as well. We follow the same methodology here.

We use data and models with different regional specifications, so we map all regional data to the country level and do all calculations there before aggregating to the GTAP-EF regions. We use the 14 region Burden of Diseases assessment of current vector-borne morbidity and mortality (Murray and Lopez, 1996)[1]. Within these regions, all countries are assumed to have the same diseases rates. We use the 9 region estimates of the change in disease burden by Tol (2002a), again mapping to the country level assuming that the countries within a region are homogenous. We use the relationship between per capita income and disease incidence developed by Tol and Heinzow (2003),[2] using the projected per capita income growth of the 8

[1] This data is updated at http://www.who.int/health_topics/global_burden_of_disease/en/
[2] Vulnerability to vector-borne diseases strongly depends on basic health care and the ability to purchase medicine. Tol and Dowlatabadi (2001) suggest a linear relationship between per

GTAP-EF regions for the countries within those regions. The resulting changes in national mortality and morbidity are then aggregated to the GTAP-EF regions. The annual loss of labour productivity is assumed to be equal to the number of additional malaria deaths plus the additional years of life diseased by malaria, divided by the total population. Table 1 summarizes the findings.

For diarrhoea, we follow Link and Tol (2004), who report the estimated relationship between mortality and morbidity on the one hand and temperature and per capita income on the other hand, using the WHO Global Burden of Disease data (Murray and Lopez, 1996).

Martens (1998) reports the results of a meta-analysis of the change in cardiovascular and respiratory mortality for 17 countries. Tol (2002a) extrapolates these findings to all other countries, using the current climate as the main predictor. Cold-related cardiovascular, heat-related cardiovascular, and (heat-related) respiratory mortality are specified separately, as are the cardiovascular impacts on the population below 65 and above. Heat-related mortality is assumed to only affect the urban population. Scenarios for urbanization and aging are based on Tol (1996, 1997).[3] We use this model directly on a country basis, before aggregating to the regions of GTAP-EF. Regional temperatures have been obtained through data elabouration from Giorgi and Mearns (2002).[4]

Besides the changes in labour productivity, the CGE is also shocked with the changes in demand for health care. The literature on the costs of diseases is thin. Substantial information appears to be in the grey literature on public health advice, specific for each country, but it is beyond this paper to review that. There are a few papers in the open literature, however. Kiiskinen *et al.* (1997) report the average costs of cardiovascular diseases, $21,000 per case, for Finland. Blomqvist and Carter (1997), Gbesemete and Gerdtham (1992), Gerdtham and Jönnson (1991), Getzen (2000), Govindaraj *et al.* (1997), Hitires and Posnett (1992), and di Matteo and di Matteo (1998) estimate the income elasticity of health expenditures for countries in the OECD, Latin America and Africa for the period 1960-1991. The average is 1.3. We use this to extrapolate the Finnish costs of cardiovascular diseases to other countries. Weiss *et al.* (2000) report the costs of asthma for the USA. The direct costs[5] amount to $430 per case, or $40,000 per year diseased.[6] We assume that asthma is representative for all respiratory disease, and again extrapolate to other countries using an income elasticity of 1.3.

The costs of vector borne diseases are taken from Chima *et al.* (2003), who report the expenditure on prevention and treatment costs per person per month. Their data suggest the following relationships

(1) $$P = \underset{(0.3103)}{0.1406} + \underset{(0.0008)}{0.0026}\,Y$$

(2) $$T = \underset{(0.8217)}{-0.4646} + \underset{(0.0018)}{0.0053}\,Y$$

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capita income and health. In this analysis, vector-borne diseases have an income elasticity of –2.7 (Tol and Heinzow, 2003).

[3] The income elasticity of the share of the population over 65 is 0.25. Urbanisation follows

$$U(t) = U(1995)\frac{0.031Y(t) - 0.011PD(t)}{1 + 0.031Y(t) - 0.011PD(t)}\frac{1 + 0.031Y(1995) - 0.011PD(1995)}{0.031Y(1995) - 0.011PD(1995)}$$

where U is the level of urbanisation, Y is per capita income and PD is population density.

[4] Regional impacts differ in a range of 20%-40% when regional temperature is used instead of average world temperature. Temperature data for 22 climatic zones has first been applied at the country level and subsequently aggregated for the eight macro-regions of the model.

[5] Weiss *et al.* (2000) also estimate the indirect costs to the economy.

[6] The average treatment for asthma lasts 4 days.

where P is monthly prevention costs ($/capita), T is monthly treatment costs ($/cap) and Y is income per capita ($/cap). We scale this up with the increase in mortality.

4. Including Impacts in the CGE model

To model the health-related impact of climate change in the computable general equilibrium model, we run a set of simulation experiments, by shocking specific variables in the model. Health impacts produce economic effects through two main mechanisms: first, there is a variation of working hours, which is equivalent to a change in the regional stock of labour force; second, there is a variation in the expenditure for health services, undertaken by public administration and private households. Both these effects could, in principle, be positive or negative in each region. This is because the incidence of some illnesses may be higher or lower when temperature increases. The "composition" also matters: some diseases are more costly to treat than are others.

Variations in the number of disease cases are estimated on the basis of specific relationships based on temperature changes and income levels described above. The number of cases has then been translated into changes of working hours; for mortality, we use years of life lost, for morbidity, years of life diseased. Next, the exogenous variable "regional labour productivity" has been shocked in the model, in a way similar to the one followed to get future equilibrium benchmarks.

Changes in the consumption of health services are more difficult to model, however, as these refer to variables which are normally endogenous in the model. One possibility is to alter the partition between exogenous and endogenous variables, by allowing the model to compute some parameter values, previously taken as a given.[7]

Here, we have chosen a different route. We interpreted our input data, expressing the additional health expenditure in terms of GDP, as coming from a partial equilibrium analysis, which disregards the simultaneous price changes occurring in all other markets. In practice, we imposed a shift in parameter values, which could produce the required variation in expenditure *if all prices and income levels would stay constant*.

It turns out that this is equivalent to a shift in factor-specific productivity, with opposite sign. A doubled factor productivity, for example, means that the same services can be obtained with half the original input. To achieve, say, an increase of health expenditure at constant prices and income, it is then sufficient to lower the health services productivity, for instance in terms of utility.

Consequently, we adopted the following procedure. We computed the magnitude of the absolute variation of expenditure from estimates expressed in terms of GDP share. Using data from the World Health Organization, we split this amount in private and public expenditure, deriving, in both cases, the percentage variation in the demand for health services. Subsequently, we shocked the productivity of health services for the final (private and public) demand, within the broader sector of non-market services. To comply with the budget constraint, we compensated the higher level of public consumption with a lower lever of aggregate private consumption and, within the latter, we compensated the higher consumption of health services with reduced expenditure shares for all other industries.

The simulation experiment is then obtained through the three simultaneous shocks on labour endowments and on the structure of final demand (public and private). The scenario produced in this way is compared with the hypothetical equilibrium benchmark. Because of the general

[7] For example, utility parameters, simulating a change in the structure of preferences.

equilibrium effects on prices and income levels, the variation in health expenditure computed by the model output turns out to be slightly different from the initial variation in the productivity parameters.

5. Results

In this section, simulation results for the year 2050 are reported and commented, in terms of variation from the no-climate-change baseline equilibrium. Results for other reference years are qualitatively similar.

Two mechanisms drive the results. Changes in labour productivity (positive and negative) directly affect the economy resources, so they have the nature of a typical macroeconomic shock. Changes in health expenditure, on the other hand, only influence the composition of demand. In particular, two effects take place here: a crowding out between private and public health expenditure and a crowding out within private expenditure between health care and the remaining commodities/services consumed by the household.

Labour productivity declines in Energy Exporting Countries [Eex] and Rest of the World [RoW] (Table 2). In the first case, the effect is mainly driven by the higher incidence of respiratory and gastro-enteric diseases, whereas in the latter case also by the incidence of malaria. In regions experiencing labour productivity gains (USA, European Union [EU], Eastern European and Former Soviet Union Countries [EEFSU], Japan [JPN], Rest of "Annex I" Countries [RoA1], China and India [CHIND]) vector borne diseases are practically absent, while the decrease in mortality/morbidity associated to cold stress related to cardiovascular diseases, more than compensates the increase in heat stress related diseases.

Higher (lower) incidence of illnesses is associated with more (less) demand for health care by the household and the public sector. The increase is particularly significant in EEx and RoW (see Table 2). Higher (lower) private demand for health care induces households to decrease (increase) their demand on other consumption items, while an increase (decrease) in public spending for health crowds out (in) total private consumption expenditure and lowers (raises) GDP (Figure 1).

The direct effect of a lower (higher) labour productivity is to lower (raise) GDP and utility (Table 5), notwithstanding the counteracting effect of the increased (decreased) health care demand (Table 3). The change in GDP is less than proportional to the change in labour productivity as the economy can substitute labour for other inputs (e.g., capital), or vice versa (Figure 1). Carbon dioxide emissions follow GDP (Table 5).

Table 5 also shows the "direct costs". Following Tol (2002a), we value a premature death at 200 times per capita income, and a year of life diseased at 80% of the annual income. Note that these estimates include the immaterial welfare losses of health impacts only; economic impacts are excluded. The direct costs, expressed as percent of GDP, are much larger than the economic impacts: The immaterial effects of risks of death and illness outweigh the economic effects. The direct costs have the same sign as the changes in GDP (that is, a cost corresponds to a GDP loss). This is intuitive: A loss of labour and forced purchase of health care are economic losses, just as death and illness are welfare losses. The direct costs, a welfare measure, also have the same sign as the change in the welfare index. Studies relying on direct costs only underestimate the true welfare impact.

Effects on prices (Table 4) are more difficult to trace, as changes in labour productivity, re-composition of demand and aggregate effects on production all influence the final result. For example, a lower labour productivity reduces labour demand, and thus wages. However, this is associated with a demand shift towards labour-intensive health care services, calling for higher wages.

A changing industry mix, for example with a higher share of services, implies a reduction in the overall propensity to import, with potential gains in the terms of trade. Also, lower labour productivity creates a relative scarcity of (differentiated) domestic goods, thereby increasing the price of exports and decreasing the price of imports. This is most evident in the case of RoW (Table 5).

In all regions, the price of capital resources moves in accordance with GDP (an exception is CHIND, but the negative figure is very small). This is particularly important for its consequences on the international capital flows. In the model, domestic investment is not constrained by the amount of domestic saving. Rather, investment is allocated in a diversified international portfolio, where higher returns on capital attract more investment (see the model description in the Appendix for more details). Therefore, this mechanism amplifies the macroeconomic impact of variations in labour productivity, whereas changing terms of trade work to the opposite direction.

6. Discussion and Conclusion

We estimate the economy-wide effects of the climate-change-induced impacts on health through changes in labour productivity and public and private demand for health care. This adds to the existing literature, which to date only included the *direct* costs of health impacts. The *indirect* costs may be positive or negative; in fact, they have the same sign as the health impacts themselves, so that direct costs are underestimates of the true impact. We find that, in 2050, climate-change-induced health impacts may increase GDP by 0.08% (Rest of Annex I) or reduce it by 0.07% (in the Rest of the World, which includes Africa).

The results presented here suffer from a number of drawbacks. We do not present any sensitivity analyses. However, the theory of computable general equilibrium models is sufficiently well understood to know that the results presented here would not change qualitatively if we were to impose different shocks, if we were to use different elasticities or a different sectoral or regional breakdown, or if we were to use different scenarios of climate change and economic development. More importantly, we use a static CGE, rather than a dynamic one. Although we do estimate the effects of climate-change-induced health impacts on investment, we do not include the effects of changing investment. We find that investment falls (rises) if health impacts are negative (positive), which would imply that the economy would shift away from those countries and sectors that are negatively affected by climate change. This would reduce global vulnerability to climate change, but increase the regional and sectoral impacts. More subtly, we omit the effects of direct impact of health on education, as well as the dynamic effects of changes in public health care via government expenditures. These issues are deferred to future research. This paper establishes that the indirect economic effects of climate-change-induced health impacts are substantial.

Acknowledgements

We had useful discussions about the topics of this paper with Carlo Carraro, Marzio Galeotti, Guy Jakeman, Sam Fankhauser, Claudia Kemfert, Hans Kremers, Marco Lazzarin, Hom Pant, Katrin Rehdanz and Kerstin Ronneberger. The Volkswagen Foundation through the ECOBICE project, the US National Science Foundation through the Center for Integrated Study of the Human Dimensions of Global Change (SBR-9521914), the Michael Otto

Foundation and the Ecological and Environmental Economics programme at ICTP-Trieste provided welcome financial support. All errors and opinions are ours.

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Appendix

A Concise Description of GTAP-EF Model Structure

The GTAP model is a standard CGE static model, distributed with the GTAP database of the world economy (www.gtap.org).
The model structure is fully described in Hertel (1996), where the interested reader can also find various simulation examples. Over the years, the model structure has slightly changed, often because of finer industrial disaggregation levels achieved in subsequent versions of the database.
Burniaux and Truong (2002) developed a special variant of the model, called GTAP-E, best suited for the analysis of energy markets and environmental policies. Basically, the main changes in the basic structure are:
- energy factors are taken out from the set of intermediate inputs, allowing for more substitution possibilities, and are inserted in a nested level of substitution with capital;
- database and model are extended to account for CO_2 emissions, related to energy consumption.
The model described in this paper (GTAP-EF) is a further refinement of GTAP-E, in which more industries are considered. In addition, some model equations have been changed in specific simulation experiments. This appendix provides a concise description of the model structure.
As in all CGE models, GTAP-EF makes use of the Walrasian perfect competition paradigm to simulate adjustment processes, although the inclusion of some elements of imperfect competition is also possible.
Industries are modelled through a representative firm, minimizing costs while taking prices are given. In turn, output prices are given by average production costs. The production functions are specified via a series of nested CES functions, with nesting as displayed in the tree diagram of figure A1.
Notice that domestic and foreign inputs are not perfect substitutes, according to the so-called "Armington assumption", which accounts for - amongst others - product heterogeneity.
In general, inputs grouped together are more easily substitutable among themselves than with other elements outside the nest. For example, imports can more easily be substituted in terms of foreign production source, rather than between domestic production and one specific foreign country of origin. Analogously, composite energy inputs are more substitutable with capital than with other factors.

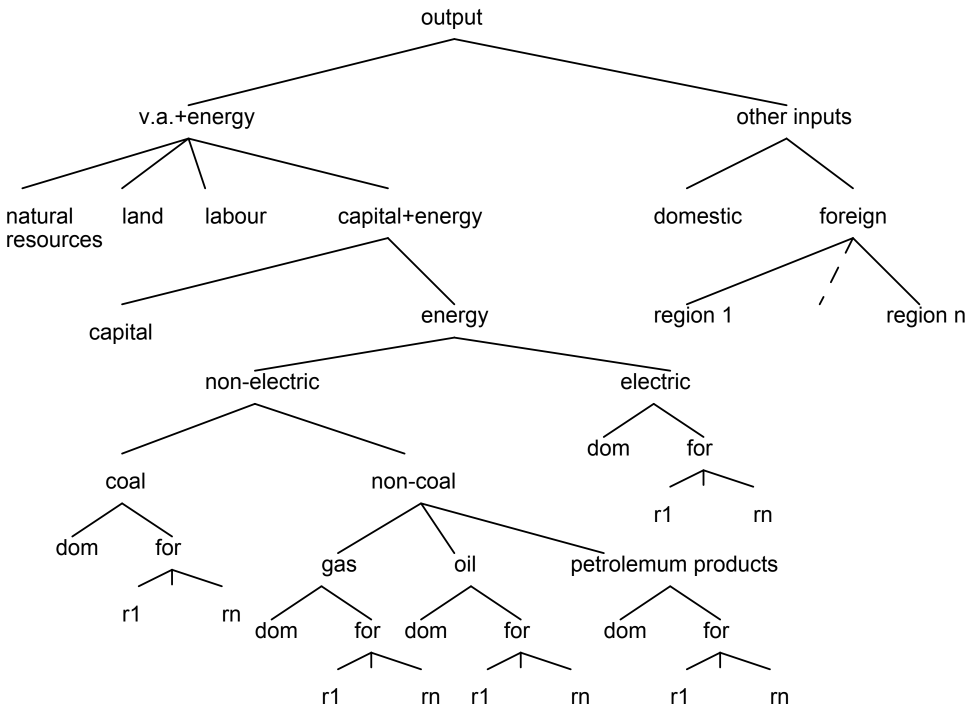

Figure A1 – Nested tree structure for industrial production processes

A representative consumer in each region receives income, defined as the service value of national primary factors (natural resources, land, labour, capital). Capital and labour are perfectly mobile domestically but immobile internationally. Land and natural resources, on the other hand, are industry-specific.

This income is used to finance the expenditure of three classes of expenditure: aggregate household consumption, public consumption and savings (figure A2). The expenditure shares are generally fixed, which amounts to saying that the top-level utility function has a Cobb-Douglas specification. Also notice that savings generate utility, and this can be interpreted as a reduced form of intertemporal utility.

Public consumption is split in a series of alternative consumption items, again according to a Cobb-Douglas specification. However, almost all expenditure is actually concentrated in one specific industry: Non-market Services.

Private consumption is analogously split in a series of alternative composite Armington aggregates. However, the functional specification used at this level is the Constant Difference in Elasticities form: a non-homothetic function, which is used to account for possible differences in income elasticities for the various consumption goods.

In the GTAP model and its variants, two industries are treated in a special way and are not related to any country, viz. international transport and international investment production.

International transport is a world industry, which produces the transportation services associated with the movement of goods between origin and destination regions, thereby determining the cost margin between f.o.b. and c.i.f. prices. Transport services are produced by means of factors submitted by all countries, in variable proportions.

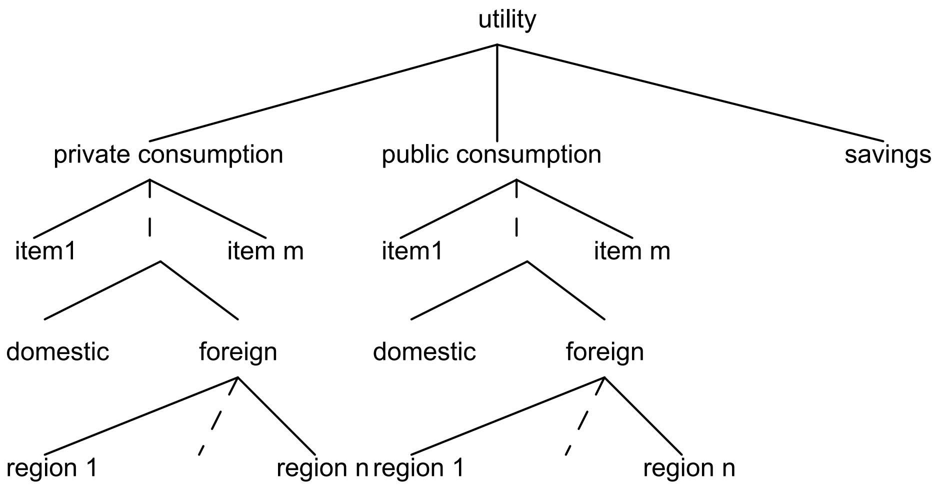

Figure A2 – Nested tree structure for final demand

In a similar way, a hypothetical world bank collects savings from all regions and allocates investments so as to achieve equality of expected future rates of return. Expected returns are linked to current returns and are defined through the following equation:

$$r_s^e = r_s^c \left(\frac{ke_s}{kb_s} \right)^{-\rho}$$

where: r is the rate of return in region s (superscript e stands for expected, c for current), kb is the capital stock level at the beginning of the year, ke is the capital stock at the end of the year, after depreciation and new investment have taken place. ρ is an elasticity parameter, possibly varying by region.

Future returns are determined, through a kind of adaptive expectations, from current returns, where it is also recognized that higher future stocks will lower future returns. The value assigned to the parameter ρ determines the actual degree of capital mobility in international markets.

Since the world bank sets investments so as to equalize expected returns, an international investment portfolio is created, where regional shares are sensitive to relative current returns on capital.

In this way, savings and investments are equalized at the international but not at the regional level. Because of accounting identities, any financial imbalance mirrors a trade deficit or surplus in each region.

Table 1. Health impacts of climate change.

Number of additional deaths in 2050 by Region and Disease.							
	Malaria	**Schisto**	**Dengue**	**Cardio-Vascular**	**Respiratory**	**Diarrhea**	**Total**
USA	0	0	0	-174158	2540	2006	-169613
EU	0	0	0	-178895	2389	590	-175916
EEFSU	0	0	0	-289210	3970	1074	-284166
JPN	0	0	0	-68009	3784	15	-64211
RoA1	0	0	0	-47070	1267	31	-45772
Eex	753	-62	53	-50088	82341	31244	64241
CHIND	632	0	626	-813307	92732	28709	-690608
RoW	63090	-568	535	-143466	175516	421683	516791
WORLD	64475	-630	1215	-1764202	364538	485352	-849252
Additional Years of Life Diseased in 2050 by Region and Disease							
	Malaria	**Schisto**	**Dengue**	**Cardio-Vascular**	**Respiratory**	**Diarrhea**	**Total**
USA	0	0	0	-167357	22257	83070	-62030
EU	0	0	0	-171908	20936	25608	-125364
EEFSU	0	0	0	-259884	46884	57717	-155283
JPN	0	0	0	-65353	33161	912	-31280
RoA1	0	0	0	-45232	11108	1361	-32763
Eex	7219	-1088	29	-66363	1706267	112633	1758698
CHIND	632	0	0	-1119902	770340	156271	-192659
RoW	232737	-154375	203	-194383	3683042	834294	4401519
WORLD	240588	-155462	233	-2090380	6293994	1271867	5560839
Additional Cost of Illness (1997 Ml US$) in 2050 by Region and Disease							
	Malaria	**Schisto**	**Dengue**	**Cardio-Vascular**	**Respiratory**	**Diarrhea**	**Total**
USA	0	0	0	-40220	9053	0.415	-31167
EU	0	0	0	-43084	4936	0.128	-38148
EEFSU	0	0	0	-4361	453	0.289	-3908
JPN	0	0	0	-34999	30057	0.005	-4941
RoA1	0	0	0	-9416	3209	0.007	-6208
Eex	0.074	-0.011	0	-826	27841	0.563	27015
CHIND	0.013	0	0	-2346	1527	0.781	-818
RoW	2.289	-1.562	0.003	-3518	50536	4.171	47023
WORLD	2.375	-1.573	0.003	-138770	127612	6.359	-11151

Table 2. Climate change impacts on health (2050): Model inputs and selected outputs.

	Inputs				Outputs	
	Labour productivity	Increase in public expend. for health care	Increase in private expend. for health care	Private demand for other comm.	Share of income devoted to public consumpt.	Share of income devoted to private consumpt.
USA	0.064	-0.557	-0.378	0.096	-0.599	0.131
EU	0.082	-0.488	-0.576	0.032	-0.588	0.18
EEFSU	0.110	-0.58	-0.481	0.039	-0.696	0.179
JPN	0.085	-0.198	-0.095	0.006	-0.273	0.044
RoA1	0.100	-0.631	-0.536	0.045	-0.719	0.222
Eex	-0.128	1.989	1.736	-0.122	2.161	-0.404
CHIND	0.028	-0.102	-0.149	0.006	-0.126	0.028
RoW	-0.152	0.87	3.219	-0.238	1.031	-0.229

Table 3. Climate change impacts on health (2050): Output by Sector/Industry

	USA	EU	EEFSU	JPN	RoA1	EEx	CHIND	RoW
Rice	0.0245	-0.0075	0.0938	0.0535	0.0763	-0.1211	0.0123	-0.1594
Wheat	0.0216	0.0301	0.0317	-0.0524	-0.0388	-0.0192	0.0079	-0.0468
CerCrops	-0.0254	-0.049	-0.032	-0.0532	-0.0714	0.0197	-0.0407	0.0979
VegFruits	-0.0252	-0.0744	-0.0409	-0.0335	-0.0787	-0.0566	-0.0004	-0.0557
Animals	0.0432	0.062	0.0422	0.0291	0.0487	-0.0419	0.0186	-0.0807
Forestry	-0.0003	0.0166	0.0287	0.0164	-0.0091	-0.2046	0.0081	-0.2719
Fishing	-0.0027	0.0596	0.0868	0.0316	0.0372	-0.2006	0.0259	-0.2223
Coal	0.0365	0.0462	0.0598	0.0667	0.0166	-0.035	0.0219	-0.0567
Oil	0.0182	-0.0101	0.0098	0.0029	0.0138	-0.0161	0.0076	-0.0469
Gas	0.0453	0.0976	0.0727	0.1057	0.0616	-0.043	0.0403	-0.1185
Oil_Pcts	0.1153	0.1163	0.0729	0.0442	0.1413	-0.1815	0.0243	-0.1891
Electricity	0.0453	0.062	0.0718	0.0145	0.0984	-0.0581	0.0236	-0.1075
Water	0.1029	0.0989	-0.1349	0.0445	-0.1181	0.209	0.001	-0.1581
En_Int_ind	0.0653	0.1181	0.1066	0.0587	0.0983	-0.2159	0.043	-0.2745
Oth_ind	0.0612	0.1016	0.108	0.0579	0.1198	-0.129	0.0212	-0.166
Mserv	0.1369	0.1685	0.1775	0.0864	0.173	-0.3405	0.0319	-0.3355
Nmserv	-0.2668	-0.4297	-0.4275	-0.109	-0.4763	1.5355	-0.0882	1.2064

Table 4. Climate change impacts on health (2050): Prices by Sector/Industry

	USA	EU	EEFSU	JPN	RoA1	EEx	CHIND	RoW
Primary Factors								
Land	-0.0341	0.0274	0.06	0.1151	-0.0441	-0.4209	0.0254	-0.6326
Lab	0.031	0.0139	0.0356	0.0505	0.0548	0.0893	-0.0091	0.1313
Capital	0.0721	0.0842	0.0917	0.05	0.0695	-0.0825	-0.0074	-0.0942
NatlRes	0.155	0.194	0.1954	0.1586	0.1013	-0.2762	0.0549	-0.8687
Sectors/Industries								
Rice	-0.0278	-0.0274	0.0428	0.0346	-0.0247	-0.314	-0.0134	-0.5005
Wheat	-0.0287	0.002	0.0105	-0.0119	-0.0721	-0.1536	-0.0193	-0.2457
CerCrops	-0.0642	-0.0483	-0.0231	-0.0217	-0.0892	-0.1885	-0.0485	-0.2416
VegFruits	-0.0609	-0.0629	-0.0306	-0.0098	-0.0891	-0.234	-0.0228	-0.3054
Animals	-0.0343	0.0109	0.0035	-0.0228	-0.0407	-0.1853	-0.0158	-0.2836
Forestry	-0.0035	0.034	0.03	-0.0175	-0.0503	-0.2658	-0.0367	-0.3033
Fishing	-0.0009	0.039	0.0575	0.0047	0.005	-0.1599	-0.0348	-0.0752
Coal	0.0057	0.0008	0.0169	-0.0175	-0.003	0.0006	-0.0247	0.0047
Oil	0.0284	0.01	0.0276	-0.0208	0.0019	-0.0356	-0.0264	-0.0711
Gas	-0.0101	0.0075	0.0241	-0.0307	0.0072	0.0217	-0.0344	0.02
Oil_Pcts	-0.0049	-0.0129	0.0195	-0.0298	-0.0109	-0.0307	-0.0322	-0.0245
Electricity	0.0085	-0.0047	0.0145	-0.0205	-0.0067	0.0078	-0.041	0.035
Water	-0.0306	-0.0046	-0.0286	-0.0295	-0.0232	0.0687	-0.0472	0.0895
En_Int_ind	-0.0183	-0.0336	-0.0307	-0.0379	-0.0319	0.0175	-0.0403	0.0402
Oth_ind	-0.0305	-0.0376	-0.0388	-0.0425	-0.0451	-0.0405	-0.0379	-0.028
MServ	-0.0216	-0.0292	-0.0467	-0.0462	-0.0455	0.0471	-0.0451	0.0922
NMserv	-0.0407	-0.0582	-0.0752	-0.059	-0.056	0.0847	-0.0487	0.1605

Table 5: Climate change impacts on health (2050): Other Macroeconomic indicators (% change from baseline, except direct cost: % of GDP)

	Direct cost	GDP	Household Utility Index	Terms of Trade	CO2 emissions	Investment /capital flows
USA	-9.339	0.042	0.045	0.011	0.087	0.070
EU	-9.664	0.070	0.071	-0.002	0.111	0.082
EEFSU	-14.234	0.072	0.073	0.001	0.081	0.095
JPN	-11.482	0.058	0.057	-0.017	0.027	0.040
RoA1	-11.710	0.077	0.076	-0.014	0.127	0.057
EEx	0.999	-0.073	-0.075	-0.018	-0.182	-0.144
CHIND	-4.435	0.014	0.013	-0.010	0.021	-0.016
RoW	3.257	-0.101	-0.093	0.023	-0.159	-0.123

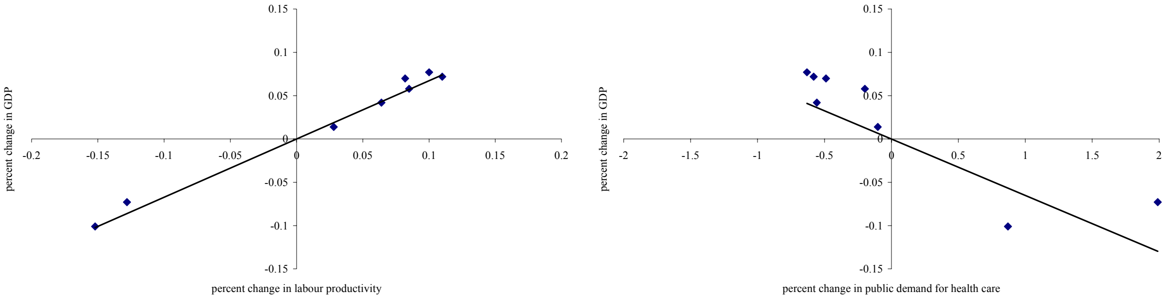

Figure 1. Change in GDP as a function of the change in labour productivity (right panel) and of the change in the public demand for health care (left panel).

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