THE SPATIAL INCIDENCE OF A CARBON TAX IN IRELAND

Eimear Leahy[a], Sean Lyons[a], Edgar L.W. Morgenroth[a] and Richard S.J. Tol[a,b,c]

[a] *Economic and Social Research Institute, Dublin, Ireland*

[b] *Institute for Environmental Studies, Vrije Universiteit, Amsterdam, The Netherlands*

[c] *Department of Spatial Economics, Vrije Universiteit, Amsterdam, The Netherlands*

July 7, 2009

Working Paper FNU-174

Abstract

We estimate carbon dioxide emissions for the 3401 electoral districts of the Republic of Ireland combining data from the Census, the Household Budget Survey, the National Accounts, Environmental Accounts, and the Labour Accounts. The source data is available for many countries, but we are not aware of other studies that combine these data to estimate the spatial incidence of environmental regulation. For consumption, currently regulated emissions are reasonably uniform over space, while currently unregulated emissions vary much more substantially and are spatially concentrated in the commuter belts. This suggests that new regulation may run into local opposition. The incidence of a carbon tax correlates negatively with votes for the Green Party in the 2007 general election. Emissions from production are clustered around the cities but the spatial pattern is dominated by a small number of point sources (which are already regulated). Consumption emissions dominate total emissions in suburbs and the countryside. Production emissions dominate total emissions in the towns and cities as well as in those electoral districts that have a point source of carbon dioxide.

Key words

Carbon tax, spatial data, voter behaviour

JEL Classification

D72, H22, R12, Q54

THE SPATIAL INCIDENCE OF A CARBON TAX IN IRELAND

1. Introduction

A substantial literature has considered the impact of climate policy on many aspects of the economy such as the incidence of environmental taxes across income groups (see Poterba, 1993) and production sectors (see Morgenstern et al., 2004), but much less is known about the spatial incidence of carbon taxes. Given the findings of a differential incidence across income groups and industries, and given the uneven distribution of the population and industry across spatial units, one would also expect to find spatial differences in the incidence of a carbon tax.

A better understanding of the spatial incidence of a carbon tax is important from a political economy perspective since large differences across space in the burden of a carbon tax on households may be seen as unfair, and could affect voting behaviour. For example, Cragg and Kahn (2009) find that representatives from poor, conservative areas with high carbon emissions are unlikely to vote in favour of greenhouse gas (GHG) mitigation measures. Thus, as all politics is local, a spatially differentiated incidence of fiscal measures may affect the political feasibility of climate policy. Furthermore, large differences across space in the burden of a carbon tax on companies may also affect the economic geography and local labour markets by affecting the cost of production.

A few papers have considered the spatial effects of curbing GHG emissions. The differential impact of climate policy on countries and groups of countries has been studied at length (Nordhaus and Yang, 1996; Weyant et al., 2006; Wiedmann et al., 2007). At the sub-national level, Bull et al. (1994) and Hassett et al. (2009) show that, for broad US regions, the incidence of energy taxes and a carbon tax do not vary significantly across space. However, they find that this even distribution is generated by large differences in the direct and indirect effects, which largely cancel out. Hassett et al. (2009) consider motor fuels to be the key driver of the variation that is found. Finally, Brännlund and Nordstrőm (2004) estimate the consumer response and welfare effects of a CO_2 tax for Sweden, with data that is broken down for six broad regions: four urban areas and two rural areas (north and south). They find that the distributional impacts are pronounced across the regions, with households in low population density regions carrying a larger share of the CO_2 tax burden.

No analysis for carbon dioxide appears to have been carried out at a more disaggregated spatial scale.[1] Yet, given finely grained differences in most countries in such pertinent factors as settlement patterns, the availability of different transport modes, the age of the housing stock, and household size, one would expect the incidence of a carbon tax to vary more *within* the large regions that have been analyzed in the literature than *between* such regions. From a political economy perspective this is also important since the hitherto analysed regions are not coterminus with the electoral constituencies.

The lack of published data is one reason why there has not been any analysis of the incidence of a carbon tax at the highly spatially disaggregated level. This paper addresses

[1] Hynes et al. (2009) estimate the average methane tax per electoral district for the Republic of Ireland. The likely carbon tax in Ireland would cover only carbon dioxide emissions.

this issue by proposing a novel method of constructing the necessary data for both consumers and firms and applies these methods to the Republic of Ireland. The input data to our method should be readily available for many other countries.

The paper is organised as follows. Section 2 discusses data and methods. Section 3 presents the results. Section 4 concludes.

2. Data and methods

Separate methods are required to identify the direct incidence of the tax on consumers and its incidence on firms. In both cases only first-round effects are identified; to the extent that agents respond to the tax by adjusting their demand for taxed goods, this would need to be modelled separately. Moreover, firms may pass on some or all of the taxes they pay to consumers. Second round effects of this kind are outside the scope of the analysis.

2.1. Direct emissions from consumption

Our estimates are derived using two different Central Statistics Office (CSO) data sets. The Census yields the Small Area Population Statistics (SAPS), which contain demographic data on household structure, age, education, and employment per electoral district (ED) as well as data on housing conditions and facilities[2]. The Household Budget Survey (HBS) has similar data on housing and demographics plus data on income, expenditures, and energy use. To impute carbon dioxide emissions for each area, we first computed emissions for all households in the HBS sample using the stated energy use by fuel and emission coefficients for Ireland (SEI, 2007). We then ran a regression of household emission in the 2004/5 HBS anonymised data file on the characteristics found in the 2006 SAPS, and used the estimated equation to impute the emissions level for each electoral district. Because the SAPS include only fairly basic information, the regression essentially computes the average income per group. It is a "classifying regression" rather than a continuous function – that is, the explanatory variables are dummies. Regional data on electricity use and household income were derived in the same way. Tables A1-3 show the estimated coefficients.

2.2. Direct emissions from production

Recently made available data from the Census of Population (2006) on travel to work that covers all persons in employment can be used to identify the location of employment by sector (see Morgenroth, 2008). By identifying the place of work of individuals this data identifies the location of employment. While the published micro-data (Place Of Work Census of Anonymised Records POWCAR), covers detail of broad sectors, a special tabulation covering the two digit NACE sectors was utilised by Morgenroth (2008) to establish the location of employment at the Electoral District level, and this data is used

[2] Electoral Districts are the smallest spatial units for which comprehensive data is available in Ireland. They range in size between 5 and 16,332 ha and in terms of population between 76 and 32,288 people.

in our analysis as this provides the most detailed data on the location of employment by sector available. It covers almost 2 million persons at work.

The 2005 Input-Output table for Ireland specifies value added per sector. The environmental accounts specify carbon dioxide emissions per sector. We constructed labour satellite accounts from the Census for Industrial Production and the Annual Services Inquiry, with supplementary data from the Quarterly National Household Survey and the Census. We thus know emissions per employee and sector, and value added per employee and sector. We combine this with our estimates of the number of employees per electoral district and sector to estimate emissions and value added per electoral district.

3. Results

3.1. Households

Figure 1 shows the average impact per household for each of the electoral districts of the introduction of a carbon tax on non-ETS CO_2 emissions. We assume a carbon tax of €20/tCO_2. Although a carbon tax is sometimes portrayed as placing an unfair burden on households at the countryside, Figure 1 shows a more nuanced pattern. A carbon tax would particularly hit the commuter belts around Cork, Dublin, Galway and Limerick, while the rest of the rural areas in fact see a below average impact. Figure 2 adds the carbon dioxide emissions from power generation, if the EU ETS permit price (assumed to be €20/tCO_2) is fully passed on to final consumers. Figure 2 also shows the impact of the EU ETS alone. The variation in electricity use is much less than the variation in the use of transport and heating fuels. This is supported by Moran's I, a measure of spatial autocorrelation. The carbon tax (Figure 1) has I=0.48, that is, electoral districts with above (below) carbon taxes tend to be close to districts with above (below) average carbon taxes. The EU ETS has I=0.18. The total climate policy package (carbon tax plus EU ETS) has I=0.45. That is, a carbon tax is more spatially inequitable than the EU ETS. The spatial pattern of the carbon tax dominates the spatial pattern of the EU ETS.

3.2. Production

Figure 3 shows the carbon dioxide emissions from production. Note that, because of the pronounced spatial concentration, the data are shown on a log scale. Figure 3 generally reflects the map of economic activity in Ireland, but with the location of power stations and industrial facilities (aluminium, cement) added.

Figure 4 displays the average carbon intensity of production, here measured as carbon dioxide emitted per Euro value added. Figure 4 shows that total carbon intensity spans more than two orders of magnitude, with a range from 20 gCO_2/€ to 5990 gCO_2/€. Figure 4 also displays non-ETS carbon intensity – that is, the amount of unregulated carbon dioxide emitted per value added. Unregulated intensity is obviously always smaller than total intensity. The data are fairly noisy. Indeed, the EU ETS covers 0% of emissions in many electoral districts but 100% in a few others. However, total and regulated carbon intensity systematically deviate in the most carbon-intensive electoral districts. In other words, the EU ETS regulates carbon-intensive industries only.[3]

3.3. *Total emissions*

Figure 6 shows total carbon dioxide emissions from consumption and production per electoral district, as well as emissions from consumption only. Figure 5 shows total emissions as a map. Total emissions are heavily concentrated, with a range of 7 $GgCO_2$ to 2 $TgCO_2$ per electoral district. The share of consumption in total emissions varies widely, with a range of 0.4% to 99.7%, and randomly for most electoral districts. However, production emissions dominate in electoral districts with very high emissions.

Figure 7 shows a map of the share of consumption emissions in total emissions. This is essentially an inverse map of the production centres of Ireland, or a map of the towns and cities.

3.4. *Election results*

We note above that the spatial incidence of a carbon tax may affect voting behaviour. While a full model of the political economy of environmental taxes is beyond the scope of this paper, we can examine the relationship between tax incidence and voting behaviour using votes for the Green Party as an indicator of environmental taxation preferences. The Green Party made significant gains in the 2007 general election, and has been a junior partner in government since. Climate change was one of its main campaign issues, and a carbon tax is one of the few Green issues in the Programme for Government.

There are 166 seats in *Dáil Éireann*. 165 *Teachtaí Dála* are elected[4] in 43 multi-seat constituencies. These constituencies are simple aggregates of the electoral districts used in the analyses above. In the 2007 election, 6 constituencies elected a single *Teachta Dála*. In these constituencies, the average carbon tax is 47.9 €/person/year. In the other constituencies, the average carbon tax is 54.4 €/p/yr. We ran a simple OLS regression of the percentage of first-preference votes for the Green Party on the estimated carbon tax, the average years of education per person, along with imputed values for per capita income and municipal waste per household. This shows that for every one euro fall in the carbon tax, the percentage of Green voters increases by 0.11, with a standard error of 0.05 (p-value: 0.03).[5]

One could conclude that Green voters favor a carbon tax, knowing that it would disproportionally fall on others. Note that for every 1000 euro increase in per capita income, the Green vote increases by 0.6 percent points. Recall that a carbon tax is regressive (Callan et al. 2009). Reverse causality is out of the question. Household carbon emissions are imputed, and the imputation method disregards political preferences.

[3] This is almost by design. The EU ETS does not regulate the chemical industry, which tends to be very energy- and emissions-intensive. There is little chemical industry in Ireland, however.
[4] The *Ceann Comhairle* is returned without vote.
[5] The R^2 of the regression is 48%. See Table A5.

However, one may also argue that Green voting is driven by other issues than climate policy. For instance, the Green Party has severely criticized agricultural practices, which could explain their poor electoral results in rural constituencies,[6] and planning practices, which could explain their poor electoral results in the newly built commuter belt.

4. Discussion and conclusion

In this paper, we estimate carbon dioxide emissions for the 3401 electoral districts of the Republic of Ireland. The main source of data is the 2006 Census, which has the location of both home and work for every one in Ireland, as well as a detailed classification of household types and information on the sector of employment. The Census data is supplemented with data on average emissions per type of household and per worker and sector. Such data is available at comparable spatial detail for many countries. We distinguish between direct emissions from consumption and direct emissions from production, and between emissions that are already regulated under the EU Emissions Trading Scheme and emissions that may soon be subject to a domestic carbon tax.

For consumption, currently regulated emissions are reasonably uniform over space, while currently unregulated emissions vary much more substantially and are spatially concentrated in the commuter belts. This suggests that a carbon tax is more likely to run into local opposition than the ETS was. We have identified a possible political economy association, finding that the incidence of a carbon tax correlates negatively with votes for the Green Party in Ireland's most recent (2007) general election.

Emissions from production are clustered around the cities but the spatial pattern is dominated by a small number of point sources. The most carbon-intensive industries are already regulated under the EU ETS.

Consumption emissions dominate total emissions in suburbs and the countryside. Production emissions dominate total emissions in the towns and cities as well as in those electoral districts that have a point source of carbon dioxide. Therefore, the electoral districts with the highest emissions are already largely regulated.

As stated in the introduction, the data we use in the current analysis is readily available for other countries as well. We show here that a combination of data yields new insights into the spatial incidence of carbon pricing. This can be reproduced for other countries and for other regulations. Future research should also try to validate the spatial patterns obtained by the method presented here.

Acknowledgements

The STRIVE programme of the Ireland Environmental Protection Agency provided welcome financial support. All errors and opinions are ours.

---

[6] Note that there is no significant relationship between the share of agricultural employment or the amount of waste generated and the share of Green votes.

References

Brännlund, R., and J. Nordstrőm (2004) "Carbon Tax Simulations Using a Household Demand Model", *European Economic Review*, Vol. 48, pp. 211-233.

Bull, N., Hassett, K., and G., Metcalf, 1994 "Who Pays Broad-Based Energy Taxes? Computing Lifetime and Regional Incidence", *Energy Journal*, Vol. 15(3) pp. 145-164.Callan, T., S. Lyons, S. Scott, R.S.J. Tol and S. Verde (2009), 'The Distributional Implications of a Carbon Tax for Ireland', *Energy Policy*, **37**, 407-412.

Callan, T., S. Lyons, S. Scott, R.S.J. Tol and S. Verde, 2009, "The Distributional Implications of a Carbon Tax in Ireland", *Energy Policy*, 37 (2), 407-412.

Hassett, K., Mathur, A., and G. Metcalf (2009) "The Incidence of a US Carbon Tax: A lifetime and Regional Analysis", *Energy Journal*, 30 (2), pp. 155-177.

Hynes, S., K. Morrissey, C. O'Donoghue and G. Clarke (2009) "A Spatial Micro-simulation Analysis of Methane Emissions from Irish Agriculture" *Ecological Complexity* 6 (2), 135-146.

Morgenroth, E., (2008) "Exploring the Economic Geography of Ireland" *Journal of the Statistical and Social Inquiry Society of Ireland,* Vol. 38, *2008/2009.*

Morgenstern, R., Ho, M., Shih, J-S., and X. Zhang (2004) "The Near-Term Impact of Carbon Mitigation Policies on Manufacturing Industries", *Energy Policy*, Vol. 32(16), pp. 1825-1841.

Nordhaus and Yang (1996) "A Regional Dynamic General-Equilibrium Model of Alternative Climate Change Strategies", *American Economic Review*, Vol. 86(4), pp. 741-765.

Poterba, J. M., (1993) "Global Warming Policy: A Public Finance Perspective", *Journal of Economic Perspectives*, Vol. 7(4), pp. 47-63.

Sustainable Energy Ireland (SEI), 2007, *Energy in Ireland: 1990-2006*.

Tol, R.S.J., N. Commins, N. Crilly, S. Lyons and E. Morgenroth, 2009, "Towards Regional Environmental Accounts for Ireland", *Journal of the Statistical and Social Inquiry Society of Ireland*, forthcoming.

Weyant, J.P., F.C. de la Chesnaye and G.J. Blanford (2006) "Overview of EMF-21: Multigas Mitigation and Climate Policy", *Energy Journal*, 1-32.

Wiedmann, T., Lenzen, M., Turner, K., and J. Barrett (2007) "Examining the Global Environmental Impact of Regional Consumption Activities – Part 2: Review of Input-Output Models for the Assessment of Environmental Impacts Embodied in Trade", *Ecological Economics,* Vol. 61(1), pp. 15-26

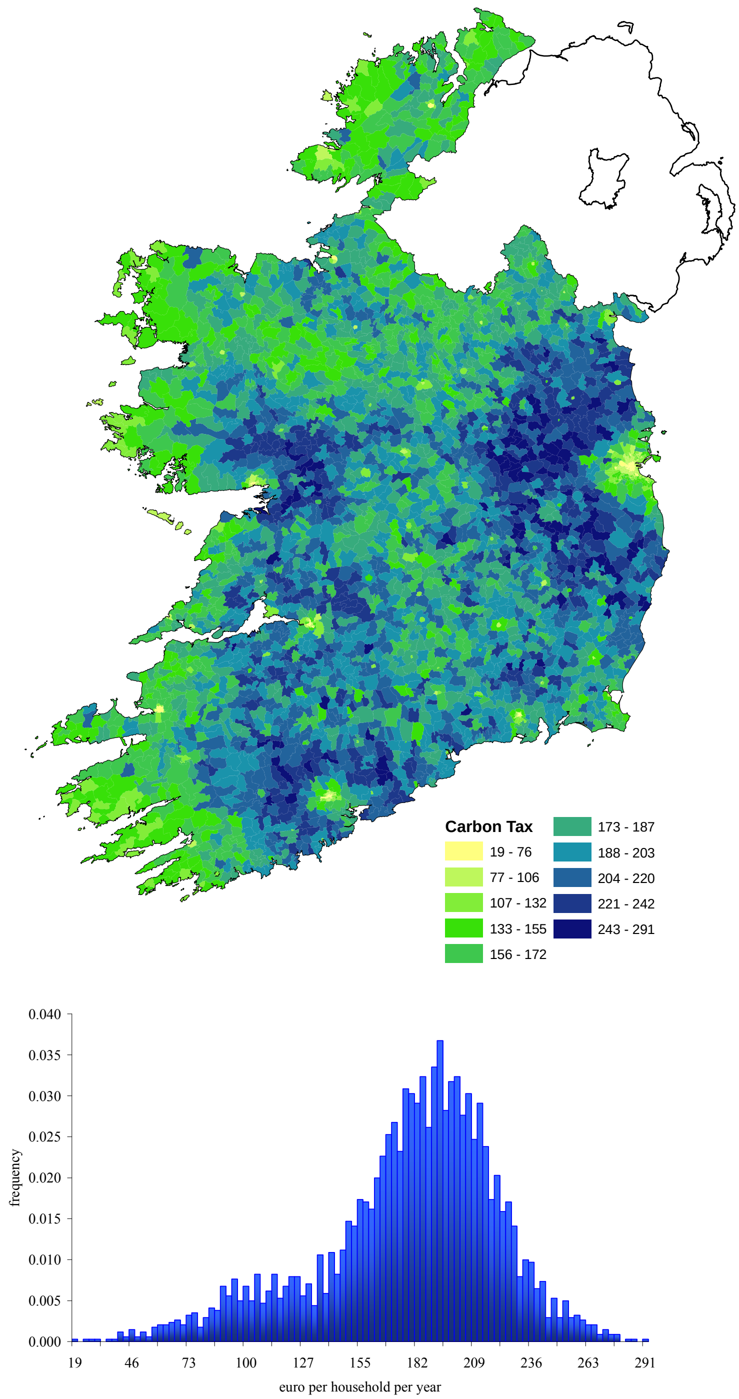

Figure 1. Average annual carbon tax per household by electoral district.

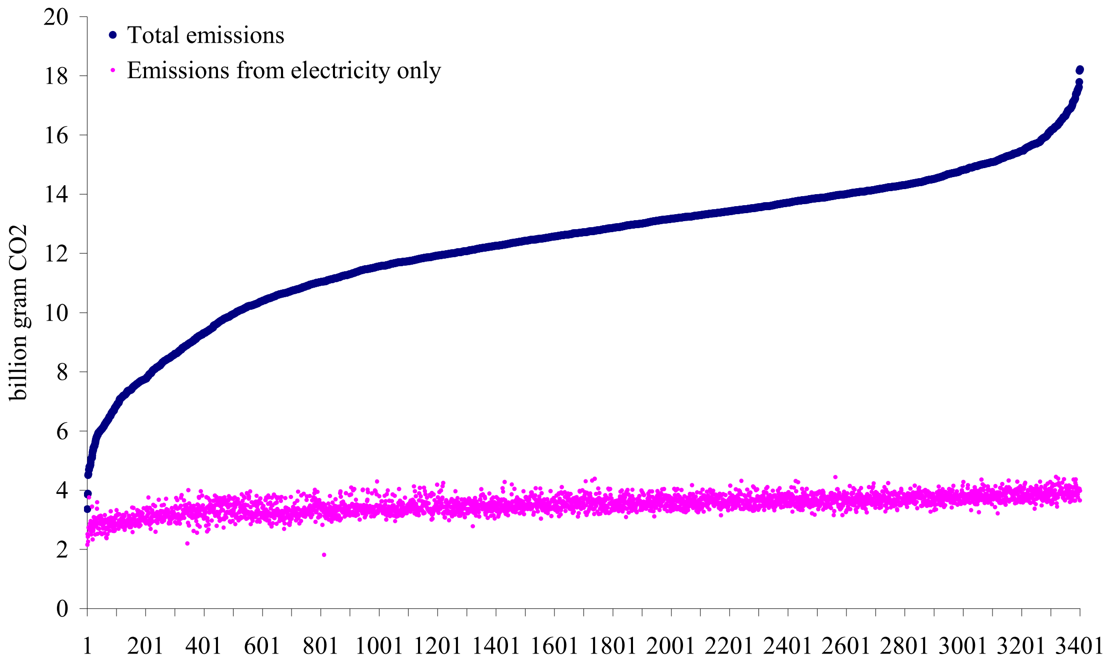

Figure 2. Average annual carbon tax on households plus pass-through of carbon permit price per household by electoral district, and permit price pass-through only; electoral districts are ordered on total carbon dioxide.

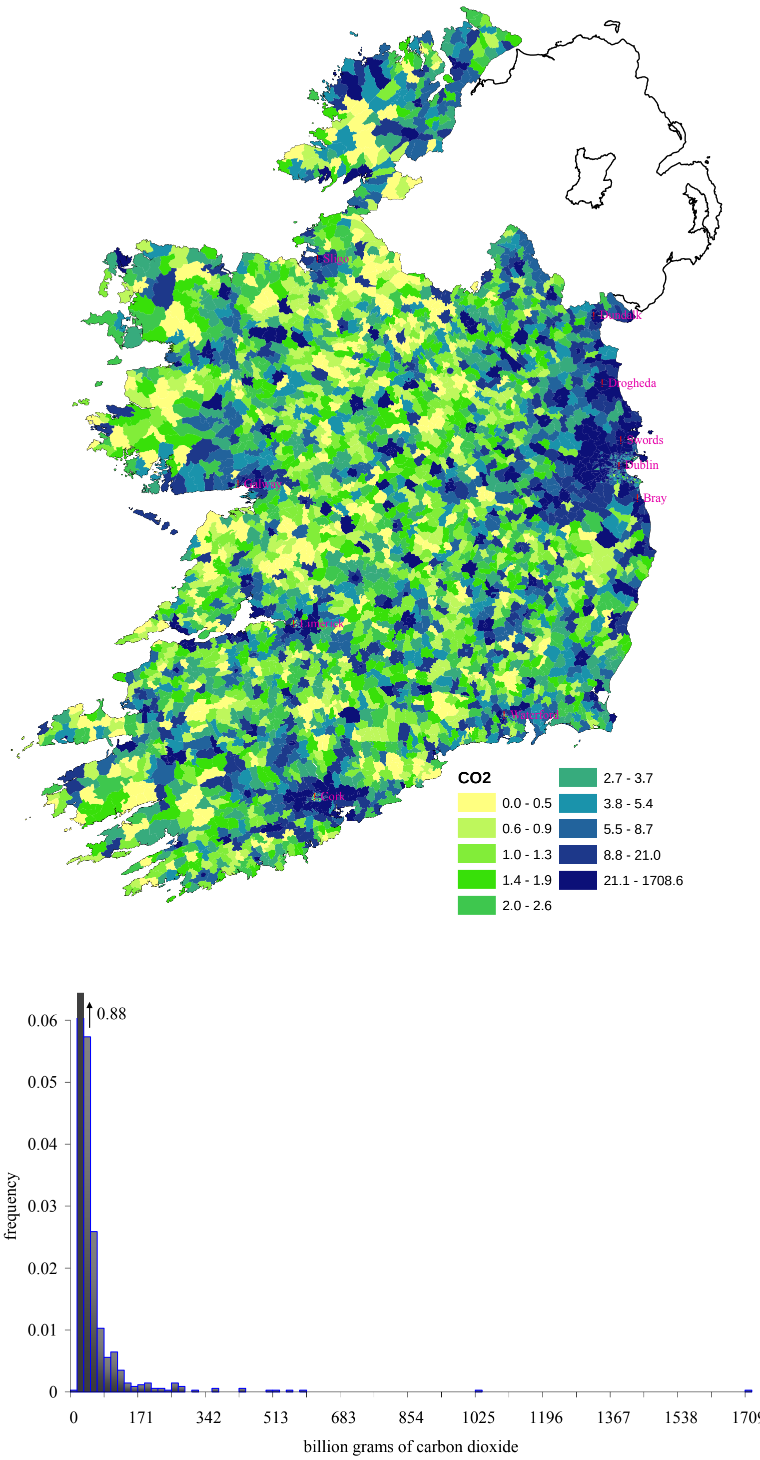

Figure 3. Total carbon dioxide emissions (billion grams of CO_2) from economic production per electoral district.

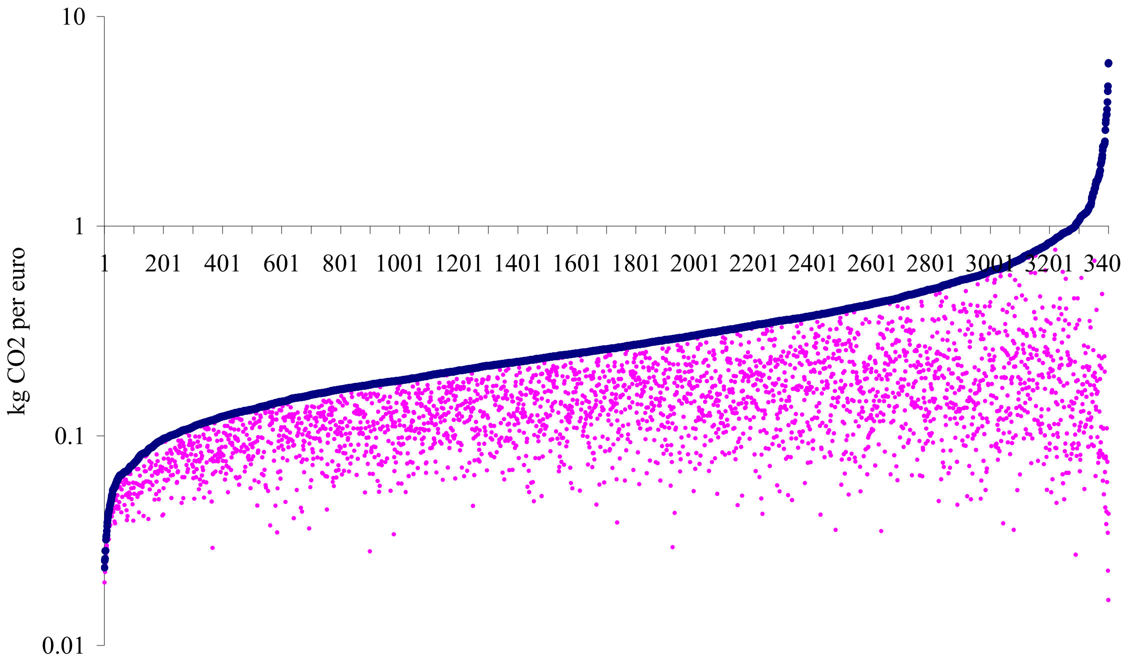

Figure 4. The average carbon intensity (kilogram of carbon dioxide emitted per euro value added) per electoral district for total carbon dioxide (large dots) and for carbon dioxide not part of the EU ETS (small dots); electoral districts are ordered on total carbon intensity.

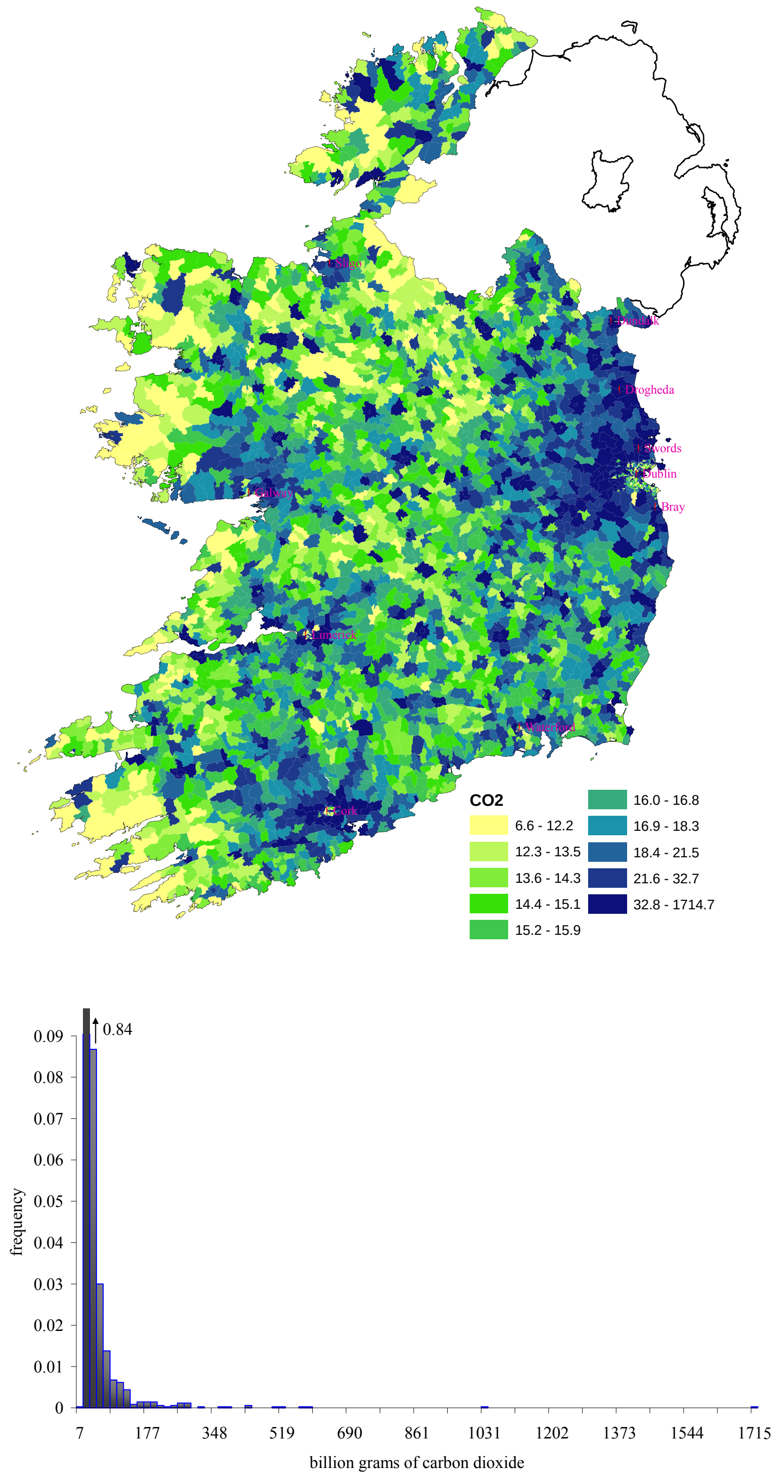

Figure 5. Total carbon dioxide emissions (billion grams of CO_2) from consumption and production per electoral district.

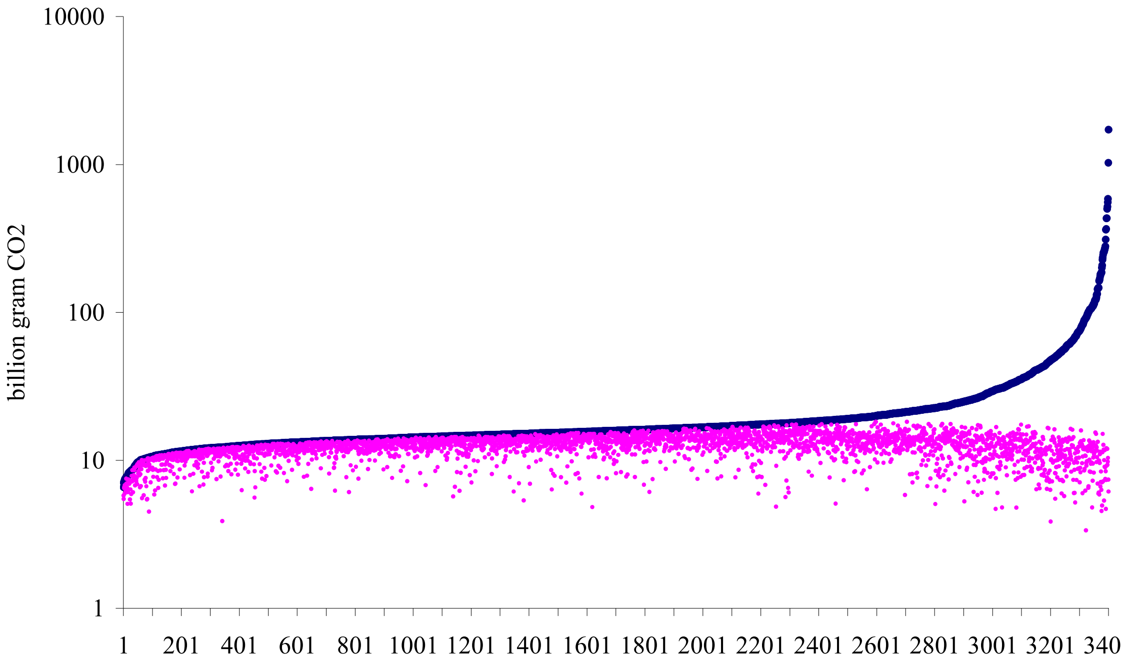

Figure 6. Total carbon dioxide emissions (billion grams of CO_2) from consumption and production per electoral district.

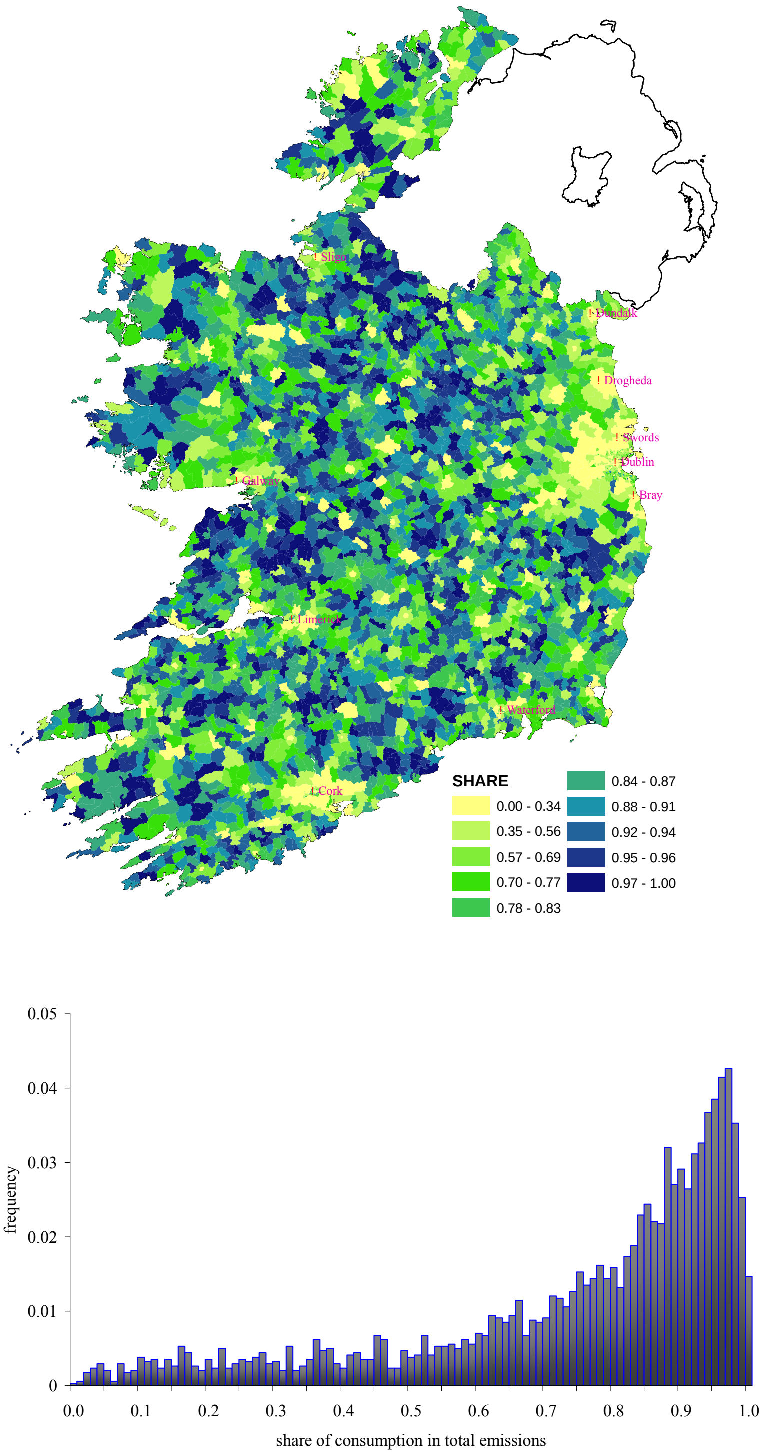

Figure 7. The share of consumption in total carbon dioxide emissions per electoral district.

Table A1: Household disposable income, OLS cross-section regression results		
Variables and statistics	**All variables**	
Dep. variable	*ln(Weekly disposable income of household, €)*	
	Coef.	Robust S.E.
d_social_1	0.318	0.0223***
d_social_2	0.366	0.0257***
d_social_3	0.219	0.0199***
d_social_5	-0.074	0.018***
d_social_6	-0.144	0.0204***
d_social_7	-0.185	0.0202***
d_social_8	-0.081	0.0309***
d_social_9	-0.148	0.0264***
d_social_10	-0.167	0.0485***
d_social_11	-0.112	0.0255***
d_empstatu~2	-1.2	0.0417***
d_empstatu~3	-1.17	0.0357***
d_empstatu~4	-0.754	0.0248***
d_empstatu~5	-1	0.0255***
d_persons_1	-0.605	0.019***
d_persons_3	0.377	0.0172***
d_persons_4	0.656	0.0198***
d_persons_5	0.815	0.0235***
d_persons_6	0.968	0.0288***
d_persons_7	1.01	0.0456***
d_persons_8	1.27	0.0644***
Constant	6.87	0.0179***
Observations	6,884	
R^2	0.654	
*Note: *, ** and *** denote significant at the 10%, 5% and 1% level respectively. Numbers in brackets are p-values.*		

Table A2: Total energy use from household fuels, OLS cross-section regression results

Variables and statistics	All variables		Preferred model	
Dep. variable	*Total energy use in household (kWh)*		*Total energy use in household (kWh)*	
	Coef.	Robust S.E.	Coef.	Robust S.E.
d_rooms_1	-113	50.3**	-78.9	37**
d_rooms_2	-210	38.9***	-183	27.7***
d_rooms_3	-112	26.4***	-110	23.9***
d_rooms_4	-13.7	19.2		
d_rooms_6	0.351	12.3		
d_rooms_7	25.4	14.2*	25.6	12.4**
d_rooms_8	72.3	17.9***	74.4	16.5***
d_built_1	-9.29	17.3		
d_built_3	-25.7	20.3		
d_built_4	-25	17.3		
d_built_5	-57.7	16.3***	-40.3	12.7***
d_built_6	-70.8	16.4***	-52.6	12.8***
d_built_7	-55.4	21.6***	-41.7	18.5**
d_social_1	3.51	16.8		
d_social_2	18.9	25.5		
d_social_3	-1.91	16.8		
d_social_5	-34.4	16.8**	-40.7	13.9***
d_social_6	-15.8	18.3		
d_social_7	27.5	31.7		
d_social_8	34	26.1		
d_social_9	-63.4	19.1***	-76.9	14.3***
d_social_10	-86.3	38.4**	-91.6	37**
d_social_11	-38.6	23*	-37.9	17.9**
d_centheat	70.7	34.3**	70.4	34.2**
d_persons_1	-84.5	13.5***	-94.8	12.3***
d_persons_3	37.1	15.4**	28.6	13.1**
d_persons_4	21.3	15.9		
d_persons_5	68.4	22.5***	65.7	21***
d_persons_6	86.1	35.1**	84.3	29.6***
d_persons_7	83.5	45.6*	86.5	42.5**
d_persons_8	40.1	61		
d_urban	13.1	11.3		
d_housetyp_2	-122	28.2***	-132	27.3***
d_housetyp_3	-154	58.8***	-188	47.2***
d_housetyp_4	101	91.9		
d_empstatu~2	0.932	36.5		
d_empstatu~3	29	32.7		
d_empstatu~4	46.5	16.4***	37	15.8**
d_empstatu~5	74.9	22.9***	65.4	18.4***
Constant	359	36.7***	374	37.2***
Observations	6,884		6,884	
R^2	0.0473		0.0449	

*Note: *, ** and *** denote significant at the 10%, 5% and 1% level respectively. Numbers in brackets are p-values.*

Table A3: Household electricity use, OLS cross-section regression results

Variables and statistics	**All variables**		**Preferred model**	
Dep. variable	*Electricity use (kWh)*		*Electricity use (kWh)*	
	Coef.	Robust S.E.	Coef.	Robust S.E.
d_rooms_1	-21.8	10.6**	-11.3	5.23**
d_rooms_2	-13	7.02*	-10.9	6.27*
d_rooms_3	0.429	4.27		
d_rooms_4	-0.158	2.40		
d_rooms_6	9.16	1.84***	9.06	1.71***
d_rooms_7	15.2	2.01***	15.2	1.91***
d_rooms_8	24.6	2.42***	24.7	2.33***
d_built_1	6.5	2.59**	6.68	2.36***
d_built_3	-1.47	2.28		
d_built_4	7.84	2.12***	7.75	1.85***
d_built_5	3.46	2.11*	3.21	1.81*
d_built_6	1.54	2.39		
d_built_7	-2.15	2.91		
d_social_1	3.67	2.30	4.31	1.87**
d_social_2	7.78	3.57**	8.49	3.31***
d_social_3	2.83	2.40		
d_social_5	-2.01	2.19		
d_social_6	-1.87	2.42		
d_social_7	0.613	3.60		
d_social_8	16.3	5.57***	16.9	5.30***
d_social_9	-10.8	3.03***	-10.5	2.48***
d_social_10	-4.65	6.47		
d_social_11	-3.05	3.46		
d_centheat	-9.38	3.14***	-9.18	3.12***
d_persons_1	-22.2	1.78***	-22.2	1.63***
d_persons_3	16	2.07***	15.4	1.99***
d_persons_4	26	2.62***	25.1	2.41***
d_persons_5	40.4	3.44***	39.0	2.88***
d_persons_6	43.4	4.09***	42.0	3.64***
d_persons_7	51.6	6.22***	49.9	5.95***
d_persons_8	63.7	12.6***	61.5	12.3***
d_urban	0.318	1.72		
d_housetyp_2	6.3	4.21		
d_housetyp_3	12	12.4		
d_housetyp_4	4.84	9.56		
d_empstatu~2	-1.91	4.62		
d_empstatu~3	-3.9	4.13		
d_empstatu~4	-23.8	2.28***	-23.6	2.11***
d_empstatu~5	-13.6	3.34***	-15.2	2.23***
Constant	81.2	4.62***	81.0	3.54***
Observations	6,884		6,884	
Adjusted R^2	0.222		0.220	

*Note: *, ** and *** denote significant at the 10%, 5% and 1% level respectively. Numbers in brackets are p-values.*

Table A4: Household direct CO_2 emissions, OLS cross-section regression results

Variables and statistics	All variables		Preferred model	
Dep. variable	*CO_2 emissions (T CO_2/ week)*		*CO_2 emissions (T CO_2/ week)*	
	Coef.	Robust S.E.	Coef.	Robust S.E.
d_rooms_1	-0.0301	0.0266		
d_rooms_2	-0.0583	0.013***	-0.0552	0.0118***
d_rooms_3	-0.0308	0.00896***	-0.0277	0.00857***
d_rooms_4	-0.00477	0.00699		
d_rooms_6	0.0201	0.00471***	0.0223	0.0046***
d_rooms_7	0.0462	0.00585***	0.0494	0.00581***
d_rooms_8	0.0949	0.0127***	0.0987	0.0123***
d_built_1	0.00752	0.00653		
d_built_3	0.0227	0.0124*		
d_built_4	0.0173	0.00606***	0.0111	0.00518**
d_built_5	0.00828	0.00811		
d_built_6	0.00135	0.00653		
d_built_7	0.0053	0.00797		
d_social_1	0.0233	0.0124*	0.0236	0.0105**
d_social_2	-0.000489	0.0103		
d_social_3	0.0142	0.00943		
d_social_5	-0.00267	0.00858		
d_social_6	-0.00867	0.0089		
d_social_7	-0.0118	0.00912		
d_social_8	0.0227	0.0121*	0.024	0.01**
d_social_9	-0.0213	0.0101**	-0.0193	0.00743***
d_social_10	-0.0102	0.0178		
d_social_11	-0.00932	0.0114		
d_centheat	0.0275	0.00751***	0.0297	0.00742***
d_persons_1	-0.0514	0.00581***	-0.0535	0.00583***
d_persons_3	0.045	0.00694***	0.0451	0.00668***
d_persons_4	0.0706	0.0082***	0.0707	0.00747***
d_persons_5	0.118	0.0112***	0.119	0.0105***
d_persons_6	0.155	0.0273***	0.155	0.0263***
d_persons_7	0.145	0.019***	0.145	0.0184***
d_persons_8	0.159	0.0269***	0.159	0.0266***
d_urban	-0.0341	0.00565***	-0.0329	0.00561***
d_housetyp_2	-0.0353	0.0116***	-0.036	0.0113***
d_housetyp_3	-0.0513	0.0276*	-0.072	0.0085***
d_housetyp_4	0.00394	0.0253		
d_empstatu~2	-0.0373	0.013***	-0.0422	0.0129***
d_empstatu~3	-0.0858	0.0191***	-0.0914	0.0158***
d_empstatu~4	-0.0251	0.00797***	-0.0263	0.0076***
d_empstatu~5	-0.0375	0.00984***	-0.045	0.0066***
Constant	0.206	0.0121***	0.209	0.00968***
Observations	6,884		6,884	
Adjusted R^2	0.165		0.185	

*Note: *, ** and *** denote significant at the 10%, 5% and 1% level respectively. Numbers in brackets are p-values.*

Table A5: First preference votes for Green Party, OLS cross-section regression results on county level data				
Variables and statistics	**All variables**		**Preferred model**	
Dep. variable	*Share of votes (percentage)*		*Share of votes (percentage)*	
	Coef.	S.E.	Coef.	S.E.
Carbon tax - *imputed*	-0.102	0.0792	-0.104	0.041**
Years of education	2.39	1.12**	2.38	1.07**
Share of farmers in work force	-1.23	18.8		
Disposable Income (average '000 per household)	0.599	0.265**	0.609	0.194***
Waste generation (T/household) - *imputed*	-3.85	47.8		
Constant	-44.5	30.9	-46.5	17.4**
Observations	43		43	
Adjusted R^2	0.476		0.503	
*Note: *, ** and *** denote significant at the 10%, 5% and 1% level respectively. Waste generation is imputed using a similar approach to the one used for the carbon tax incidence: by applying the results from classifying regressions to population characteristics for each area. See Tol, et al. (2009) for details.*				

Working Papers

Research Unit Sustainability and Global Change

Hamburg University and Centre for Marine and Atmospheric Science

Leahy, E., S. Lyons, E.L.W. Morgenroth and R.S.J. Tol (2009), *The Spatial Incidence of a Carbon Tax in Ireland*, **FNU-174** (submitted)

Genova Koleva, N. and U.A. Schneider (2009), *The impact of climate change on aquatic risk from agricultural pesticides in the US*, **FNU-173** (submitted)

Osmani, D. (2009), *Burden Sharing Emissions and Climate Change: A Theoretic Welfare Approach,* **FNU-172** (submitted)

Genova Koleva, N., U.A. Schneider, and R.S.J. Tol (2009), *The impact of weather variability and climate change on pesticide applications in the US - An empirical investigation*, **FNU-171** (submitted)

Calzadilla, A., T. Zhu, K. Rehdanz, R.S.J. Tol and C. Ringler (2009), *Economy-Wide Impacts of Climate Change on Agriculture in Sub-Saharan Africa,* **FNU-170** (submitted)

Calzadilla, A., K. Rehdanz and R.S.J. Tol (2008), The Economic Impact of More Sustainable Water Use in Agriculture: A Computable General Equilibrium Analysis, **FNU-169** (submitted)

Schleupner, C. and P.M. Link (2008), *Eiderstedt im Spannungsfeld zwischen Naturschutz- und Agrarpolitik - Entwicklung eines methodischen Ansatzes für ein nachhaltiges Ressourcenmanagement in ökologisch sensiblen Regionen*, **FNU-168** (submitted)

Sauer, T., P.M. Link and U.A. Schneider (2008), *The role of water resources in agricultural land use modeling: an extension of the land use model KLUM*, **FNU-167**

Meier, H. and K. Rehdanz (2008), *Determinants of Residential Space Heating Expenditures in Great Britain*, **FNU-166** (submitted)

Link, P.M., C.I. Ramos, U.A. Schneider, E. Schmid, J. Balkovic and R. Skalsky (2008), *The interdependencies between food and biofuel production in European agriculture - an application of EUFASOM*, **FNU-165** (submitted)

Schneider, U.A. and P. Smith (2008), *Greenhouse Gas Emission Mitigation and Energy Intensities in Agriculture*, **FNU-164** (submitted)

Maddison, D. and K. Rehdanz (2008), *Carbon Emissions and Economic Growth: Homogeneous Causality in Heterogeneous Panels*, **FNU-163** (submitted)

Osmani, D. and R.S.J. Tol (2008), Evolution in time of Farsightedly Stable Coalitions: An Application of FUND, **FNU-162** (submitted)

Schneider U.A., P. Havlik, E. Schmid, I. Huck, M. Obersteiner, T. Sauer, C. Llull, R. Skalsky, J. Balkovic, S. Fritz, B. Dorin, and S. Leduc (2008), *Global interdependencies between population, water, food, and environmental policies*, **FNU-161** (submitted)

Calzadilla, A, K. Rehdanz and R.S.J. Tol (2008), *Water Scarcity and the Impact of Improved Irrigation Management: A CGE Analysis*, **FNU-160** (submitted)

Schleupner, C. and U.A. Schneider (2008), *A cost-effective spatial wetland site-selection model for European biotope restoration*, **FNU-159** (submitted)

Schleupner, C. and U.A. Schneider (2008), *Evaluation of European wetland restoration potentials by considering economic costs under different policy options*, **FNU-158** (submitted)

Bigano, A., J.M. Hamilton and R.S.J. Tol (2008), Climate Change and Tourism in the Mediterranean, **FNU-157** (submitted).

Schneider U.A., J. Balkovic, S. De Cara, O. Franklin, S. Fritz, P. Havlik, I. Huck, K. Jantke, A.M.I. Kallio, F. Kraxner, A. Moiseyev, M. Obersteiner, C.I. Ramos, C. Schleupner, E. Schmid, D. Schwab, R. Skalsky (2008), *The European Forest and Agricultural Sector Optimization Model – EUFASOM*, **FNU-156**.

Schneider, U.A. and P. Kumar (2008), *Greenhouse Gas Emission Mitigation through Agriculture*, **FNU-155**.

Tol, R.S.J. and S. Wagner (2008), *Climate Change and Violent Conflict in Europe over the Last Millennium*. **FNU-154** (forthcoming, *Climatic Change*).

Schleupner, C. (2007), *Regional Spatial Planning Assessments for Adaptation to accelerated sea level rise – an application to Martinique's coastal zone*. **FNU-153** (submitted).

Schleupner, C. (2007). *Evaluating the Regional Coastal Impact Potential to Erosion and Inundation caused by Extreme Weather Events and Tsunamis*. **FNU-152** (submitted).

Rehdanz, K. (2007), *Species diversity and human well-being: A spatial econometric approach*, **FNU-151** (submitted).

Osmani, D. and R.S.J. Tol (2007), *A short note on joint welfare maximization assumption*, **FNU-150** (submitted).

Osmani, D. and R.S.J. Tol (2007), *Towards Farsightedly Stable International Environmental Agreements: Part Two*, **FNU-149** (submitted).

Ruane, F.P. and R.S.J. Tol (2007), *Academic Quality, Power and Stability: An Application to Economics in the Republic of Ireland*, **FNU-148** (submitted).

Tol, R.S.J. (2007), *A Rational, Successive g-Index Applied to Economics Departments in Ireland*, **FNU-147** (*Journal of Informetrics*, **2**, 149-155).

Tol, R.S.J. (2007), *Of the h-Index and its Alternatives: An Application to the 100 Most Prolific Economists*, **FNU-146** (forthcoming, *Scientometrics*).

Yohe, G.W. and R.S.J. Tol (2007), *Precaution and a Dismal Theorem: Implications for Climate Policy and Climate Research*, **FNU-145** (submitted).

Tol, R.S.J. (2007), *The Social Cost of Carbon: Trends, Outliers and Catastrophes*, **FNU-144** (E*conomics the Open-Access, Open-Assessment E-Journal*, **2** (25), 1-24).

Tol, R.S.J. (2007), *The Matthew Effect Defined and Tested for the 100 Most Prolific Economists*, **FNU-143** (*Journal of the American Society for Information Science and Technology*, **60** (2), 420-426).

Berrittella, M., K. Rehdanz, R.S.J. Tol and J. Zhang (2007), *The Impact of Trade Liberalisation on Water Use: A Computable General Equilibrium Analysis,* **FNU-142** (*Journal of Economic Integration,* **23** (3), 631-655).

Lyons, S., K. Mayor and R.S.J. Tol (2007), *Convergence of Consumption Patterns during Macroeconomic Transition: A Model of Demand in Ireland and the OECD,* **FNU-141** (*Economic Modelling*, **26**, 702-714).

Osmani, D. and R.S.J. Tol (2007), *Towards Farsightedly Stable International Environmental Agreements,* **FNU-140** (*Journal of Public Economic Theory*, **11** (3), 455-492).

Rehdanz, K. and S. Stöwhase (2007), *Cost Liability and Residential Space Heating Expenditures of Welfare Recipients in Germany*, **FNU-139** (submitted).

Schleupner, C. and P.M. Link (2007), *Potential impacts on bird habitats in Eiderstedt (Schleswig-Holstein) caused by agricultural land use changes*, **FNU-138** (*Applied Geography*, doi: 10.1016/j.apgeog.2008.04.001).

Link, P.M. and C. Schleupner (2007), *Agricultural land use changes in Eiderstedt: historic developments and future plans*, **FNU-137** (*Coastline Reports*, **9**, 197-206).

Anthoff, D., R.J. Nicholls and R.S.J. Tol (2007), *Global Sea Level Rise and Equity Weighting*, **FNU-136** (submitted).

Schleupner, C. (2007), *Wetland Distribution Modelling for Optimal Land Use Options in Europe*, **FNU-135** (submitted).

Mayor, K. and R.S.J. Tol (2007), *The Impact of the EU-US Open Skies Agreement on International Travel and Carbon Dioxide Emissions*, **FNU-134** (*Journal of Air Transport Management*, **14**, 1-7).

Schneider, U.A., M. Obersteiner, and E. Schmid (2007), *Agricultural adaptation to climate policies and technical change*, **FNU-133** (submitted).

Lychnaras, V. and U.A. Schneider (2007), *Dynamic Economic Analysis of Perennial Energy Crops - Effects of the CAP Reform on Biomass Supply in Greece*, **FNU-132** (submitted).

Mayor, K. and R.S.J. Tol (2007), The Impact of the UK Aviation Tax on Carbon Dioxide Emissions and Visitor Numbers, **FNU-131** (*Transport Policy,* **14** (6), 407-513).

Ruane, F. and R.S.J. Tol (2007), *Refined (Successive) h-indices: An Application to Economics in the Republic of Ireland*, **FNU-130** (*Scientometrics*, **75** (2), 395-405).

Yohe, G.W., R.S.J. Tol and D. Murphy (2007), *On Setting Near-Term Climate Policy as the Dust Begins the Settle: The Legacy of the Stern Review*, **FNU-129** (*Energy & Environment*, **18** (5), 621-633).

Maddison, D.J. and K. Rehdanz (2007), *Happiness over Space and Time*, **FNU-128** (submitted).

Anthoff, D. and R.S.J. Tol (2007), *On International Equity Weights and National Decision Making on Climate Change*, **FNU-127** (submitted).

de Bruin, K.C., R.B. Dellink and R.S.J. Tol (2007), *AD-DICE: An Implementation of Adaptation in the DICE Model*, **FNU-126** (forthcoming, *Climatic Change*).

Tol, R.S.J. and G.W. Yohe (2007), *The Stern Review: A Deconstruction*, **FNU-125** (*Energy Policy*, **37** (3), 1032-1040).

Keller, K., L.I. Miltich, A. Robinson and R.S.J. Tol (2007), *How Overconfident Are Current Projections of Anthropogenic Carbon Dioxide Emissions?*, **FNU-124** (submitted, *Energy Journal*).

Cowie, A., U.A. Schneider and L. Montanarella (2006), *Potential synergies between existing multilateral environmental agreements in the implementation of Land Use, Land Use Change and Forestry activities*, **FNU-123** (submitted)

Kuik, O.J., B. Buchner, M. Catenacci, A. Goria, E. Karakaya and R.S.J. Tol (2006), *Methodological Aspects of Recent Climate Change Damage Cost Studies*, **FNU-122** (*Integrated Assessment Journal*, **8** (1), 19-40)

Anthoff, D., C. Hepburn and R.S.J. Tol (2006), *Equity Weighting and the Marginal Damage Costs of Climate Change*, **FNU-121** (*Ecological Economics,* **68**, 836-849)

Tol, R.S.J. (2006), *The Impact of a Carbon Tax on International Tourism*, **FNU-120** (*Transportation Research D: Transport and the Environment*, **12** (2), 129-142).

Rehdanz, K. and D.J. Maddison (2006), *Local Environmental Quality and Life Satisfaction in Germany*, **FNU-119** (forthcoming, *Ecological Economics*)

Tanaka, K., R.S.J. Tol, D. Rokityanskiy, B.C. O'Neill and M. Obersteiner (2006), *Evaluating Global Warming Potentials as Historical Temperature Proxies: An Application of ACC2 Inverse Calculation*, **FNU-118** (forthcoming, *Climatic Change*)

Berrittella, M., K. Rehdanz and R.S.J. Tol (2006), *The Economic Impact of the South-North Water Transfer Project in China: A Computable General Equilibrium Analysis*, **FNU-117** (submitted, *China Economic Review*)

Tol, R.S.J. (2006), *Why Worry about Climate Change? A Research Agenda*, **FNU-116** (*Environmental Values,* **17** (4), 437-470)

Hamilton, J.M. and R.S.J. Tol (2006), *The Impact of Climate Change on Tourism in Germany, the UK and Ireland: A Simulation Study*, **FNU-115** (*Regional Environmental Change,* **7** (3), 161-172)

Schwoon, M., F. Alkemade, K. Frenken and M.P. Hekkert (2006), *Flexible transition strategies towards future well-to-wheel chains: an evolutionary modelling approach*, **FNU-114** (submitted).

Ronneberger, K., L. Criscuolo, W. Knorr and R.S.J. Tol (2006), *KLUM@LPJ: Integrating dynamic land-use decisions into a dynamic global vegetation and crop growth model to assess the impacts of a changing climate. A feasibility study for Europe,* **FNU-113** (submitted)

Schwoon, M. (2006), *Learning-by-doing, Learning Spillovers and the Diffusion of Fuel Cell Vehicles*, **FNU-112** (submitted).

Strzepek, K.M., G.W. Yohe, R.S.J. Tol and M. Rosegrant (2006), *The Value of the High Aswan Dam to the Egyptian Economy*, **FNU-111** (*Ecological Economics,* **66** (1), 117-126).

Schwoon, M. (2006), *A Tool to Optimize the Initial Distribution of Hydrogen Filling Stations*, **FNU-110** (*Transportation Research D: Transport and the Environment*, **12** (2), 70-82).

Tol, R.S.J., K.L. Ebi and G.W. Yohe (2006), *Infectious Disease, Development, and Climate Change: A Scenario Analysis*, **FNU-109** (*Environment and Development Economics,* **12**, 687-706).

Lau, M.A. (2006), *An analysis of the travel motivation of tourists from the People's Republic of China,* **FNU-108** (submitted).

Lau, M.A. and R.S.J. Tol (2006), *The Chinese are coming – An analysis of the preferences of Chinese holiday makers at home and abroad*, **FNU-107** (submitted).

Röckmann, C., R.S.J. Tol, U.A. Schneider, and M.A. St.John (2006), *Rebuilding the Eastern Baltic cod stock under environmental change - Part II: The economic viability of a marine protected area.* **FNU-106** (*Natural Resources Modelling,* **22** (1), 1-25)

Ronneberger, K., M. Berrittella, F. Bosello and R.S.J. Tol (2006), *KLUM@GTAP: Introducing biophysical aspects of land-use decisions into a general equilibrium model. A coupling experiment,* **FNU-105** (*Environmental Modelling and Assessment*, **14**, 149-169).

Link, P.M. and Tol, R.S.J. (2006), *Economic impacts on key Barents Sea fisheries arising from changes in the strength of the Atlantic thermohaline circulation*, **FNU-104** (submitted).

Link, P.M. and Tol, R.S.J. (2006), *Estimation of the economic impact of temperature changes induced by a shutdown of the thermohaline circulation: an application of FUND*, **FNU-103** (submitted, *Climatic Change*).

Tol, R.S.J. (2006), *Integrated Assessment Modelling*, **FNU-102** (submitted).

Tol, R.S.J. (2006), *Carbon Dioxide Emission Scenarios for the USA*, **FNU-101** (*Energy Policy*, **35**, 5310-5326).

Tol, R.S.J., S.W. Pacala and R.H. Socolow (2006), *Understanding Long-Term Energy Use and Carbon Dioxide Emissions in the USA*, **FNU-100** (*Journal of Policy Modelling*, **31**, 425-445).

Sesabo, J.K, H. Lang and R.S.J. Tol (2006), *Perceived Attitude and Marine Protected Areas (MPAs) establishment: Why households' characteristics matters in Coastal resources conservation initiatives in Tanzania*, **FNU-99** (submitted).

Tol, R.S.J. (2006), *The Polluter Pays Principle and Cost-Benefit Analysis of Climate Change: An Application of* FUND, **FNU-98** (submitted)

Tol, R.S.J. and G.W. Yohe (2006), *The Weakest Link Hypothesis for Adaptive Capacity: An Empirical Test*, **FNU-97** (*Global Environmental Change,* **17**, 218-227)

Berrittella, M., K. Rehdanz, R.Roson and R.S.J. Tol (2005), *The Economic Impact of Water Pricing: A Computable General Equilibrium Analysis*, **FNU-96** (*Water Policy,* **10** (3), 259-271)

Sesabo, J.K. and R. S. J. Tol (2005), *Technical Efficiency and Small-scale Fishing Households in Tanzanian coastal Villages: An Empirical Analysis*, **FNU-95** (submitted)

Lau, M.A. (2005), *Adaptation to Sea-level Rise in the People's Republic of China – Assessing the Institutional Dimension of Alternative Organisational Frameworks*, **FNU-94** (submitted)

Berrittella, M., A.Y. Hoekstra, K. Rehdanz, R. Roson and R.S.J. Tol (2005), *The Economic Impact of Restricted Water Supply: A Computable General Equilibrium Analysis*, **FNU-93** (*Water Research*, **42**, 1799-1813)

Tol, R.S.J. (2005), *Europe's Long Term Climate Target: A Critical Evaluation*, **FNU-92** (*Energy Policy*, **35** (1), 424-434)

Hamilton, J.M. (2005), *Coastal Landscape and the Hedonic Price of Accommodation*, **FNU-91** (Ecological Economics, **62** (3-4), 594-602)

Hamilton, J.M., D.J. Maddison and R.S.J. Tol (2005), *Climate Preferences and Destination Choice: A Segmentation Approach*, **FNU-90** (submitted)

Zhou, Y. and R.S.J. Tol (2005), *Valuing the Health Impacts from Particulate Air Pollution in Tianjin*, **FNU-89** (submitted)

Röckmann, C. (2005), *International Cooperation for Sustainable Fisheries in the Baltic Sea,* **FNU-88** (forthcoming, in Ehlers,P./Lagoni,R. (Eds.): *International Maritime Organisations and their Contribution towards a Sustainable Marine Development*.)

Ceronsky, M., D. Anthoff, C. Hepburn and R.S.J. Tol (2005), *Checking the price tag on catastrophe: The social cost of carbon under non-linear climate response* **FNU-87** (submitted, *Climatic Change*)

Zandersen, M. and R.S.J. Tol (2005), *A Meta-analysis of Forest Recreation Values in Europe,* **FNU-86** (*Journal of Forest Economics,* **15** (9), 109-130)

Heinzow, T., R.S.J. Tol and B. Brümmer (2005), Offshore-Windstromerzeugung in der Nordsee -eine ökonomische und ökologische Sackgasse? **FNU-85** (*Energiewirtschaftliche Tagesfragen*, **56** (3), 68-73)

Röckmann, C., U.A. Schneider, M.A. St.John, and R.S.J. Tol (2005), *Rebuilding the Eastern Baltic cod stock under environmental change - a preliminary approach using stock, environmental, and management constraints,* **FNU-84** (*Natural Resources Modelling,* **20** (2), 223-262)

Tol, R.S.J. and G.W. Yohe (2005), *Infinite uncertainty, forgotten feedbacks, and cost-benefit analysis of climate policy,* **FNU-83** (*Climatic Change*, **83**, 429-442)

Osmani, D. and R.S.J. Tol (2005), *The case of two self-enforcing international agreements for environmental protection*, **FNU-82** (submitted)

Schneider, U.A. and B.A. McCarl, (2005), *Appraising Agricultural Greenhouse Gas Mitigation Potentials: Effects of Alternative Assumptions*, **FNU-81** (submitted)

Zandersen, M., M. Termansen, and F.S. Jensen, (2005), *Valuing new forest sites over time: the case of afforestation and recreation in Denmark,* **FNU-80** (submitted)

Guillerminet, M.-L. and R.S.J. Tol (2005), *Decision making under catastrophic risk and learning: the case of the possible collapse of the West Antarctic Ice Sheet*, **FNU-79** (*Climatic Change,* **91** (1-2), 193-209)

Nicholls, R.J., R.S.J. Tol and A.T. Vafeidis (2005), *Global estimates of the impact of a collapse of the West Antarctic Ice Sheet: An application of FUND,* **FNU-78** (forthcoming, *Climatic Change,* **91** (1-2), 171-191)

Lonsdale, K., T.E. Downing, R.J. Nicholls, D. Parker, A.T. Vafeidis, R. Dawson and J.W. Hall (2005), *Plausible responses to the threat of rapid sea-level rise for the Thames Estuary,* **FNU-77** (submitted, *Climatic Change*)

Poumadère, M., C. Mays, G. Pfeifle with A.T. Vafeidis (2005), *Worst Case Scenario and Stakeholder Group Decision: A 5-6 Meter Sea Level Rise in the Rhone Delta, France,* **FNU-76** (submitted, *Climatic Change*)

Olsthoorn, A.A., P.E. van der Werff, L.M. Bouwer and D. Huitema (2005), *Neo-Atlantis: Dutch Responses to Five Meter Sea Level Rise,* **FNU-75** (forthcoming, *Climatic Change*)

Toth, F.L. and E. Hizsnyik (2005), *Managing the inconceivable: Participatory assessments of impacts and responses to extreme climate change*, **FNU-74** (submitted, *Climatic Change*)

Kasperson, R.E. M.T. Bohn and R. Goble (2005), *Assessing the risks of a future rapid large sea level rise: A review,* **FNU-73** (submitted, *Climatic Change*)

Schleupner, C. (2005), *Evaluation of coastal squeeze and beach reduction and its consequences for the Caribbean island Martinique,* **FNU-72** (submitted)

Schleupner, C. (2005), *Spatial Analysis As Tool for Sensitivity Assessment of Sea Level Rise Impacts on Martinique,* **FNU-71** (submitted)

Sesabo, J.K. and R.S.J. Tol (2005), *Factors affecting Income Strategies among households in Tanzanian Coastal Villages: Implication for Development-Conservation Initiatives,* **FNU-70** (submitted)

Fisher, B.S., G. Jakeman, H.M. Pant, M. Schwoon. and R.S.J. Tol (2005), *CHIMP: A Simple Population Model for Use in Integrated Assessment of Global Environmental Change*, **FNU-69** (*Integrated Assessment Journal*, **6** (3), 1-33)

Rehdanz, K. and R.S.J. Tol (2005), *A No Cap But Trade Proposal for Greenhouse Gas Emission Reduction Targets for Brazil, China and India*, **FNU-68** (*Climate Policy,* **18** (3), 293-304)

Zhou, Y. and R.S.J. Tol (2005), *Water Use in China's Domestic, Industrial and Agricultural Sectors: An Empirical Analysis*, **FNU-67** (*Water Science and Technoloy: Water Supply*, **5** (6), 85-93)

Rehdanz, K. (2005), *Determinants of Residential Space Heating Expenditures in Germany*, **FNU-66** (*Energy Economics* **29**)

Ronneberger, K., R.S.J. Tol and U.A. Schneider (2005), *KLUM: A Simple Model of Global Agricultural Land Use as a Coupling Tool of Economy and Vegetation,* **FNU-65** (submitted, *Climatic Change*)

Tol, R.S.J. (2005), *The Benefits of Greenhouse Gas Emission Reduction: An Application of* FUND, **FNU-64** (submitted, *Global Environmental Change*)

Röckmann, C., M.A. St.John, U.A. Schneider, F.W. Köster, F.W. and R.S.J. Tol (2006), *Testing the implications of a permanent or seasonal marine reserve on the population dynamics of Eastern Baltic cod under varying environmental conditions,* **FNU-63-revised** (*Fisheries Research,* **85**, 1-13)

Letsoalo, A., J. Blignaut, T. de Wet, M. de Wit, S. Hess, R.S.J. Tol and J. van Heerden (2005), *Triple Dividends of Water Consumption Charges in South Africa*, **FNU-62** (*Water Resources Research*, **43**, W05412)

Zandersen, M., Termansen, M., Jensen,F.S. (2005), *Benefit Transfer over Time of Ecosystem Values: the Case of Forest Recreation,* **FNU-61** (submitted)

Rehdanz, K., Jung, M., Tol, R.S.J. and Wetzel, P. (2005), *Ocean Carbon Sinks and International Climate Policy*, **FNU-60** (*Energy Policy*, **34**, 3516-3526)

Schwoon, M. (2005), *Simulating the Adoption of Fuel Cell Vehicles*, **FNU-59** (submitted)

Bigano, A., J.M. Hamilton and R.S.J. Tol (2005), *The Impact of Climate Change on Domestic and International Tourism: A Simulation Study*, **FNU-58** (submitted, *Integrated Assessment Journal*)

Bosello, F., R. Roson and R.S.J. Tol (2004), *Economy-wide estimates of the implications of climate change: Human health*, **FNU-57** (*Ecological Economics,* **58**, 579-591)

Hamilton, J.M. and M.A. Lau (2004) *The role of climate information in tourist destination choice decision-making,* **FNU-56** (forthcoming, Gössling, S. and C.M. Hall (eds.), Tourism and Global Environmental Change. London: Routledge)

Bigano, A., J.M. Hamilton and R.S.J. Tol (2004), *The impact of climate on holiday destination choice*, **FNU-55** (*Climatic Change*, **76** (3-4), 389-406)

Bigano, A., J.M. Hamilton, M. Lau, R.S.J. Tol and Y. Zhou (2004), *A global database of domestic and international tourist numbers at national and subnational level*, **FNU-54** (*International Journal of Tourism Research,* **9**, 147-174)

Susandi, A. and R.S.J. Tol (2004), *Impact of international emission reduction on energy and forestry sector of Indonesia*, **FNU-53** (submitted)

Hamilton, J.M. and R.S.J. Tol (2004), *The Impact of Climate Change on Tourism and Recreation*, **FNU-52** (forthcoming, Schlesinger et al. (eds.), Cambridge University Press)

Schneider, U.A. (2004), *Land Use Decision Modelling with Soil Status Dependent Emission Rates*, **FNU-51** (submitted)

Link, P.M., U.A. Schneider and R.S.J. Tol (2004), *Economic impacts of changes in fish population dynamics: the role of the fishermen's harvesting strategies*, **FNU-50** (submitted)

Berritella, M., A. Bigano, R. Roson and R.S.J. Tol (2004), *A General Equilibrium Analysis of Climate Change Impacts on Tourism*, **FNU-49** (*Tourism Management*, **27** (5), 913-924)

Tol, R.S.J. (2004), *The Double Trade-Off between Adaptation and Mitigation for Sea Level Rise: An Application of* FUND, **FNU-48** (*Mitigation and Adaptation Strategies for Global Change*, **12** (5), 741-753)

Erdil, E. and Yetkiner, I.H. (2004), *A Panel Data Approach for Income-Health Causality*, **FNU-47**

Tol, R.S.J. (2004), *Multi-Gas Emission Reduction for Climate Change Policy: An Application of* FUND, **FNU-46** (*Energy Journal* (Multi-Greenhouse Gas Mitigation and Climate Policy Special Issue), 235-250)

Tol, R.S.J. (2004), *Exchange Rates and Climate Change: An Application of* FUND, **FNU-45** (*Climatic Change*, **75**, 59-80)

Gaitan, B., Tol, R.S.J, and Yetkiner, I. Hakan (2004), *The Hotelling's Rule Revisited in a Dynamic General Equilibrium Model*, **FNU-44** (submitted)

Rehdanz, K. and Tol, R.S.J (2004), *On Multi-Period Allocation of Tradable Emission Permits*, **FNU-43** (submitted)

Link, P.M. and Tol, R.S.J. (2004), *Possible Economic Impacts of a Shutdown of the Thermohaline Circulation: An Application of* FUND, **FNU-42** (*Portuguese Economic Journal*, **3**, 99-114)

Zhou, Y. and Tol, R.S.J. (2004), *Evaluating the costs of desalination and water transport*, **FNU-41** (*Water Resources Research*, **41** (3), W03003)

Lau, M. (2004), *Küstenzonenmanagement in der Volksrepublik China und Anpassungsstrategien an den Meeresspiegelanstieg*,**FNU-40** (*Coastline Reports* (1), 213-224.)

Rehdanz, K. and D.J. Maddison (2004), *The Amenity Value of Climate to German Households*, **FNU-39** (submitted)

Bosello, F., Lazzarin, M., Roson, R. and Tol, R.S.J. (2004), *Economy-wide Estimates of the Implications of Climate Change: Sea Level Rise*, **FNU-38** (*Environmental and Resource Economics*, **37**, 549-571)

Schwoon, M. and Tol, R.S.J. (2004), *Optimal CO_2-abatement with socio-economic inertia and induced technological change*, **FNU-37** (*Energy Journal*, **27** (4), 25-60)

Hamilton, J.M., Maddison, D.J. and Tol, R.S.J. (2004), *The Effects of Climate Change on International Tourism*, **FNU-36** (*Climate Research*, **29**, 255-268)

Hansen, O. and R.S.J. Tol (2003), *A Refined Inglehart Index of Materialism and Postmaterialism*, **FNU-35** (submitted)

Heinzow, T. and R.S.J. Tol (2003), *Prediction of Crop Yields across four Climate Zones in Germany: An Artificial Neural Network Approach*, **FNU-34** (submitted, *Climate Research*)

Tol, R.S.J. (2003), *Adaptation and Mitigation: Trade-offs in Substance and Methods*, **FNU-33** (*Environmental Science and Policy*, **8** (6), 572-578)

Tol, R.S.J. and T. Heinzow (2003), *Estimates of the External and Sustainability Costs of Climate Change*, **FNU-32** (submitted)

Hamilton, J.M., Maddison, D.J. and Tol, R.S.J. (2003), *Climate change and international tourism: a simulation study*, **FNU-31** (*Global Environmental Change*, **15** (3), 253-266)

Link, P.M. and R.S.J. Tol (2003), *Economic impacts of changes in population dynamics of fish on the fisheries in the Barents Sea*, **FNU-30** (*ICES Journal of Marine Science*, **63** (4), 611-625)

Link, P.M. (2003), *Auswirkungen populationsdynamischer Veränderungen in Fischbeständen auf die Fischereiwirtschaft in der Barentssee*, **FNU-29** (*Essener Geographische Arbeiten*, **35**, 179-202)

Lau, M. (2003), *Coastal Zone Management in the People's Republic of China – An Assessment of Structural Impacts on Decision-making Processes*, **FNU-28** (*Ocean & Coastal Management*, No. 48 (2005), pp. 115-159.)

Lau, M. (2003), *Coastal Zone Management in the People's Republic of China – A Unique Approach?*, **FNU-27** (*China Environment Series*, Issue 6, pp. 120-124; http://www.wilsoncenter.org/topics/pubs/7-commentaries.pdf)

Roson, R. and R.S.J. Tol (2003), *An Integrated Assessment Model of Economy-Energy-Climate – The Model Wiagem: A Comment*, **FNU-26** (*Integrated Assessment*, **6** (1), 75-82)

Yetkiner, I.H. (2003), *Is There An Indispensable Role For Government During Recovery From An Earthquake? A Theoretical Elaboration*, **FNU-25**

Yetkiner, I.H. (2003), *A Short Note On The Solution Procedure Of Barro And Sala-i-Martin for Restoring Constancy Conditions*, **FNU-24**

Schneider, U.A. and B.A. McCarl (2003), *Measuring Abatement Potentials When Multiple Change is Present: The Case of Greenhouse Gas Mitigation in U.S. Agriculture and Forestry*, **FNU-23** (submitted)

Zhou, Y. and Tol, R.S.J. (2003), *The Implications of Desalination to Water Resources in China - an Economic Perspective*, **FNU-22** (*Desalination*, **163** (4), 225-240)

Yetkiner, I.H., de Vaal, A., and van Zon, A. (2003), *The Cyclical Advancement of Drastic Technologies*, **FNU-21**

Rehdanz, K. and Maddison, D. (2003) *Climate and Happiness*, **FNU-20** (*Ecological Economics*, **52** 111-125)

Tol, R.S.J., (2003), *The Marginal Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties*, **FNU-19** (*Energy Policy*, **33** (16), 2064-2074).

Lee, H.C., B.A. McCarl, U.A. Schneider, and C.C. Chen (2003), *Leakage and Comparative Advantage Implications of Agricultural Participation in Greenhouse Gas Emission Mitigation*, **FNU-18** (submitted).

Schneider, U.A. and B.A. McCarl (2003), *Implications of a Carbon Based Energy Tax for U.S. Agriculture*, **FNU-17** (submitted).

Tol, R.S.J. (2002), *Climate, Development, and Malaria: An Application of* FUND, **FNU-16** (forthcoming, *Climatic Change*).

Hamilton, J.M. (2003), *Climate and the Destination Choice of German Tourists,* **FNU-15** (revised and submitted).

Tol, R.S.J. (2002), *Technology Protocols for Climate Change: An Application of* FUND, **FNU-14** (*Climate Policy,* **4**, 269-287).

Rehdanz, K (2002), *Hedonic Pricing of Climate Change Impacts to Households in Great Britain*, **FNU-13** (*Climatic Change* **74**).

Tol, R.S.J. (2002), *Emission Abatement Versus Development As Strategies To Reduce Vulnerability To Climate Change: An Application Of* FUND, **FNU-12** (*Environment and Development Economics,* **10**, 615-629).

Rehdanz, K. and Tol, R.S.J. (2002), *On National and International Trade in Greenhouse Gas Emission Permits*, **FNU-11** (*Ecological Economics*, **54**, 397-416).

Fankhauser, S. and Tol, R.S.J. (2001), *On Climate Change and Growth*, **FNU-10** (*Resource and Energy Economics*, **27**, 1-17).

Tol, R.S.J.and Verheyen, R. (2001), *Liability and Compensation for Climate Change Damages – A Legal and Economic Assessment*, **FNU-9** (*Energy Policy*, **32** (9), 1109-1130).

Yohe, G. and R.S.J. Tol (2001), *Indicators for Social and Economic Coping Capacity – Moving Toward a Working Definition of Adaptive Capacity*, **FNU-8** (*Global Environmental Change*, **12** (1), 25-40).

Kemfert, C., W. Lise and R.S.J. Tol (2001), *Games of Climate Change with International Trade*, **FNU-7** (*Environmental and Resource Economics*, **28**, 209-232).

Tol, R.S.J., W. Lise, B. Morel and B.C.C. van der Zwaan (2001), *Technology Development and Diffusion and Incentives to Abate Greenhouse Gas Emissions*, **FNU-6** (submitted).

Kemfert, C. and R.S.J. Tol (2001), *Equity, International Trade and Climate Policy*, **FNU-5** (*International Environmental Agreements*, **2**, 23-48).

Tol, R.S.J., Downing T.E., Fankhauser S., Richels R.G. and Smith J.B. (2001), *Progress in Estimating the Marginal Costs of Greenhouse Gas Emissions*, **FNU-4**. (*Pollution Atmosphérique – Numéro Spécial: Combien Vaut l'Air Propre?*, 155-179).

Tol, R.S.J. (2000), *How Large is the Uncertainty about Climate Change?*, **FNU-3** (*Climatic Change*, **56** (3), 265-289).

Tol, R.S.J., S. Fankhauser, R.G. Richels and J.B. Smith (2000), *How Much Damage Will Climate Change Do? Recent Estimates*, **FNU-2** (*World Economics,* **1** (4), 179-206)

Lise, W. and R.S.J. Tol (2000), *Impact of Climate on Tourism Demand*, **FNU-1** (*Climatic Change*, **55** (4), 429-449).